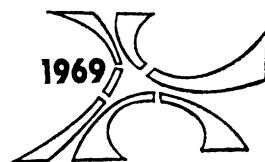# Speech Intelligibility of a Seven-Year-Old Girl with Severe Congenital Hypoplasia of the Tongue

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Weinberg and associates (*11*) recently used cineradiologic and photographic techniques to describe compensatory speech articulation patterns of a seven-year-old girl with severe, congenital hypoplasia of the tongue. In that report, it was stated that the young aglossic talker had readily intelligible speech, a conclusion that was based solely on the informal observations of experienced clinicians. The present report describes an experiment designed to evaluate the speech intelligibility of this aglossic talker in more formal terms.

Methods

The aglossic talker recorded the 300 words used to form the six 50-item word lists of the rhyme test described by House and associates (*5*). The words were recorded without instrumental monitoring, with the patient instructed to maintain a constant level of vocal effort. Since the talker was not experienced in recording speech materials for analysis or related uses, her success in following instructions was investigated. Accordingly, the recorded words were played into a Bruel and Kjaer graphic level recorder (Model 2305), and the level of the vocalic maxima of each word was measured relative to a 1000-Hz reference signal. Within each 50-word list, the range of level for vocalic maxima was about 6 to 8dB, a range not much greater than that usually found for vowels produced by normal talkers (*2*). The average level of the six test lists varied only about 3dB, and consequently the recordings were not adjusted for level variations. The word lists were presented to 18 listeners under earphones through high-quality listening equipment. The average level of the speech was about 80dB SPL measured under the headphones.

Results and Discussion

The general results of the listening tests are shown in Table 1, arranged according to listeners and test forms. The variation in response level from subject to subject and among tests is comparable to that usually found in intelligibility test data. The variation in the mean results for the six forms of the rhyme test is reasonably small and supports the conclusion that the quality of the recordings from list to list was uniform. The talker's average intelligibility of 86% supports the earlier clinical report that this aglossic child developed readily intelligible speech (11). Indeed the high over-all intelligibility of speech of this child without a tongue is surprising, since her average intelligibility corresponded closely to that reported by House and associates (5) for rhyme tests recorded by two trained talkers presented at a signal-to-noise ratio of −4dB. Under signal-to-noise conditions comparable to those used in the present investigation, normal talkers would be expected to demonstrate near-perfect intelligibility (4, 5, 8).

The recognition scores for individual consonants are of particular interest to the study of articulation and intelligibility since they give insight into the articulatory patterns that characterize the speech of the talker and provide a basis for understanding the total impression of the

TABLE 1. Per cent correct word identifications of 18 listeners tabulated according to test form.

	test form	A	B	C	D	E	F	mean	sigma
listeners	1	78	92	90	96	94	86	89.33	6.53
	2	80	86	74	84	94	90	84.67	7.12
	3	80	86	90	94	96	90	89.33	5.75
	4	82	92	94	94	92	94	91.00	4.68
	5	84	86	84	86	90	76	84.33	4.63
	6	86	96	86	90	86	82	87.67	4.82
	7	86	92	88	86	90	92	89.00	2.76
	8	80	86	80	90	92	84	85.33	5.00
	9	82	86	78	84	86	86	83.67	3.20
	10	84	84	78	78	82	76	80.33	3.49
	11	82	84	86	88	92	84	86.00	3.58
	12	84	82	78	90	82	82	83.00	3.95
	13	82	90	82	86	86	86	85.30	3.01
	14	88	90	84	92	92	84	88.33	3.67
	15	82	86	76	86	86	78	82.30	4.46
	16	80	94	84	86	82	84	85.00	4.86
	17	90	94	92	88	96	84	90.67	4.32
	18	88	88	88	94	90	92	90.00	2.53
mean		83.22	88.56	84.00	88.44	89.33	85.00		
sigma		3.30	4.05	5.78	4.53	4.65	5.24		

grand mean = 86.43

TABLE 2. Average intelligibility (per cent correct) of the 23 consonant elements. Initial (I), final (F) and initial and final word position combined (I&F) are tabulated separately.

	I	F	$I+F$		I	F	$I+F$		I	F	$I+F$
p	97	81	89	f	81	97*	85	h	96		96
b	90	81	87	v	100**	53*	61				
t	96	86	91	θ	100**	92*	93	m	99	56	75
d	72	73	72	ð	100**	17**	58	n	91**	88	89
k	69	91	81	s	99	95	97	ŋ		79*	79
g	70	76*	73	z		93	93				
				ʃ	98*		98	w	90		90
✳	100*	89*	94	tʃ		93*	93	r	99	100	99
				dʒ	78**	94**	83	l	75	99*	89

* Indicates that a sound in a given position is in at least two but less than six test forms.
** Indicates that a sound occurs in only one test form.
✳ Omission: Consonant element not present.

talker's intelligibility given to the listener. The average intelligibility of each of the 23 consonants under test in the listening task is tabulated in Table 2. In general, these data show that the talker's consonants in the word-initial position were slightly more intelligible than her consonants in the word-final position. There are instances, however, for individual sounds, where no appreciable differences or where reversals to this general finding, are found. The patterning of consonant intelligibility as a function of word position, however, is essentially that described for normal talkers (5). Similarly, the data show that voiceless consonants were more intelligible than voiced consonants. This tendency for voiceless forms of cognate pairs to be more intelligible than voiced forms is in agreement with the findings of the House study, but at variance with the results of speech-sound discrimination studies of Fletcher (3) and Fairbanks (1). With respect to consonant type, glides, fricatives, and affricates were consistently more intelligible than plosives and nasals.

Study of the data of Table 2 demonstrates that the talker's intelligibility for consonants with a major lingual component—that is, postdental and velar stops, fricatives and nasals, postdental affricates, and liquids—was essentially equal to her intelligibility for consonants without a lingual component; each category of sounds was heard correctly at a level of about 85%. These results suggest strongly that the talker developed highly satisfactory compensatory patterns of articulation to overcome her severe structural deficit. The success of these compensatory gestures in eliciting the proper responses from listeners is particularly noteworthy, since they were developed independently; that is, they were self-acquired. The present data reinforce the idea that

our previous descriptions of this talker's unique mechanisms of speech articulation (*11*) might be used to develop procedures for teaching speech sound production to persons with severe hypoplasia of the tongue.

Another informative method of analyzing listening results is to examine the errors made by the listeners. In the present case the listening conditions were optimal and the responses might be construed to constitute a highly accurate description of the patient's articulatory behavior. Since the talker's speech mechanism was abnormal, however, this interpretation of the data must be tempered with the realization that the listener's identifications may not be an accurate description of the actual articulatory events that produced the speech. In Table 3, the responses for the 18 listeners are shown in the form of a matrix; the entries in each row indicate the number of responses of each column category made to the stimuli shown on the left. The clustering of responses along the main diagnonal indicates the high level of correct response. The confusion in this matrix may not be identical with confusions generated in a free-response intelligibility test, since the rhyme test format uses a closed set of six items. On the average, however, the influence of these constraints—which may be unexpected in a specific response ensemble—is not strong enough to change the general patterning of response. In general, listener identifications of voiced for unvoiced consonants were infrequent; nasals were usually confused with other nasals; /r/ and /l/ were seldom confused with other phonemes; and plosives were generally confused with other plosives. These results follow theoretic expectations with respect to the acoustic and/or articulatory properties of the stimuli (*7, 11*). The unusually high number of omission responses to /v/, which generally occurred when this sound was in the word-final position, suggests that this young talker may have some articulatory characteristics appropriate to her age and speech maturation level (*9*). These omissions are not related to her severe oral deficits, but may reflect normal maturational factors that can affect speech intelligibility.

In order to evaluate the speech of this atypical subject in terms more familiar to the speech pathologist, the Templin-Darley Test of Articulation (*10*) was selected as a typical instrument for deriving a phonetic inventory of her speech and administered in its standard form. The results showed, for singleton consonants, that the aglossic talker consistently distorted all sibilants, affricates, and velar stops, while interdental fricatives sometimes were produced as labiodental fricatives. Most other consonants and vowels were rated normal, except for a consistent substitution of /ɛ/ for /I/.

Our overall evaluation of her connected speech placed her in the least severe category with respect to judged severity of defectiveness of articulation (*6*). In general, these observations agree with Jordan (*6*) who found that distortion errors had the smallest impact on listener

TABLE 3. Confusion matrix: initial and final word position pooled.

											Response												
Stimulus	p	b	t	d	k	g	f	v	θ	ð	s	z	ʃ	tʃ	dʒ	h	m	n	ŋ	w	r	l	⁎
p	369		18	3			3			1											1		
b	6	315	1	12	23						1	1								1	1	3	
t	18		476	1	19	16								1		1		17	8				
d	2	29	1	248	6	18	1			13								1					
k	25	20	20	1	395	13																	1
g	15	4	5	2	14	183	3												1			9	
f			2	1			246	1			1					1	1					18	16
v	1	1	1				1	66			22	1	2			2				2	2	2	
θ	2						3	1	84		17							4			11	1	
ð				8			4		8	21	3											1	
s	1		1						8		456	1											
z											4	67											
ʃ	1		3	2		1							53										
tʃ					1									50									
dʒ															45								
h			1				1		4		1					207					1		
m											2						215	70	1				2
n		1															29	384	14			1	3
ŋ																	1	17	71		1		
w		7															1			145	6	2	
r																				8	215	1	
l	1	3		1	1	2		1			3							1			20	272	
⁎			1	2	1				2		1												84

judgments of severity of defectiveness of articulation. Judgments of severity of defectiveness of articulation and judgments of speech intelligibility, however, are not the same. For example, although a sizeable proportion of the consonants was judged defective on the articulation test, these articulatory errors had little effect on speech intelligibility. It would appear that in spite of her atypical articulatory gestures and accompanying visual and acoustic distortions, this talker has learned the crucial distinctive features which differentiate phonetic elements and which are necessary for the production of intelligible speech.

The relationships between articulatory competence and speech intelligibility, particularly in the speech articulation disorders, require continued study. The methods we have used suggest one experimental approach to the evaluation of speech intelligibility that may prove to be helpful to the speech pathologist. Although this approach is time consuming, it provides information about communication ability and information transfer not obtainable from traditional phonetic invenories.

Summary

The intelligibility of the speech of a seven-year-old aglossic talker was investigated by means of rhyme-test procedures and materials. The results of the tests indicate that the average intelligibility for consonantal gestures involving the tongue was not significantly different from her intelligibility for the production of consonants relatively independent of tongue action. The overall intelligibility was approximately 86% correct; voiceless consonants were consistently more intelligible than voiced consonants; and fricatives, affricates, and glides were more intelligible than plosives and nasals. The general patterning of errors was similar to those of a normal talker. The present findings support earlier clinical impressions that the aglossic subject had developed highly intelligible speech without professional assistance.

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