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Evaluation of Adult Aphasics with the Pediatric Speech Intelligibility Test

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Abstract

Results of conventional adult speech audiometry may be compromised by the presence of speech/language disorders, such as aphasia. The purpose of this project was to determine the efficacy of the speech intelligibility materials and techniques developed for young children in evaluating central auditory function in aphasic adults. Eight adult aphasics were evaluated with the Pediatric Speech Intelligibility (PSI) test, a picture-pointing approach that was carefully developed to be relatively insensitive to linguistic-cognitive skills and relatively sensitive to auditory-perceptual function. Results on message-to-competition ratio (MCR) functions or performance-intensity (PI) functions were abnormal in all subjects. Most subjects served as their own controls, showing normal performance on one ear coupled with abnormal performance on the other ear. The patterns of abnormalities were consistent with the patterns seen (1) on conventional speech audiometry in brain-lesioned adults without aphasia and (2) on the PSI test in brain-lesioned children without aphasia. An exception to this general observation was an atypical pattern of abnormality on PI-function testing in the subgroup of nonfluent aphasics. The nonfluent subjects showed substantially poorer word-max scores than sentence-max scores, a pattern seen previously in only one other patient group, namely young children with recurrent otitis media. The unusually depressed word-max abnormality was not meaningfully related to clinical diagnostic data regarding the degree of hearing loss and the location and severity of the lesions or to experimental data regarding the integrity of phonologic processing abilities. The observations of ear-specific and condition-specific abnormalities suggest that the linguistically- and cognitively-simplified PSI test may be useful in the evaluation of auditory-specific deficits in the aphasic adult.

Key Words: Pediatric Speech Intelligibility test, fluent aphasics, nonfluent aphasics, otitis media, performance intensity, speech perception, speech audiometry

Results of conventional speech audiometry may be compromised by the presence of speech/language disorders, such as aphasia. Previous investigators have noted generalized performance deficits on both ears in aphasic patients, rather than the expected unilateral deficits typically seen in patients with unilateral cortical lesions without accompanying language disorders (e.g., Jerger and Jerger, 1975a). Complications in testing aphasic patients arise primarily from the linguistic-cognitive complexities of traditional adult speech audiometric procedures. Tests involving phonemically-balanced (PB) words, for example, require patients to identify and repeat words from a set of unknown alternatives. Tests involving the Synthetic Sentence Identification (SSI) materials, as another example, require patients to identify target sentences from a list of 10 printed alternatives and to report the numbers corresponding to the sentences that were heard. The linguistic-cognitive demands of such tasks may produce generalized performance deficits, rather than auditory-specific deficits, in aphasic adults (Speaks, 1980).

To evaluate central auditory status in the presence of aphasia, a speech audiometric test must be (1) sufficiently easy in terms of linguistic-cognitive demands, but (2) sufficiently difficult in terms of auditory-perceptual demands. These requirements for diagnostic

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speech audiometry in aphasic adults are reminiscent of the preconditions for successful speech audiometry in young children. A primary consideration in the construction of pediatric speech intelligibility tests, for example, has been the development of verbally-simplified test materials and cognitively-simplified testing paradigms (Jerger et al, 1983a). The development of pediatric speech intelligibility tests has been a prime consideration of several investigators for the last 10 years (Bench and Bamford, 1979; Elliott and Katz, 1980; Jerger, 1984). The development of speech audiometric tests for language-disordered adults, on the other hand, has received scant attention to date (see Niccum, 1984, for exceptions). In the present study, we addressed the question of whether the speech intelligibility materials and picture-pointing techniques developed for young children are useful for evaluating speech perception in adult aphasics.

One approach to diagnostic speech audiometry in young children that has attempted to maximize sensitivity to auditory-perceptual abilities and to minimize sensitivity to linguistic-cognitive abilities is the Pediatric Speech Intelligibility (PSI) test (Jerger and Jerger, 1984). The PSI test utilizes speech materials that were composed by normal children between 3 and 6 years of age. The test items are the actual utterances (internal vocabulary) of the normal young children. Utterances were elicited by carefully selected pictures representing the nouns and verbs from children's first vocabularies (Jerger et al, 1980). The test items are organized into lists of five items each. Each list has a corresponding picture-identification response card, containing the same pictures that were used to generate the test items. The purpose of this study was to determine the efficacy of the PSI test in evaluating central auditory function in aphasic adults.

METHOD

Subjects

Subjects were eight males with aphasia who were referred to the study by a cooperating speech therapist. The sole selection criterion was that single-word comprehension, as measured by the Peabody Picture Vocabulary Test, was no more than two standard deviations below the mean for adults (Dunn and Dunn, 1981). The purpose of this selection criterion was to ensure that subjects could understand simple test instructions. Tables 1 and 2 summarize the diagnostic findings and personal characteristics of the subjects. The general locations of the lesions (Table 1) involved the frontal, temporal, and/or parietal areas in seven subjects and the region of the basal ganglia in one subject. The nature of the lesions was left cerebral infarction in five subjects and left cerebral hemorrhage in three subjects. All lesions were confirmed by computerized axial tomography.

The speech-language diagnoses (Fluency column, Table 1) were nonfluent aphasia in three subjects (S1 to S3) and fluent aphasia in five subjects (S4 to S8). All subjects continued to exhibit speech/language impairments that limited the applicability of conventional adult speech audiometry (Present Degree of Severity column, Table 1). The onsets of the aphasia occurred from 2 to 12 years prior to the present study (Years Post-Insult column, Table 2). The ages at the time of insult ranged from 44 to 65 years (Table 2); the present ages of the subjects ranged from 55 to 69 years. The years of education and the types of occupations varied widely.

Instrumentation and Test Materials

Pure-tone and speech audiometric measures were carried out on a two-channel diagnostic audiometric system comprised of two single-channel audiometers (Rion, BA-75) and a two-channel cassette tape recorder (Sansui, SC-3110). Immittance audiometry was carried out on a standard clinical immittance bridge (Amplaid, model 720). Speech materials were the sentence and word test items and the competing sentence messages of the PSI test (Jerger and Jerger, 1984). Table 3 presents illustrative PSI words and sentences. The test items (words and sentences) and the competing sentences were recorded by different male talkers with general American dialect. The inter-item interval was 10 sec for the sentences and 7.5 sec for the words. Speech level was defined as the sound pressure level (SPL) of a 1000 Hz signal recorded at the average level of frequent peaks of the speech as monitored on a VU meter. The pure-tone and speech signals were delivered to the subjects via matched earphones (Telephonic TDH-50P) mounted in circumaural cushions (Zwislocki CZW-6). The instrumentation was calibrated to the ANSI-69 standard for audiometric equipment.

Table 1 Speech-Language and Medical Findings for Eight Male Subjects with Aphasia

Subject	*Fluency*	*General Location of Lesion*	*Degree of Severity and Symptomatology at Onset*	*Present Degree of Severity*
1	Nonfluent	Left frontotemporal	Severe expression/mild comprehension, right hemiparesis	Severe expression/ mild comprehension
2	Nonfluent	Left frontoparietal	Severe expression/moderate comprehension, right hemiplegia	Severe expression/ mild comprehension
3	Nonfluent	Left temporal and insular structures	Severe expression/severe comprehension, severe dysarthria, right hemiplegia	Moderate expression/ mild comprehension
4	Fluent	Left parietotemporal	Mild expression/mild comprehension, moderate to severe difficulties in reading and writing, right upper extremity monoparesis	Mild expression/ mild comprehension
5	Fluent	Left frontoparietal	Severe expression/moderate comprehension, right hemiparesis	Mild expression/ mild comprehension
6	Fluent	Left parietal	Severe expression/moderate comprehension, severe difficulty with confrontation naming, right hemiparesis	Mild expression/ mild comprehension
7	Fluent	Left frontal operculum	Severe expression/severe comprehension, severe anomia, right facial nerve palsy	Moderate expression/ mild comprehension
8	Fluent	Left basal ganglia	Mild expression/mild comprehension, moderate dysarthria, right hemiplegia	Mild expression/ mild comprehension

Table 2 Subject Characteristics for the Nonfluent and Fluent Aphasics

Subject	*Years Post-Insult*	*Age at Insult*	*Education*	*Premorbid intelligence*	*Occupation*
Nonfluent					
1	4	65	16	Normal	Commercial artist
2	11	44	16	Normal	Engineer
3	12	48	16	Normal	Engineer
Fluent					
4	2	58	11	Normal	Truck driver
5	9	59	19	Normal	Lawyer
6	2	61	16	Normal	Management
7	4	53	12	Normal	Laborer
8	4	58	14	Normal	Security guard

Table 3 Illustrative PSI Messages

	Sample Items
Word test items	dog, tree, house, car, book
Sentence test items	The horse is eating an apple. The bear is brushing his teeth.
Sentence competing messages	The kitty cat is bouncing a ball. The big bad wolf is catching some fish.

Procedure

Subjects were tested inside a sound-treated booth in a single session of approximately 1 hour. Pure-tone audiograms were obtained on each ear at the octave frequencies from 250 to 8000 Hz. Immittance audiometry defined tympanograms, static compliance, and crossed and uncrossed acoustic reflex thresholds (ARTs). Test frequencies for ARTs were 500, 1000, 2000, and 4000 Hz for the crossed mode and 1000 and 2000 Hz for the uncrossed mode. If immittance audiometry indicated the possibility of middle ear disorder, conventional bone-conduction audiometry was carried out at frequencies of 500, 1000, 2000, and 4000 Hz.

For the PSI test, the subject was seated at a table with a picture-identification response card. After each sentence or word had been presented, the subject responded by pointing to the picture corresponding to the sentence or word that was heard. Performance was evaluated both in quiet and in the presence of a competing speech message. For the quiet condition, performance for both words and sentences was measured at one intensity level, 50 dB SPL. This level yielded 100 percent correct performance in 7 of the 8 subjects. For the atypical subject (S2), intensity had to be raised to 60 dB SPL to achieve 100 percent correct performance. A speech threshold was obtained for sentences in quiet by decreasing the intensity level in 10 dB steps until performance was less than 50 percent correct.

There were two competing message conditions, one consisting of performance-intensity (PI) functions and one consisting of message-to-competition ratio (MCR) functions. PI functions were constructed by presenting the speech materials, both test items and competing messages, to the same ear (monotically) at several suprathreshold intensity levels. The MCR was constant across intensity levels: +4 dB for words and 0 dB for sentences. The standardized test procedures dictate different MCRs for words and sentences on PI-function testing in order to equate performance for the two different types of speech materials in normal preschool listeners (Jerger et al, 1981).

The initial test intensity for PI functions in competition was 50 (seven subjects) or 60 (S2) dB SPL, levels that yielded 100 percent correct in quiet. If performance was greater than 50 percent correct, intensity was decreased in 10 dB steps until the subject scored less than 50 percent correct. Intensity was then raised to 75 and 100 dB SPLs to define the high-intensity region of the PI function. If initial performance at 50 or 60 dB SPL was less than 50 percent correct, intensity was immediately raised to the higher test intensities.

For the second competing message task, MCR functions for the PSI sentence materials were obtained for both monotic and dichotic conditions. For the monotic condition, the primary sentences and the competing sentences were presented to the same ear. For the dichotic condition, the primary sentences were presented to one ear and the competing sentences were presented to the opposite ear. For both conditions, the intensity level of the test sentences was held constant at either 50 dB SPL (seven subjects) or 60 dB SPL (S2), levels that yielded 100 percent correct in quiet. The intensity level of the competing sentences was varied to produce MCRs of +10 and 0 dB for the monotic condition and of 0 and −20 dB for the dichotic condition. The MCRs represent standardized PSI test conditions that yield near-ceiling performance in normal children. For both the PI functions and the MCR functions, subjects were instructed to ignore the competition and to attend only to the target voice saying one of the five test items.

For all PSI tasks, a listening trial consisted of the presentation of each of the five sentences or words of a list. If performance on this trial was at least four out of five (80 to 100 percent) or at most one out of five (0 to 20 percent), only one trial was presented at that test condition. If performance on the first trial was two or three out of five, however, a second trial was presented at that test condition. This approach concentrates testing time in the performance midrange where variability is greatest. A flexible number of listening trials per performance level also produces an irregular pace to the testing protocol, which theoretically helps to focus and to maintain the attention of individuals with limited cognitive skills.

Criteria for Interpretation of PSI Results

Performance was considered abnormal if results were not within previously established 95 percent normal-confidence intervals for young children with receptive language ages of approximately 5 to 6 years (Receptive Language Level II Norms; Jerger and Jerger, 1984). The Receptive Language Level II Norms seem generalizable to adults since results are at or near the ceiling of the test for all indices. Table 4 summarizes the specific criteria of abnormality. For MCR functions, performance of less than 100 percent at 0 dB MCR and less than 90 percent at −20 dB MCR was considered abnormal for the dichotic condition. For the monotic condition, performance of less than 100 percent at +10 dB MCR and less than 80 percent at 0 dB MCR was considered abnormal.

PI functions were considered abnormal if either one of two indices were outside the 95 percent normal confidence intervals. Indices were based on the rollover phenomenon (Jerger and Jerger, 1971) and the difference between maximum intelligibility scores for quiet versus competing conditions. The degree of rollover was defined by the difference between (1) the maximum speech intelligibility score and (2) the lowest intelligibility score at any speech level above the level yielding the maximum score. For word materials, rollover of more than 40 percent was classified as abnormal. For sentence materials, rollover of more than 10 percent was defined as abnormal. For both sentence and word

Table 4 Criteria of Abnormality for PSI Measures

Measure	*Criterion of abnormality (5% level)*
MCR functions	
Dichotic condition	
0 dB MCR	less than 100%
−20 dB MCR	less than 90%
Monotic condition	
+10 dB MCR	less than 100%
0 dB MCR	less than 80%
PI functions in competition	
Rollover for words	greater than 40%
Rollover for sentence	greater than 10%
Quiet-competition difference for words and sentences	greater than 25%

Table 5 Pure-Tone (500–4000 Hz) and Speech Thresholds (in dB HL) on the Right and Left Ears for Eight Male Subjects with Nonfluent or Fluent Aphasia

	Right Ear					*Left Ear*				
Subject	*500*	*1000*	*2000*	*4000*	*Speech Threshold*	*500*	*1000*	*2000*	*4000*	*Speech Threshold*
Nonfluent										
1	20	20	10	30	16	05	00	05	30	14
2	15	55	70	75	13	10	25	30	60	06
3	05	05	35	40	18	00	05	10	35	05
Fluent										
4	10	05	25	15	06	05	10	30	20	04
5	10	10	20	55	04	10	15	15	60	15
6	05	10	25	75	11	05	10	30	65	11
7	10	10	00	30	14	05	10	05	30	14
8	15	15	10	10	13	10	20	05	20	15

materials, a difference between maximum intelligibility scores in quiet versus competition of greater than 25 percent was considered abnormal.

RESULTS

Hearing Sensitivity

Table 5 summarizes the pure-tone (500 through 4000 Hz) and speech thresholds, in dB HL, on the right and left ears of the subjects. All subjects had normal middle-ear function as characterized by either type A tympanograms and normal static compliance or by interweaving air-conduction and bone-conduction thresholds. Pure-tone thresholds were relatively symmetric on the two ears for the fluent group, but showed poorer sensitivity on the right ear than on the left ear for the nonfluent group. Average pure-tone sensitivity (average of 500, 1000, and 2000 Hz) was within normal limits (3 to 17 dB HL) on both ears for seven of the eight subjects and showed a bilateral, sensorineural, hearing loss of approximately 25 dB HL on the left ear and 45 dB HL on the right ear for one subject (S2). Speech thresholds were within the normal range (4 to 18 dB HL) on both ears of all subjects.

Table 6 Maximum Performance and Degree of Rollover for Performance-Intensity Functions in Competition, Obtained with PSI Words and PSI Sentences, in the Nonfluent and Fluent Aphasics

	Right Ear		Left Ear	
Materials: Subjects	*Words*	*Sentences*	*Words*	*Sentences*
	Maximum performance (in percent correct)			
Nonfluent				
1	0	100	100	100
2	0	50	40	100
3	20	100	100	80
Fluent				
4	100	80	100	80
5	100	100	80	100
6	80	80	80	80
7	100	100	100	100
8	80	100	100	100
	Degree of rollover (in percent)			
Nonfluent				
1	–	0	20	0
2	–	0	40	0
3	20	80	20	0
Fluent				
4	0	0	0	0
5	20	20	0	0
6	60	0	60	30
7	20	0	10	0
8	50	50	0	40

PSI-PI Functions

Table 6 details maximum percent-correct performance and the degree of rollover for PI functions in competition for each subject. Figure 1 interprets the data as normal or abnormal results. Abnormality is depicted as either (1) an abnormally reduced maximum intelligibility score in competition (C) relative to quiet (Q) or (2) a normal maximum intelligibility score coupled with abnormal rollover of the PI function. No subject had both an abnormal maximum score and abnormal rollover.

Six of the eight subjects (3 nonfluent and 3 fluent) showed abnormal PI functions. Abnormality in the fluent subjects (S5, S6, S8) was characterized by the rollover phenomenon. Abnormality in the nonfluent subjects (S1 to S3), in contrast, was typically characterized by unusually depressed maximum performance in the competing condition. Figure 2 illustrates this finding in S3, a nonfluent aphasic with a left

SUBJECTS		RIGHT EAR		LEFT EAR	
		Words	Sentences	Words	Sentences
Nonfluent	1	●	○	○	○
	2	●	●	●	○
	3	●	⊘	○	○
	4	○	○	○	○
Fluent	5	○	⊘	○	○
	6	⊘	○	⊘	⊘
	7	○	○	○	○
	8	⊘	⊘	○	⊘
KEY		○ NORMAL	⊘ ROLLOVER	● ABNORMAL Q - C DIFFERENCE	

Figure 1 Distribution of normal and abnormal results for performance-intensity (PI) functions, obtained with PSI words and sentences, in eight adult aphasics. Subjects 1-3 are nonfluent aphasics and subjects 4-8 are fluent aphasics.

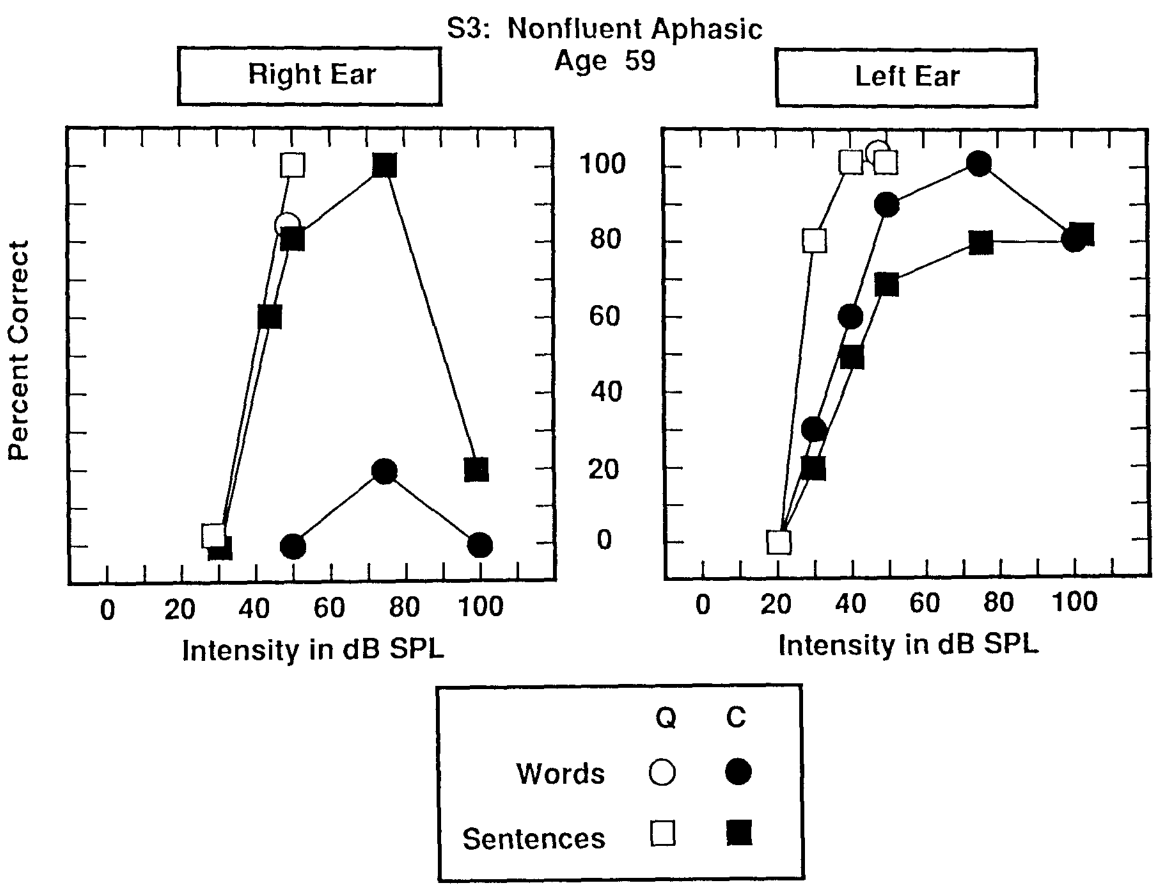

Figure 2 PSI-PI functions for word and sentence materials on the right and left ears of a nonfluent aphasic (S3).

temporal lesion. The pattern of abnormality on the right ear (poorer word-maximum-in-competition than sentence-maximum-in-competition) characterized all subjects in the nonfluent group, as shown in Table 6.

PSI-MCR Functions

Table 7 summarizes average performance for the monotic and dichotic conditions in each subject. Figure 3 interprets the normalcy or abnormalcy of PSI results for the two conditions. Whereas the pattern of results for PI functions differed between the nonfluent and fluent groups, results for the monotic and dichotic conditions did not differ between the groups, Performance was normal for the monotic condition and abnormal for the dichotic condition in five of the eight subjects (S1, S3, S4, S5, S6). Figure 4 illustrates this pattern of results in S1, a nonfluent aphasic with a left frontotemporal lesion. Such a pattern of results is the classic finding on adult speech audiometric tests in nonaphasic individuals with unilateral cerebral lesions (Jerger and Jerger, 1975a).

For four of the five subjects with normal monotic and abnormal dichotic findings (S1, S3, S4, S5), the performance deficits were observed on the right ear, the ear contralateral to the side of the lesion. A "contralateral ear effect" on dichotic listening agrees with the findings of most previous investigators (Berlin et al, 1972; Speaks et al, 1975). In the remaining subject (S6), a pattern of abnormality known as the "paradoxical ipsilateral ear effect" was observed (Sparks et al, 1970). Performance for the dichotic condition was normal on the right ear and abnormal on the left ear. The unusual ipsilateral (left) ear deficit on dichotic speech perception is attributed to interruption of the interhemispheric auditory pathways. The signal from the left ear to the right hemisphere is assumed to be blocked from proceeding from the right hemisphere to the left hemisphere for processing. This pattern of abnormality has been noted previously for both aphasic and nonaphasic adults and children with deep-seated lesions of the dominant, typically the left, hemisphere (Sparks et al, 1970; Rubens et al, 1978; Damasio and Damasio, 1979; Jerger and Zeller, 1989). The present subject (S6) was a fluent aphasic with a left parietal lesion. Damasio and Damasio (1979) also observed the ipsilateral ear effect in subjects with deep, left, parietal lesions.

In contrast to the above findings, results for the three other subjects did not show a consistent pattern. Performance in S2, a nonfluent aphasic with a lesion in the left fronto-parietal

Table 7 Average Performance (Percent Correct) for the Monotic and Dichotic Conditions in the Nonfluent and Fluent Aphasics. (Results were averaged across the two test message-to-competition ratios [MCRs]: +10 and 0 dB MCRs [monotic] and 0 and −20 dB MCRs [dichotic].)

	Right Ear		*Left Ear*	
Conditions: Subjects	*Monotic*	*Dichotic*	*Monotic*	*Dichotic*
Nonfluent				
1	90	10	90	100
2	75	0	100	100
3	90	30	90	100
Fluent				
4	90	90	90	95
5	90	70	90	95
6	90	100	90	60
7	100	100	80	100
8	100	100	100	95

SUBJECTS		RIGHT EAR Monotic	RIGHT EAR Dichotic	LEFT EAR Monotic	LEFT EAR Dichotic
Nonfluent	1	○	●	○	○
	2	●	●	○	○
	3	○	●	○	○
	4	○	●	○	○
Fluent	5	○	●	○	○
	6	○	○	○	●
	7	○	○	●	○
	8	○	○	○	○
KEY		○ NORMAL		● ABNORMAL	

Figure 3 Distribution of normal and abnormal results for monotic and dichotic conditions, obtained with PSI sentences, in eight adult aphasics. Subjects 1-3 are nonfluent aphasics and subjects 4-8 are fluent aphasics.

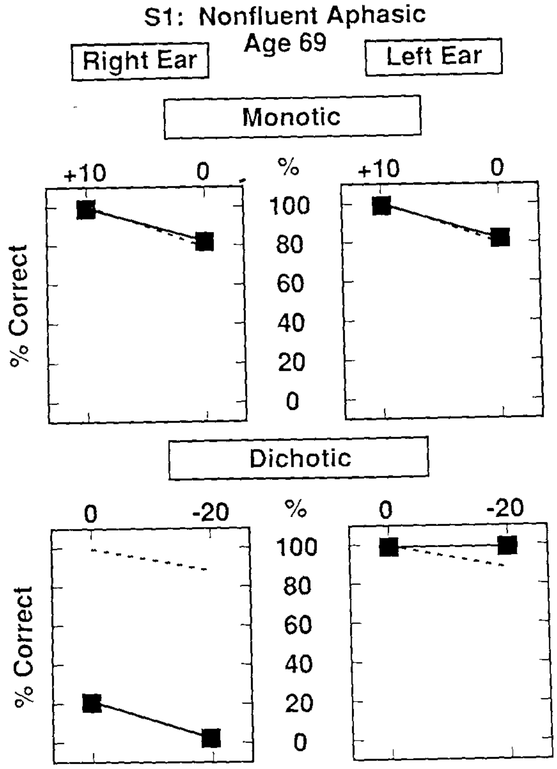

Figure 4 Message-to-competition ratio (MCR) functions for the monotic and the dichotic conditions, as defined with PSI sentences, on the right and left ears of a nonfluent aphasic (S1).

area, showed a well-known variant of the classic pattern (Jerger and Jerger, 1981). Abnormality was observed for both the monotic and dichotic conditions on the affected (right) ear. The degree of abnormality was greater for the dichotic condition than for the monotic condition, again in agreement with previous findings for nonaphasic adults (Berlin et al, 1972; Jerger and Jerger, 1975a; Speaks et al, 1975).

Performance in S7, a fluent aphasic with a lesion in the left frontal operculum, showed an isolated performance deficit for the monotic condition on the left ear only, the ear ipsilateral to the lesion. In nonaphasic adults and children, this pattern of results is typically observed in individuals with brainstem, rather than cortical, lesions (Jerger and Jerger, 1975b; Jerger and Jerger, 1981; Jerger, 1987). Auditory evoked potentials and acoustic reflex testing in this subject also suggested abnormality of the auditory system at the level of the brain stem. A brainstem site of disorder was supported by the presence of abnormal auditory brainstem responses and abnormal offset latency measures for crossed acoustic reflexes (see Jerger et al, 1986, for technical details). Middle latency responses were also abnormal in this subject, but late vertex potentials were normal. Finally, performance for S8, a fluent aphasic with a left basal ganglia lesion, was within the normal range for all MCR conditions. Results for auditory evoked potentials and acoustic reflex testing were also normal in this subject.

Overall Pattern of Results

Results on the PSI test were abnormal for at least one condition in all subjects. The nonfluent aphasics (S1–S3) consistently showed abnormal results on both the PI and MCR functions, as seen in Figures 1 and 3. The fluent aphasics, in contrast, showed a variety of findings—abnormal PI functions only, abnormal MCR functions only, or abnormality on both measures. For both the PI and MCR functions, the degree of abnormality was more pronounced in the nonfluent group than in the fluent group. As an example, dichotic speech perception (Fig. 3) was abnormal in six subjects: three fluent and three nonfluent aphasics. The criterion for abnormality (Table 4) at −20 dB MCR is an absolute score of less than 90 percent correct. Absolute performance on the affected ear at −20 dB MCR was 20 percent, 40 percent, and 80 percent in the three fluent aphasics, but only 0 percent, 0 percent, and 20 percent in the three nonfluent aphasics. Maximum performance for PSI words-in-competition also reflected differences between the groups, with absolute scores on the right ear consistently within normal limits in the fluent group (80 to 100 percent) and consistently abnormal in the nonfluent group (0, 0, and 20 percent).

DISCUSSION

An Auditory-Specific Versus a Generalized-Linguistic Deficit

It is important to consider whether the abnormalities on the PSI test reflect auditory-specific disabilities or more generalized linguistic-cognitive dysfunctions. There are at least two findings that support an auditory basis for the abnormalities. First, the subjects showed normal performance for one ear coupled with abnormal performance for the other ear. In other words, all difficult listening conditions did not produce abnormal results. Second, for the paired conditions (PI functions for words versus sentences, MCR functions for monotic versus dichotic modes), the subjects showed normal performance for one condition coupled with abnormal performance for the other condition. Again, some difficult listening conditions were performed normally. It is also the case that the subjects showed normal (100 percent) performance in the quiet control conditions. If linguistic-cognitive deficits were producing the abnormal results, then performance should have been depressed on both ears and for all conditions utilizing the same speech materials. The observations of ear-specific and condition-specific abnormalities support an auditory basis for the PSI deficits.

Performance for Words Versus Sentences

Traditionally, the normalcy or abnormalcy of PI functions in adults is revealed by the relation between maximum performance for words versus sentences (PB versus SSI) (Jerger and Hayes, 1977). In contrast, the normalcy or abnormalcy of the PSI-PI functions for each type of speech material is referenced to the relation between maximum scores in quiet versus in competition (Table 4). The relation between performance for words versus sentences can be inferred, however, from the PSI approach. An abnormal word-maximum-in-competition (word-max) coupled with a normal sentence-maximum-in-competition (sentence-max), for example, may be thought of as a greater depression of performance for words than for sentences. It is also the case that PSI performance in quiet is typically 100 percent correct, even for young children. In this circumstance, referring the competing conditions to the quiet control conditions is superfluous, and the absolute word-max and sentence-max scores can be interpreted directly. Viewed from this orientation, the present results may be related to the traditional word versus sentence adult measures (PB versus SSI).

The typical adult word-sentence pattern of abnormality in nonaphasic individuals with central auditory disorders shows poorer maximum performance for sentences than for words (Jerger and Hayes, 1977; Jerger and Jerger, 1981). This pattern of abnormality also seems to be observed on the PSI test in nonaphasic children with CNS lesions affecting the central auditory system, coupled with an additional pattern in which both the word-max and sentence-max scores are abnormal (Jerger, 1987). In the present subjects, abnormality of the word-max and sentence-max relation did not conform to the above patterns.

The relation between word-max versus sentence-max scores in these eight subjects differed between the fluent and nonfluent groups. The fluent group consistently showed word-max and sentence-max scores within normal limits, whereas the nonfluent group consistently showed abnormal word-max scores. The sentence-max scores in the nonfluent group varied, sometimes normal and sometimes abnormal, but were always better than word-max performance. The word deficits in the nonfluent group were striking (word-max scores of 0 to 20 percent), as seen in Table 6.

Possible Bases for the Word-Max Abnormality in the Nonfluent Aphasics

One possible explanation for the poor word-max scores is the high-frequency hearing losses that characterized the nonfluent aphasics (Table 5). Several pieces of evidence, however, do not support hearing loss as the basis for the word-max abnormality. First, one of the nonfluent aphasics (S1) had a symmetric, mild high-frequency loss on both ears, but showed depressed word performance on the right ear only. Second, some of the fluent aphasics had normal word-max scores in the presence of high-frequency hearing losses of 55 to 75 dB HL (S5 and S6). Finally, PSI results were obtained in three nonaphasic subjects with sensorineural hearing losses, who were carefully matched to the three nonfluent aphasics in terms of age, degree of loss, and audiometric contour. Results were normal on the entire PSI battery, including word-max intelligibility scores of 100 percent in all three subjects. Thus, a hearing-loss explanation of the depressed word-max intelligibility scores does not seem sufficient.

Another possible explanation is that abnormal word-max performance was due to the nonfluent patients' inability to identify targets in competition. On close inspection, however, this explanation is also unsatisfactory. The standardized test conditions designate a more difficult MCR for the sentences (0 dB) than for the words (+4 dB) (see the Methods section for explanation). Thus, a problem with identifying targets in competition per se should have produced the opposite pattern, poorer sentence-max than word-max scores.

It is difficult to discern why only the nonfluent aphasics showed the word-max pattern of abnormality. Although the nonfluent subjects typically had more severe expression problems, they did not have more severe comprehension deficits, as seen in Table 1. The general locations of the lesions also did not reveal any area uniquely associated with the word-max deficits. In short, the clinical diagnostic data regarding the degree of hearing loss and the location and severity of the lesions do not illuminate a basis for the word-max pattern of abnormality.

The unusual word-max pattern of abnormality has been observed previously for one other patient group, namely, young children with recurrent otitis media (Jerger et al, 1983). Jerger and colleagues described the development of maximum performance for PSI words and sentences in competition as a function of age from about 24 to 36 months. Whereas the developmental course for normal children showed better performance for words than for sentences, the developmental course for children with recurrent otitis media showed the converse—better performance for sentences than for words.

Jerger and her associates speculated that the children with recurrent otitis media may have had abnormal or developmentally-delayed phonologic processing abilities that disproportionately penalized word performance relative to sentence performance. Findings in the aphasics, however, do not support a straightforward association between word-max performance on the PSI test and integrity of phonologic abilities. Some of the fluent aphasics, for example, had normal PSI word-max scores, yet showed abnormalities on more specific measures of phonologic abilities, such as discriminating nonsense syllables representing minimal-pair contrasts. A further complication for a phonologic hypothesis is that some of the nonfluent subjects showed an abnormal word-max score on one ear coupled with a normal word-max score on the other ear (Table 6). If "pure" phonologic factors were producing the word deficits, then PSI performance should have been abnormal on both ears and in all subjects evidencing phonologic abnormalities on other measures. These results suggest that the abnormality for PSI words is reflecting an auditory, ear-specific disability.

Overall Patterns of Abnormality on PSI-PI Functions

In short, the present data, coupled with previous findings for the PSI test, suggest three distinct patterns of abnormality on PI function testing: (1) abnormal sentence-max and normal word-max, (2) abnormal word-max and normal sentence-max, and (3) abnormal sentence-max and abnormal word-max. Further data are needed to understand the three patterns of abnormality and the striking similarity on PI-function testing between the nonfluent aphasics and young children with recurrent otitis media. If it is the case that the different patterns are reflecting meaningful differences in aspects of central auditory processing, results on the PSI test may have important implications for understanding, differentiating, and perhaps remediating types of central auditory disorders.

SUMMARY

The Pediatric Speech Intelligibility (PSI) test was administered to eight subjects with aphasia. Results (message-to-competition ratio [MCR] functions or the performance-intensity [PI] functions) were abnormal in all subjects. The subjects served as their own controls, showing normal performance on one ear coupled with abnormal performance on the other ear. The patterns of abnormalities were consistent with the patterns seen (1) on conven-

tional diagnostic speech audiometry in brain-lesioned adults without aphasia and (2) on the PSI test in brain-lesioned children without aphasia. An exception to this general observation was an atypical pattern of abnormality on P1-function testing in the subgroup of nonfluent aphasics. The nonfluent subjects showed substantially poorer word-max scores than sentence-max scores, a pattern seen previously in only one other patient group, namely young children with recurrent otitis media. The unusual word-max abnormality was not meaningfully related to clinical diagnostic data regarding the degree of hearing loss and the location and severity of the lesions or to experimental data regarding the integrity of phonologic processing abilities. The observations of ear-specific and condition-specific abnormalities suggest that the linguistically and cognitively simplified PSI test may be useful in the evaluation of auditory-specific deficits in the aphasic adult.

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