

IN SEARCH OF THE OTITIS MEDIA-SPEECH CONNECTION

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What I would like to share in this paper may best be characterized as a detective story. Many years ago I was struck by the speech of a 4-year-old girl who used to come "calling" for my daughter Kathy. Following the ageless custom of young children, Kathy's friend would loudly call out from the backyard "[æpi]" curiously leaving out the presumably easy initial /k/ sound in "Kathy" and substituting /p/ for medial /θ/. She was later found to have significant middle-ear problems. In the University of Wisconsin-Madison Phonology Clinic I observed another child who also had a recurrent middle-ear history and who deleted initial stop and fricative sounds in words, provided the intended sounds were voiceless. Still another young child I tested at the request of a friend who was concerned about his daughter's frequent bouts with otitis media turned out to have essentially normal speech—except for shortened vowels and a curious nasal sound change. For example, in a free speech sample she said that her birthday party was held in the "afternoond," at the party she got a "greend balloond."

Notice that each of the sound changes produced by these three young children must be termed *non-natural* from an articulatory-phonetic perspective. That is, they are not the kinds of deletion, substitution, or distortion errors commonly observed in children experiencing either normal or delayed speech acquisition. In contrast to their status as less than difficult sounds to say, errors on the intended sounds, however, may be well-motivated if one considers how difficult they are to *hear*. That is, each of the sound changes patterns illustrated above might reasonably be predicted from an assumption that they reflect an acoustic-perceptual constraint occurring at some critical stage of lexical acquisition. From this perspective, they would implicate deficits in *comprehension phonology*, rather than deficits in *articulatory competence*. Could the documentation of such behaviors support casual links among otitis media, speech perception, and speech production—with associated implications for academic and psychosocial functioning?

We have conducted a series of five clinical studies in search of the otitis media-speech connection. The primary question has been: Can the effects of fluctuant hearing loss due to early recurrent otitis media with effusion be manifested in certain non-natural speech sound changes? The two goals of this paper are to underscore some thoughts on research needs in this area and to provide a brief chronicle of our experiences. The analogy to a detective story is, of course, not perfect. But for those interested in research careers, much of the business of research does indeed involve "the chase," albeit seldom requiring high-speed pursuit. The first half of the paper will address research design issues and the second half will summarize our five clinical studies. For convenience, OME will be

used to refer to the general case of children with histories of early recurrent or persistent otitis media with effusion.

RESEARCH DESIGN ISSUES

A basic task in designing research projects is to select dependent and independent variables appropriate to the researcher's theoretical model and the hypotheses being tested. Let us examine, in sequence, some issues in the selection process that seem to be particularly troublesome in the search for the otitis media-speech connection.

Dependent Variables

Figure 1 portrays what might be termed a *minimalist* model (Cleveland, 1985) of the phonologic component of language. Its only purpose is to illustrate those basic elements thought to characterize phonologic systems and, hence, potential dependent variables for OME research. One rather obvious aspect of the large literature on the effects of OME on communicative functioning is that dependent variables continue to be sharply divided into our traditional three areas of cognition, language, and speech—with their important implications for subsequent development of academic and psychosocial competence. What this means at a theoretical level is that, with few exceptions, the dependent variables studied have been housed within the circled domain at the bottom of Figure 1, *speech*. In turn, most designs reflect the same structuralist models of phonology that have typified—until very recently—disorders research in our discipline. The most widely referenced studies have used articulation test results to assess the *distribution* of children's speech errors, rather than test descriptive-theoretic hypotheses and describe

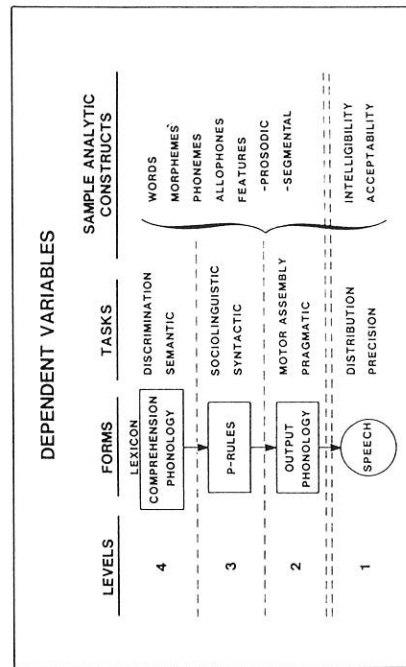


FIGURE 1. Elements of the phonologic component of language to suggest potential dependent variables in otitis media-speech research.

Independent Variables

The control of independent variables has been a major problem in efforts to construct OME research designs. Figure 2 illustrates three independent variables that demand our attention if we are to avoid the high probability of obtaining both *false negatives* and *false positives* when assigning subjects to OME and non-OME subject groups. The first sample entry, degree/duration of hearing loss, refers to measurement problems associated with episodes of OME, particularly in the host of retrospective studies carried out with or without concurrent audiometric data. Relevant OME research questions cover the period from birth through at least elementary-school age, and each developmental period presents a set of challenging measurement problems. As a result of such factors, we believe that some of our control subjects have fallen into the category of false negatives. These might have included asymptomatic children who were placed in a non-OME group but who, in fact, did experience OME and associated fluctuant hearing loss.

False positives are also a likely error source in OME research, particularly in light of the well-known individual differences in the degree of hearing loss associated with OME (Fria, Canteikin, & Eichler, 1985). As suggested in the second entry, listed in Figure 2, the intensity/quality of the caregiver's speech could compensate for the effects of the otherwise reduced input levels created by a hearing loss. There is ample documentation of functional intensity level patterns in adult-to-adult conversational speech but not in adult-to-child speech, which is of primary concern when investigating OME. I suspect that these adult-to-child intensity levels are quite often very low, but perhaps some caregivers, knowingly or otherwise, provide sufficient intensity for their young OME child to detect and process the relevant acoustic cues.

Finally, perhaps the potentially negative effects of fluctuant hearing loss can be unpuzzled by attending to the third entry in Figure 2. The cognitive styles of certain children may permit them to extract maximum information from degraded linguistic input. Here too, assumptions of a simple linear relationship among OME episodes or measured hearing losses and a significant communication deficit can

INDEPENDENT VARIABLES	
SAMPLE VARIABLES	EFFECT ON OME GROUP ASSIGNMENT (IF FALSE NEGATIVE OR FALSE POSITIVE)
• DEGREE/DURATION OF HEARING LOSS	?
• INTENSITY/QUALITY OF CAREGIVER'S INPUT	?
• EFFECTIVENESS OF CHILD'S COGNITIVE STYLE	?

FIGURE 2. Sample independent variables in otitis media-speech research suggesting the potential for false negatives and false positives in OME group assignments.

articulatory *precision* based on elaborated models of phonologic acquisition and performance. My point here is that the premise tested in nearly all studies relating OME to errors in speech production is that the effects of OME may depress a child's total articulation score.

There are two problems with this "across-the-board" model of association between otitis media and speech production. The first, which is linked to the assumption that effects of OME depress overall speech development, assumes that sounds are pretty much like one another—which of course they are not. Sounds differ greatly in articulatory and perceptual features. Much of the work in the phonetic and phonologic sciences has attempted to characterize the relevant differences. The acoustic and perceptual features of sounds are particularly central for the *input* side of speech-language acquisition, but the across-the-board differences in *output* characteristics may also be important. To develop and maintain articulate speech, the child with inconsistent air-borne speech feedback associated with OME may require more dependence on sensory-motor, proprioceptive cues. We will return to the one-sound-is-like-another notion in the second section of this paper.

The second problem with the "across-the-board" model is that it assumes that manifest speech as shown in Figure 1 encompasses all of what we mean by use of the term *speech*. What Figure 1 portrays is that there are at least three other levels operative in the phonologic component of language. In our view of the elephant, in fact, these are the more interesting levels to explore in the complex chain of events that link OME to serious problems in communication. Working from the top down, Level 4, the development of a child's *comprehension* phonology (or lexicon of stored word forms), presumes the integrity of auditory-perceptual and discriminatory processes. This level is now being studied elegantly with samples of OME children by Eimas and colleagues (e.g., Eimas & Clarkson, 1986). Data currently being collected by this research group are indeed fundamental to models linking OME to communicative deficits at this level (i.e., breakdowns in comprehension phonology).

Level 3 presumes a form of rule learning that requires a child to tune in to syntactic and sociolinguistic forms in efforts to sound like a native speaker of the ambient language. Next, Level 2 presumes learning involving speech-motor assembly and pragmatic processes that impact linguistic productivity. Operational efficiency at these levels, too, is vulnerable to the consequences of OME, as suggested several years ago by Menyuk (1980). But to date, such processes have not been studied closely. As we return to Level 1, the manifest level of speech, the position taken here differs from the across-the-board deficit model: An OME child's surface speech forms should include *specific* differences in *precision*, in turn, reflecting complex processing deficits at the upper three levels outlined in Figure 1. Moreover, these deficits should be associated with both the degree and time course of fluctuating hearing loss within central periods of the normal speech acquisition process. Simply put, the child's grasp of phonological units other than those reflected in scores on commonly used articulation tests is too often totally missed in the search for the OME-speech connection.

yield false negatives or false positives. These, in turn, may be important sources of error variance in research studies that fail to find significant mean differences on target variables.

Effects Models

Figure 3 displays the potential effects of OME in relation to three parameters. The Z axis or dimension, labelled *Transitivity*, reflects assumptions about implicational relationships existing among the developmental domains of speech, language, academics, and social behavior. Toward the left or restricted end of this dimension, one can model relatively autonomous sequelae on any one of the domains. Alternatively, extensive transitive relationships can be posited such that speech-language and language-academics relationships, for example, would imply causal relationships involving speech-academics. Research models and allied theories need to be further elaborated by considerations represented on the X axis, labelled *Chronology of Effects*, where such theories can be placed on a time dimension. Possibilities range from early immediate consequences in any of the domains to considerably delayed consequences for any of the domains themselves or in transitive associations. And as we move to the Y axis, labelled *Severity of Effects*, models must address the magnitude or severity of effects, which can range from temporary and relatively insignificant within any time or developmental stage in a domain, to lasting and significant.

Some of the hypotheses the schema in Figure 3 can generate, such as the familiar "critical developmental stage" hypothesis, are discussed in a thoughtful paper by Feldman and Gelman (1986). Of the more interesting models one can assemble from this schema I am particularly intrigued by what might be termed a *mild-*

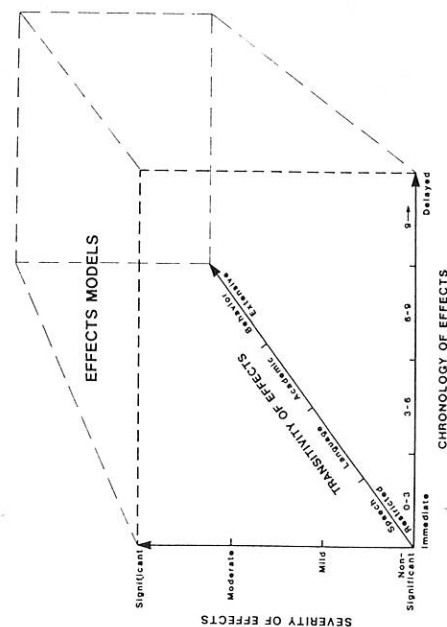


FIGURE 3. A conception of the potential effects of otitis media in relation to severity, transitivity, and chronology.

transitive-delayed-speech effects model. This conception would predict that phonologic processing delays due to mild but developmentally significant effects of hearing loss consequent to OME—effects that are unmitigated by certain caregiver, child, or other saving factors—are not evident academically and behaviorally until children reach later elementary grades. Such a model seems to best match assumptions that subtle linguistic deficits are cumulative over time, and represents the favored hypothesis of some of my research colleagues who have worked closely with involved children.

The point is that despite the fairly large OME literature, these three effects dimensions create a research matrix that has barely been tapped. Most studies have been committed to only certain dependent variables, certain time periods for observation, and certain levels of sensitivity to potentially real effects in the measures employed. Problems in each of these areas should be apparent in the following brief chronicle of five studies in search of certain links in the connection.

REVIEW OF RESEARCH

Study I

In Study I (Shriberg & Smith, 1980), the speech patterns of two groups of speech-delayed children were inspected. The two groups were each divided into subgroups on the basis of children meeting one or more of four criteria, which essentially ranged from frequent referrals for suspected otitis media to having ventilation tubes inserted. We then looked at the speech patterns of the subsamples to tally the number of children who produced initial position sound changes like the [æpi] for "Kathy," which we called Sound Change Category I and children who produced the nasal sound changes like [bdun^d] for "balloon," which we called Sound Change Category II.

Figure 4 contains the criterial data. The solid bars are the percentage of OME children who produced outputs fitting into one or both of these two sound change categories. The open bars represent the noninvolved children. In each of the two samples (OME involved: Wisconsin, $n = 11$; Illinois, $n = 15$), significantly more OME children produced forms fitting into one or both of the two sound change categories. These first findings were exciting, but the n 's were small and the groups were not well-described in terms of audiological histories.

Study II

In Study II (Kwiatkowski & Shriberg, 1983; Shriberg & Kwiatkowski, 1983), we tried to cross-validate and extend the previous findings. We examined continuous speech transcripts and case records for a sample of 34 speech-delayed children whose medical histories had been assembled and coded. Within this larger sample we could identify only three children as being purely middle ear involved, in the

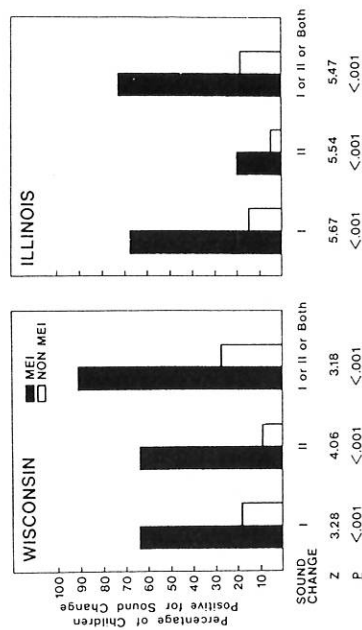


FIGURE 4. Percentage of speech-delayed children positive for Sound Change I, Sound Change II, or Both Sound Changes. For both the Wisconsin and Illinois data, filled bars are children with histories of middle-ear involvement (MEI) and open bars are children without such histories (NON-MEI).

sense that their histories did not also implicate other developmental issues. Trends in the data suggested that, in comparison to other speech-delayed children, these three children produced relatively fewer final consonant deletions. Yet, in contrast, they produced relatively more lateral sibilant distortions and nasal distortions. The latter two findings were viewed as reflecting non-natural behavior from an articulatory perspective. Still, arguments could be made that they were consistent with the perceptual deficits that might follow from fluctuant conductive loss as experienced during early phonologic development.

Study III

In Study III (Kertoy & Shriberg, 1984; Shriberg, Kwiatkowski, Block, Katcher, Kertoy, & Nellis, 1984) we decided to deal with our previous sample size problems by turning to a more controlled group of presumably normally developing children. We elected to take a retrospective look at a cohort of (speech) normal 3-year-olds who had been followed since birth at a university-affiliated pediatrics clinic. Our central question was: Could *subtle* signs of the effects of OME be found in the speech of these children? Using a set of decision rules to chronicle the diverse physician entries indicating otitis media, OME histories were assembled for the first 3 years (156 weeks) of each child's life. Thirty-five children were individually tested on a 2-hour battery that included measures of speech and language perception, comprehension, and production. The children were divided into an OME group ($n = 19$) and a non-OME group ($n = 16$), based on total weeks of middle-ear involvement.

Essentially, all comparisons of the two groups were negative. Table 1 is a summary of the results for the language measures. There were no significant differences between the noninvolved and involved groups, even on such workhorse

measures as the *Peabody Picture Vocabulary Test* and *Mean Length of Utterance* (MLU). On the battery of speech measures, as shown in Table 2, we also could find no statistically significant differences in speech perception or speech production scores. Even after extensive analyses of individual children, we could find no evidence that a significant middle-ear history, as defined by percentage of weeks of involvement, was associated with even subtle speech or language errors.

Study IV

In Study IV (Shriberg & Kwiatkowski, 1985), we decided to return in part to children who had speech disorders of unknown origin. We again were able to locate in our clinic only eight children who had significant OME histories not mixed with deficits in speech mechanism, cognitive-linguistic, or psychosocial functions. This

TABLE 1. Comparison of the non-involved and involved OME groups on several measures of language comprehension and language production.

Test	Non-involved		Involved	
	<i>n</i>	$\bar{x}$	<i>n</i>	$\bar{x}$
Peabody Picture Vocabulary Test	16	43.8	19	42.8
Miller-Yoder Test of Linguistic Comprehension	16	7.9	19	8.6
ITPA Grammatic Closure Subtest	14	9.8	16	10.3
Mean Length of Utterance	16	3.96	19	3.85
Elicited Production	14	.87	19	.77
				SD
				11.5
				2.8
				4.3
				1.00
				.32

TABLE 2. Comparison of the non-involved and involved OME groups on several measures of speech perception and speech production.

Variable	Measure	Statistical findings	
		Inferential	Descriptive
Speech perception	NU-CHIPS	ns	no trends
	30-item nonsense syllables	ns	no trends
Speech production	Natural Process Analysis Percentage Consonants Correct	ns	no trends
	Diacritic indices	ns	no trends
	Intelligibility	ns	no trends
		ns	no trends

time we were able to obtain more comprehensive records on these "pure" OME children, six of whom had had ventilation tubes in one or both ears.

We began by comparing these children's percentage of *natural* phonological process errors to percentages taken from those data on children with speech delays of unknown origin. As expected, neither the percentage nor types of natural process errors differentiated children in this group from other children with speech delays. Recall from our earlier discussion that the otitis media-speech connection is presumed to involve errors not typically seen in other speech-delayed children. On close inspection, the profile of errors for the eight children with middle-ear involvement was in general similar to profiles we have generated for several groups of children with speech delays of unknown origin.

Figure 5 includes a comparison of the eight speech-delayed children with children in two of the previous studies on a preliminary checklist of *non-natural* sound changes that we suspected to be associated with OME. The main point of Figure 5 is that more of these non-natural sound changes were made by five of the eight children than by any of the 69 children in the two comparison groups. Of 19 possible sound-change items on our initial list of non-natural sound changes, these children produced as many as seven of these sound changes at least once in their conversational speech samples. Thus, the results of this descriptive comparison did provide modest support for the findings reported in Study I. However, the number of subjects and total number of non-natural sound changes in the data base were still insufficient to address adequately the types of phonologic questions raised in relation to these variables listed in Figure 1.

What did we learn from the studies subsequent to Study I? What we learned is that this was not the way to do the research. We had learned much about the relative reliability of parental reports and much about the diversity of nomenclature used for medical entries in patient charts. We concluded that even if retrospective data were reliable, the data were not useful unless the otologic records were corroborated by audiologic findings. Essentially, we were stymied because we could not find an available and appropriate subject group for retrospective pursuit of answer to our

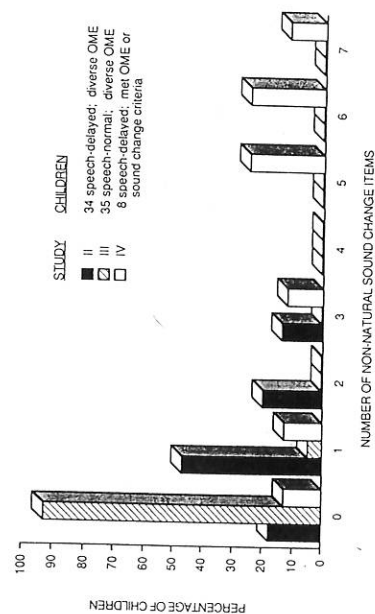


FIGURE 5. Comparison of the eight speech-delayed, OME children in Study IV to children in two previous studies on the number of non-natural speech-sound change items.

investigative questions—and without solid preliminary findings it would be difficult to seek grant funding for a prospective study. As the plot twists in detective fiction, what we really needed in this case was "the break."

Study V

And the break came! We received a call from a clinician working on a Native American reservation in Wisconsin. This experienced clinician was very concerned about the high prevalence of OME on the reservation and its potential long-term effects on language, academics, and behavioral functioning. She had noticed some speech perception differences and wanted to research her observations. Remember our opening anecdotes about some children's non-natural speech errors? Consider now a sample response that puzzled this experienced clinician. She asked a young boy who had a significant OME history to listen carefully to every word she said as she held up a picture and said, "Sue is riding a brown horse." The boy replied, "No, zoo can't ride a horse—that's a place where you put animals." This clinician went on to describe such children and what she had concluded were significant problems in short-term memory, particularly as it affects phonics in early instructional activities. Moreover, some of the speech-sound changes she had noticed were consistent with our observations described earlier.

Procedures governing ventilation tube insertion are fairly stringent in this setting, and many of the children have continuous middle-ear problems for which they receive excellent medical aid. Treatment is thoroughly documented at the tribal health clinic. In association with a comprehensive hearing screening program in existence for several years, audiologic records are also readily available. Those children who were brought to our attention were from monolingual English speaking parents, and associated demographics allowed for good subject matching. Arrangements were thus made to study the speech-language characteristics of a small sample of Native American children (Thielke & Shriberg, 1987).

A total of 28 preschool children were evenly divided into OME and non-OME groups based on detailed tribal health clinic records, which included audiologic and impedance data. All children were given a battery of speech-language measures, including a continuous speech sample. The latter was transcribed in narrow phonetic transcription by a team of two well-trained speech-language pathologists who were blind to subject assignment. The transcripts were then processed by a computerized phonologic analysis procedure (Shriberg, 1986) that yields data on many of the phonetic and phonologic variables described at the outset of this presentation (Figure 1).

Figure 6 includes central tendencies and individual scores for the 14 children in each otitis media history group on two measures. The left panel includes scores on a measure termed Percentage of Consonants Correct (PCC), which assesses overall severity of involvement. The comparison for these scores, indicated no statistically significant differences between groups. The right panel includes scores on the Intelligibility Index, which also was determined by the consensus transcription

team. Differences between group means on this dependent variable were statistically significant, with the OME children scoring below the non-OME children. Note the clearly different distributions of individual scores, with 9 of the 14 OME children having lower intelligibility scores than the lowest scoring non-OME child.

CONCLUSIONS

The results of our recent study provided the first solid statistical support for the clinical observations introduced earlier. We currently are investigating the exact sources for the significantly lower intelligibility levels found in OME children, which include but are not limited to, certain non-natural speech-sound errors. Intelligibility is a rich construct that indeed invokes the upper domains of phonologic processing, as shown in Figure 1, including aspects of lexical and syntactic processing, suprasegmental tiers, and certain discourse pragmatics. Additional analyses of existing data and other data gathering efforts with younger children will be dedicated to the pursuit of our basic hypothesis: Early constraints imposed on speech perception due to middle-ear disease are reflected in specific communication involvements. Hopefully this brief account of our past investigations has provided readers of this journal an interesting example of the types of puzzling challenges that are encountered in the pursuit of answers to clinically relevant research questions.

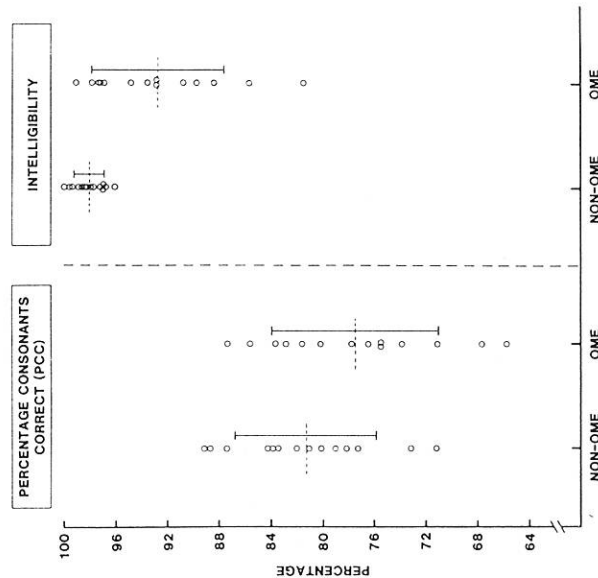


FIGURE 6. Means, standard deviations, and individual scores for children in the two OME status groups on the Percentage of Consonants Correct and the Intelligibility Index.

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