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Speech Recognition in Recurrent Otitis Media: Results in a Set of Identical Twins

Denice P. Brown*

Abstract

Performance–intensity functions for Pediatric Speech Intelligibility Test (PSI) word and sentence materials presented in competition were obtained for a set of identical female twins, aged 4 years, 2 months. Twin B had a medical history significant for recurrent otitis media, while Twin A had only one reported occurrence of the disease. Twin A yielded normal functions for both word and sentence materials. Twin B, however, yielded an essentially normal function for sentences, but the function for monosyllabic words was grossly depressed. These findings support the hypothesis that transient conductive hearing loss and auditory deprivation resulting from recurrent otitis media can affect the processing of phonetic information essential to the development of word recognition skills.

Key Words: Otitis media, pediatric hearing assessment, Pediatric Speech Intelligibility Test (PSI)

The orderly development of speech and language is critically dependent upon a normal, intact auditory system through which speech signals can be received and interpreted. Furthermore, the crucial period for such input to take place is within the first 2 to 3 years of life, when a child's capacity for speech and language acquisition is optimal (Ling and Ling, 1978; Pollack, 1985; Northern and Downs, 1991). Fluctuating conductive hearing sensitivity loss associated with otitis media with effusion (OME) is observed frequently in children during the critical period of speech and language learning, and it is estimated that between 75 and 95 percent of children will manifest at least one episode during the first 3 years of life (Howie, 1977; Klein, 1980; Friel-Patti, 1990). This typically results in pure-tone air-conduction thresholds within the 20-dB range (Paradise, 1981; Fria et al, 1985), although as much as a 50-dB conductive impairment can occur (Paradise, 1981).

While a 20- to 25-dB hearing sensitivity loss will have little impact on an adult who has the contextual strategies necessary for interpreting speech firmly in place, a child who is just beginning to acquire these strategies requires undistorted auditory input if he or she is to develop adult speech and language skills. In addition, a typical episode of otitis media is characterized by middle ear effusion that can persist as long as 1 to 3 months, even when treated with appropriate antibiotics (Paradise, 1981; Teele et al, 1984; Roland and Brown, 1990). A child who experiences repeated bouts of otitis media during the language-learning years may thus spend much of this critical period with fluctuating unilateral or bilateral hearing sensitivity loss, a situation viewed by various investigators as analogous to studies of auditory deprivation in animals (Sak and Ruben, 1981; Finitzo et al, 1990). Such research has

*University of Houston Program in Communication Disorders, Houston, Texas

Reprint requests: Denice Brown, University of Houston Program in Communication Disorders, School of Communication, Houston, TX 77204-6611

suggested that the acoustic stimuli experienced by a developing animal influence various aspects of auditory system maturation, including cortical and subcortical brain structures (Webster and Webster, 1977, 1979; Coleman and O'Connor, 1979; Clopton, 1980; Feng and Rogowski, 1980; Blatchley et al, 1983; Evans et al, 1983; Webster, 1983a, b).

Although surrounded by controversy, numerous professionals believe that there is a direct relationship between recurrent OME early in life and abnormalities in speech and language, cognitive, academic, and central auditory processing skills (Zinkus and Gottlieb, 1980; Downs, 1985; Davis et al, 1986; Silva et al, 1986; Baden et al, 1987; Wallace et al, 1988; Friel-Patti and Finitzo, 1990; Menyuk, 1992). Researchers have fostered a theory that hearing sensitivity loss associated with OME results in the presentation of inconsistent speech signals, thus compromising a developing child's ability to evolve phonetic discriminations required for speech and language learning (Berko-Gleason, 1985; Friel-Patti, 1990).

A report by Susan Jerger and colleagues (1983) supports this concept. They retrospectively examined the influence of recurrent conductive hearing loss associated with otitis media on the development of speech intelligibility in children 24 to 56 months of age. Developmental performance–intensity functions were acquired for Pediatric Speech Intelligibility Test (PSI) word and sentence materials presented in quiet and in the presence of competing speech for 25 children with histories of recurrent OME and 25 age-matched controls. Children with positive histories of OME generated normal developmental functions for words and sentences in quiet and for sentences presented in competition. Monosyllabic word recognition in competition, however, was grossly abnormal and depressed relative to the otitis-negative group. This finding was felt to be the result of a degradation of acoustic-phonetic information essential to single syllable word recognition that had been imposed by the OME-related hearing sensitivity loss.

More recently, Gravel and Wallace (1992) employed an adaptive test paradigm to determine the message-to-competition ratio (MCR) at which 50 percent correct PSI sentence identification was achieved in a group of 23 children followed prospectively and categorized by otoscopic examinations carried out during the first year of life as otitis-positive (n = 10) or otitis-negative (n = 13). Their findings revealed that the otitis-positive children required a more advantageous MCR to achieve and maintain the 50 percent performance criterion than their otitis-negative peers.

The intent of the present report is to highlight further the impact of recurrent otitis media on speech recognition in competition. Subjects were a set of identical female twins, aged 4 years, 2 months. Based on parental report as documented in the children's baby books, Twin B had a medical history significant for repeated bouts of otitis media, while Twin A had only one known occurrence of the disease.

Subject History

The twins were the product of a normal pregnancy, and were delivered without complication by Caesarian section at 37.5 weeks gestation. Developmental milestones were achieved within age-appropriate normal limits, and there was no parental concern regarding speech and language development. Medical history was nonsignificant, with the exception of Twin B's recurrent episodes of otitis media, which had reportedly increased in frequency during the 3- to 4-month period preceding audiologic assessment. Twin A had experienced only one documented episode of OME at 3 years of age, which was treated successfully with antibiotics.

METHOD

Materials and Instrumentation

A standard clinical audiometer (Grason-Stadler, GSI 10) was utilized to assess puretone hearing sensitivity. Immittance audiometry, including tympanometry, static compliance, and acoustic reflex threshold determination, was carried out with a Madsen Z073A electroacoustic bridge. Speech recognition was evaluated with commercially available (Auditec Inc.) recordings of the Pediatric Speech Intelligibility (PSI) Test (Jerger and Jerger, 1984). Stimulus items were delivered through a stereo cassette tape deck (Pioneer CT-6R) and routed through the tape-input ports of a GSI 10 clinical audiometer to earphones (TDH-39) mounted in circumaural cushions. The 1000-Hz calibration tone recorded on each tape was adjusted to peak at 0 on the audiometer's VU meter. Readers unfamiliar with the PSI Test are referred to Jerger et al (1980) for additional information.

Procedure

Immittance audiometry was performed in the standardized manner utilizing a Madsen Z073A middle ear analyzer. Tympanometry and static compliance measures were acquired, and crossed acoustic reflex thresholds were determined for broadband noise and for pure-tone signals at octave intervals from 500 through 4000 Hz. Uncrossed acoustic reflex thresholds were measured at 500, 1000, and 2000 Hz. Pure-tone audiograms were generated at octave intervals from 250 through 8000 Hz, employing an ascending manual technique (ASHA, 1978).

For speech audiometry, each child was seated at a table in a sound-treated room. The Northwestern Syntax Screening Test (NSST) (Lee, 1971) was administered prior to PSI assessment to ascertain appropriate sentence format. The child was then acquainted with the PSI word and sentence cards and required to label each picture target (words) or label and describe the depicted activity (sentences).

To familiarize the children with the required picture pointing task, speech recognition for PSI words was examined initially at 40 dB HL in quiet, and then in the presence of an ipsilateral competing speech message at +10 dB MCR. Following the practice trials, performance–intensity (P–I) functions for words were generated at an MCR of +4 dB for signal intensity levels of 40, 60, and 80 dB HL. As for single syllable words, sentence intelligibility at 40 dB HL was examined initially in quiet and at +10 dB MCR to familiarize the child with the task. Recognition was then determined at 0 dB MCR for the above-stated intensities and a P–I function plotted. For both word and sentence tasks, a listening trial consisted of five stimulus items. If performance on a listening trial yielded a score of 80 to 100 percent (4 or 5 correct) or 0 to 20 percent (0 or 1 correct), only one trial was required at that signal intensity. If performance ranged from 30 to 70 percent (2 or 3 correct), however, a second trial was presented at the specified intensity.

RESULTS

Pure-Tone and Immittance Audiometry

As illustrated in Figure 1, pure-tone air-conduction thresholds for the two subjects were within normal limits, bilaterally. In addition, intersubject threshold differences were no greater than ±10 dB at any test frequency. Twin A had normal middle ear function as determined by immittance audiometry. Tympanometry yielded Type A tympanograms and normal static compliance values for each ear. Acoustic reflexes were present within normal limits, and crossed/uncrossed reflex thresholds yielded good agreement at each test frequency. In contrast, Twin B demonstrated significant negative middle ear pressure, characterized by Type C tympanograms with peak compliance at –260 daPa and –160 daPa for the right and left ears, respectively. All acoustic reflexes were elevated (>100 dB HL) or absent, bilaterally. Unmasked (nonspecific to either ear) bone-conduction threshold testing confirmed the presence of a slight conductive component in at least one ear.

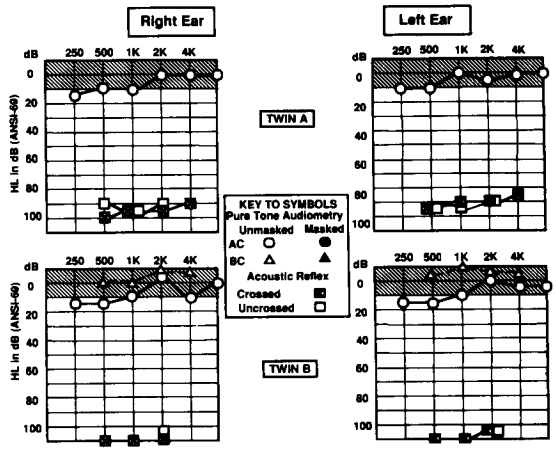

Figure 1 Pure-tone and acoustic reflex thresholds in a set of identical twins evaluated at 4 years, 2 months of age.

Speech Audiometry

Both subjects yielded a receptive language score of 27 (50th percentile) on the NSST, which, according to established norms, qualified them for Format I sentence presentation. Figure 2 illustrates the P–I functions for PSI speech materials. The twins demonstrated 100 percent correct identification in each ear for word and sentence stimuli presented in quiet and in competition at 40 dB HL. Twin A, with no history of otitis media, also achieved normal word and sentence performance (80–100 percent) at 60 and 80 dB HL. In contrast, Twin B's speech recognition scores in competition ranged from 30 to 100 percent, with superior performance for sentence materials. Although the P–

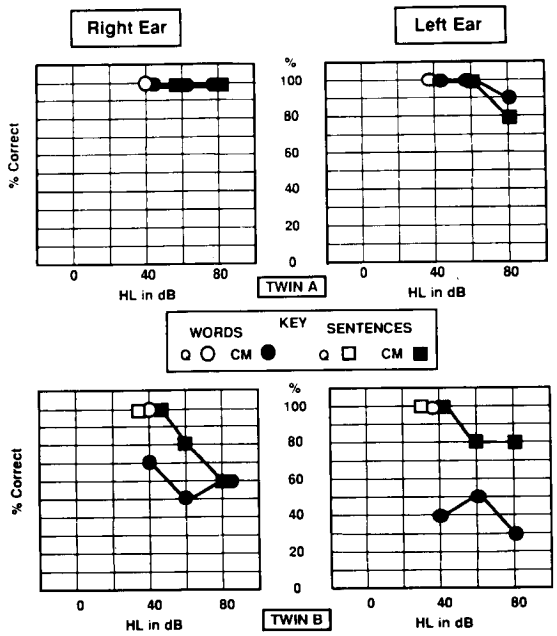

Figure 2 Performance–intensity functions for Pediatric Speech Intelligibility Test word and sentence materials in a set of identical twins evaluated at 4 years, 2 months of age. Testing was carried out in quiet (Q) and in the presence of an ipsilateral competing message (CM) at +4 dB MCR and 0 dB MCR for word and sentence materials, respectively. Note the depressed word performance for Twin B, whose medical history was significant for recurrent otitis media.

I functions for sentences were within relatively normal limits, word functions were grossly depressed, bilaterally.

DISCUSSION

A number of studies exploring the effects of otitis media on child development are retrospective in nature and have been criticized because of flawed methodologic and experimental design, including inappropriate subject selection and matching (Paradise, 1981). While retrospective in nature, this investigation is unique since the two subjects were identical twins, one of whom possessed a history of recurrent OME. There were thus no differences in age, race, socioeconomic level, language experience, or other environmental factors that could have contributed to the intersubject discrepancy noted for PSI word recognition. Furthermore, receptive language abilities, as screened by the NSST, were equivalent and within normal limits according to age-matched normative values. Although Twin B exhibited negative middle ear pressure at the time of evaluation, pure-tone air-conduction thresholds for the twins were in good agreement. It is therefore unlikely that peripheral hearing sensitivity at the time of assessment was a contributing factor.

The striking discrepancy in performance for word versus sentence materials is not unlike that observed by Jerger and colleagues (Jerger et al, 1983) in a group of children with histories of early OME. As discussed by these investigators, such findings are consistent with the research of Dobie and Berlin (1979), in which speech waveforms were filtered to simulate a hearing sensitivity loss typical of OME. Analysis demonstrated a loss of high-frequency information and subsequent loss of intelligibility for brief utterances. The vocalic and temporal information required for sentence identification, however, was preserved. Mustain (1979) similarly reported impaired speech recognition in individuals with otitis media, and Menyuk (1980) theorized that hearing loss associated with OME may impact phoneme categorization as well as word retrieval skills.

Prospective investigations of the relationship between OME and speech-language abnormalities propose that a child receives inconsistent auditory input during bouts of OME, leading to an inability to attend adequately to spoken language (Friel-Patti and Finitzo, 1990; Gravel and Wallace, 1992). Gravel and Wallace (1992) further hypothesized that the consequences are more prominent if auditory deprivation takes place during the early critical period for language development. In addition, these researchers believe that deficiencies present not only as attentional deficits, but also as a lack of development of higher order auditory listening skills pertinent to successful performance in the classroom.

Twin B demonstrated deficient performance in competition for single syllable words, although sentence identification was within normal limits, bilaterally. It has been well documented that PSI results for children with central auditory disorder are typically characterized by poorer performance for sentence versus word recognition (Jerger et al, 1988). Neither Twin B nor the children in the Jerger study (Jerger et al, 1983) manifested this pattern of results. The findings of Gravel and Wallace (1992), however, suggest that PSI sentence identification may indeed be reduced in children with early recurrent OME, but that the recommended MCR of 0 dB employed in the acquisition of the PSI performance–intensity functions is not of sufficient difficulty to observe any abnormality within this population.

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