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Binaural Interference in a Child: A Case Study

Janet R. Schoepflin*

Abstract

A case study of a child (KB) who demonstrated binaural interference is reported. KB wore unilateral amplification from 1.6 to 4.6 years of age, at which time word-recognition scores under phones were markedly asymmetric, reflecting significantly better performance for the aided ear than the unaided ear, despite similar unaided pure-tone sensitivity. Suspecting the asymmetry in word-recognition performance might be the result of auditory deprivation, bilateral amplification was prescribed at 4.6 years of age. Three months later, adverse changes in the child's behavior were reported. At 5.3 years, significant interaural asymmetry was noted in word-recognition scores under phones, in unilateral-aided word-recognition scores (90% vs. 36%), and in the bilateral-aided score (56%), supporting the presence of binaural interference.

Key Words: Auditory deprivation, bilateral amplification, binaural, binaural interference, speech audiometry, speech perception, speech-recognition ability, unilateral amplification

Sumario

Se reporta el estudio de caso de un niño (KB) quién demostró un interferencia binaural. KB utilizó amplificación unilateral desde la edad de 1.6 a los 4.6 años, donde sus puntajes de reconocimiento de palabras bajo auriculares eran marcadamente asimétricos, reflejando un desempeño significativamente mejor en el oído amplificado que en el no amplificado, a pesar de una sensibilidad tonal sin amplificación similar para los dos oídos. Bajo la sospecha de que la asimetría en el reconocimiento de palabras se debiera a un deprivación auditiva, se prescribió una amplificación binaural a la edad de 4.6 años. Tres meses después, se reportaron cambios adversos en la conducta del niño. A los 5.3 años, se notó una significativa asimetría interauricular en los puntajes de reconocimiento de palabras con auriculares, en reconocimiento de palabras con amplificación unilateral (90% vs. 36%), y el puntaje bilateral con amplificación (56%), apoyando la presencia de una interferencia binaural.

Palabras Clave: Deprivación auditiva, amplificación bilateral, binaural, interferencia binaural, logoaudiometría, percepción del lenguaje, capacidad de reconocimiento del lenguaje, amplificación unilateral

*Department of Communication Sciences and Disorders, Adelphi University

Janet R. Schoepflin, Department of Communication Sciences and Disorders, Adelphi University, Rm. 21 Hy Weinberg Center, 158 Cambridge Avenue, Garden City, NY 11530; Phone: 516-877-3343; Fax: 516-877-4783; E-mail: schoepfl@adelphi.edu

The binaural interference phenomenon, in which auditory performance is poorer when both ears receive auditory input than when only one ear receives auditory input, was first described by Jerger et al (1993). This seminal paper demonstrated the binaural interference effect on both behavioral (speech recognition) and electrophysiologic (middle-latency auditory-evoked response) measures in four elderly patients with symmetric, or nearly symmetric, sensorineural hearing loss. In two of the four cases, aided speech-recognition performance was poorer under the bilateral-aided condition than the better ear unilateral-aided condition. In three of the four cases, the middle-latency auditory-evoked responses showed less activity or reduced amplitude under the bilateral-aided condition than under the better ear unilateral-aided condition. The authors hypothesized that the binaural interference phenomenon may be the auditory equivalent of binocular rivalry in the visual system, in which responses to binocular stimulation are poorer than responses to monocular stimulation (Wanger and Nilsson, 1978; Katsumi et al, 1986, 1988). Binaural interference also has been described on behavioral (word-recognition performance) and physiologic measures (brainstem and middle-latency auditory evoked responses) in an adult male, the interference decreasing with progression from the active to remission phase of multiple sclerosis (Silman, 1995). In a case of an 87-year-old female, Chmiel et al (1997) demonstrated binaural interference on speech-recognition performance, which seemed to result from abnormal interhemispheric transfer of auditory information.

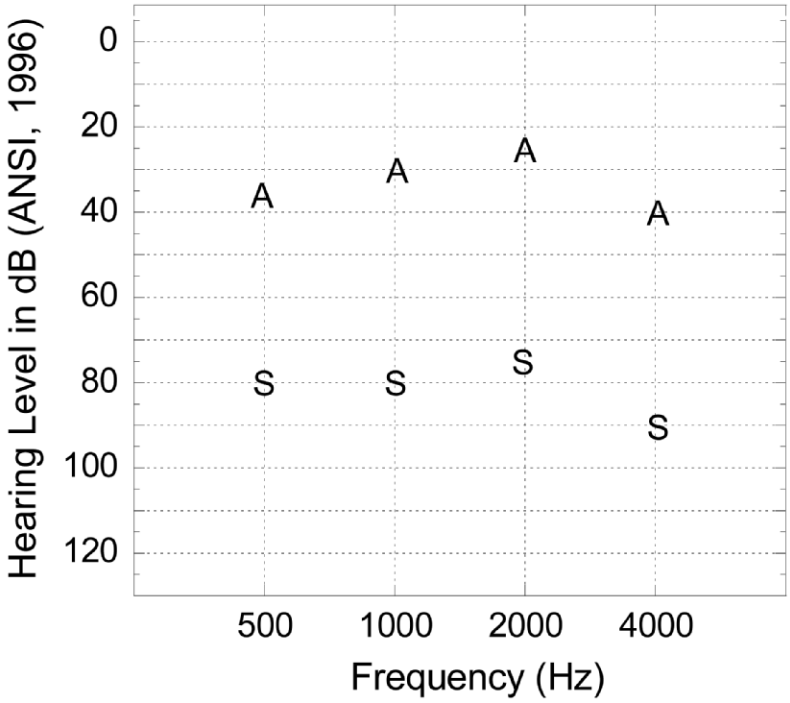
More recently, Carter and colleagues (2001) and Holmes (2003) described cases in which adult patients performed better and were more satisfied with unilateral than bilateral amplification. Even more recently, Walden and Walden (2005) reported that average performance on the QuickSIN test was significantly better (less signal-to-noise ratio loss) with unilateral than bilateral amplification in their group of older adult participants. In fact, 23 of the 28 adults demonstrated binaural interference. For 16, speech-recognition performance in noise under the bilateral-aided condition was worse than that under the poorer ear unilateral-aided condition (superinterference). For another six, performance in the bilateral-aided condition was equal to that in the poorer ear unilateral-aided condition. And, in another adult, speech-recognition performance in noise under the bilateral-aided condition was worse than that for the better ear but not worse than that for the poorer ear unilateral-aided condition. Although recommending caution in the interpretation of their results, the authors found that binaural interference occurred for most of their subjects, and they suggested that susceptibility to binaural interference increases with age.

Indeed, all of the literature on binaural interference to date has been on adult patients. Reported here is a case study of a male child, KB, who appears to demonstrate the binaural interference effect, which has previously only been reported for adults.

CASE REPORT

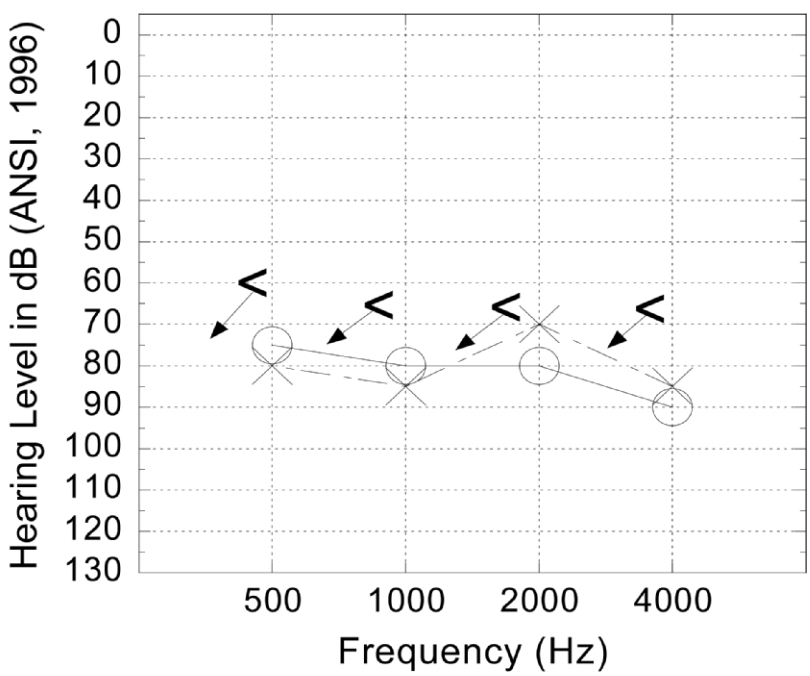
KB was first evaluated audiologically at 1.6 years of age in a metropolitan medical center. The results of the initial evaluation are shown in Figure 1. As can be seen, soundfield thresholds were obtained for warble tones at 75 to 90 dB HL for the octave frequencies 500 Hz through 4000 Hz. KB was fitted with unilateral amplification (Zenith body aid) for the right ear. At the time of the fitting, audiologists differed in management philosophies (unilateral versus bilateral amplification) for symmetric sensorineural hearing loss, and the fitting of this aid was in accordance with the practice of the facility at that time. Aided soundfield thresholds were obtained at 25 to 40 dB HL for the same test frequencies. Speech testing was not conducted. The tympanometric peak pressure (-50 daPa for the right ear and -75 daPa for the left ear) was consistent with normal middle ear function, bilaterally.

The pure-tone and word-recognition results obtained when KB was 4.6 years old, just before he entered kindergarten, are shown in Figure 2. The pure-tone thresholds indicated a severe, bilaterally symmetric sensorineural hearing loss. The speech reception thresholds (SRTs) corroborated the pure-tone findings. Suprathreshold word-recognition performance, assessed using the full Phonetically-Balanced Kindergarten (PBK-50) word lists presented at 25 dB SL re: SRT, was 88% in the right ear and 40% in the left ear, a statistically significant interaural difference according to the binomial model (Thornton and Raffin, 1978). The tympanometric peak



Ear	SRT (dB HL)	PBK score (%)	Tympanometric peak pressure (daPa)
Right	DNT	DNT	-50
Left	DNT	DNT	-75

Figure 1. Audiogram (unilaterally aided and unaided results) in sound field at age 1.6 years. A = aided, S = unaided, DNT = Did not test.



Ear	SRT (dB HL)	PBK (%) at 100 dB HL	Tympanometric peak pressure (daPa)
Right	75	88	-80
Left	75	40	-80

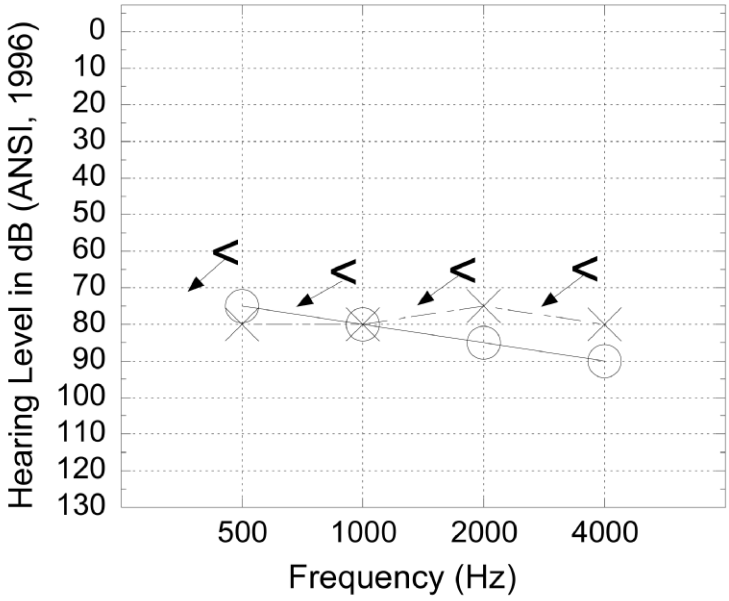
Figure 2. Audiometric findings at age 4.6 years. After three years of monaural amplification, word-recognition performance under phones was significantly poorer in the left (unaided) ear than the right (aided) ear.

pressure (-80 daPa in each ear) remained consistent with normal middle ear function, bilaterally.

Recognizing that the poor word-recognition performance in the left, unaided ear (as compared with the right, aided ear, despite the symmetric pure-tone configuration) could represent auditory deprivation over a three-year period from a lack of auditory stimulation in the unaided ear due to the use of unilateral amplification (Silman et al, 1984; Silverman and Silman, 1990; Gelfand and Silman, 1993), a hearing aid (Zenith body aid) was fitted in the left ear. The addition of amplification to the left ear provided the child with bilateral amplification for the first time.

Three months after the addition of the second hearing aid, the mother reported that she and KB's teachers saw unfavorable changes in the child's behavior; specifically, they reported inattentiveness, temper tantrums, and hyperactivity. Further, KB's teachers informed her that he was frequently distracted and often exhibited disruptive outbursts in class. Conduct of this nature had not been observed previously in KB at home or in school.

After nine months of bilateral amplification, at 5.3 years of age, KB was evaluated by this author for a second opinion regarding his use of amplification. The second opinion was sought as a result of the adverse behavior changes observed in KB following the fitting of the second hearing aid. An audiological reevaluation and aided SRT and word-recognition tests were administered, the results of which are shown in Figure 3. These results indicated essentially no change in pure-tone sensitivity or SRTs from the evaluation at 4.6 years of age. Suprathreshold word-recognition performance, essentially unchanged from the previous test, again yielded a statistically significant interaural difference with poorer performance in the formerly unaided left ear. Tympanometric peak pressure (0 daPa for the right ear and 10 daPa for the left ear) continued to indicate normal middle-ear function, bilaterally. Aided SRTs were obtained in sound field at 40 dB HL for the right-ear-aided condition and the left-ear-aided condition. Aided soundfield word-recognition performance in quiet at conversational level (50 dB HL) was 90% for the better ear unilateral-aided condition



Ear	Speech reception threshold for spondees (SRT) in dB HL	PBK word-recognition score (%)[a]
Right	80	88[b]
Left	80	38[b]
Aided right	40	90[c]
Aided left	40	36[c]
Aided bilaterally	DNT	56[c]

Figure 3. Audiometric findings at age 5.3 years. After nine months of bilateral amplification, word-recognition performance under phones remained significantly poorer in the initially unaided (left) ear than the initially aided (right) ear. Unilateral-aided word-recognition performance was significantly poorer in the left ear than the right ear, and the bilateral-aided word-recognition score was significantly poorer than the better (right) unilateral-aided score.

and 36% for the poorer ear unilateral-aided condition; the score for the poorer ear condition fell below the 95th percentile critical difference limits associated with the better ear condition (Thornton and Raffin, 1978). Because of the adverse academic and behavioral changes following the bilateral fitting, and significant interaural asymmetry in the unilateral-aided as well as unaided under-phones conditions, binaural interference was suspected. Therefore, performance was assessed in the bilateral-aided condition. The resultant bilateral-aided score (56%) was significantly poorer than the better ear unilateral-aided score (but was not poorer than the poorer ear unilateral-aided score), supporting the presence of binaural interference.

In light of these findings and the unfavorable scholastic and psychosocial behavior subsequent to the bilateral fitting, it was recommended to the mother that she remove KB's left hearing aid to return him to a unilateral better-ear fitting for regular, everyday use. It was further recommended that KB be enrolled in an intensive home treatment program of auditory training and speechreading to attempt to increase use of the second hearing aid to effect binaural integration and develop improved aided binaural performance on speech-recognition measures. The training consisted of twice weekly home visits (for one hour each session) by a speech-language pathologist and listening activities carried out by the mother for one hour each day. The auditory training was conducted with unilateral (newly aided left ear) and bilateral amplification, with the period of the bilateral amplification gradually being extended toward the goal of full-time, daily use.

After three months of returning to the regular, everyday (including school) use of unilateral amplification in the right ear and with participation in the recommended daily home amplification program, the mother reported that she and KB's teachers saw substantial improvement in KB's behavior as evidenced by (a) better listening and attending in school, (b) more positive interactions with his peers, (c) less hyperactivity, and (d) fewer disruptive actions. She also stated that KB used bilateral amplification without opposition or negative behavior for a two-hour period daily. Verification of the subjective improvement of word-recognition performance under the bilateral-aided condition could not be obtained because the child became lost to follow-up.

DISCUSSION AND CONCLUSIONS

In summary, KB initially wore unilateral amplification for three years (from 1.6 to 4.6 years of age). At 4.6 years, his word-recognition scores under phones were markedly asymmetric, reflecting significantly better performance for the right, aided ear than the left, unaided ear. Suspecting that the asymmetry in word-recognition performance, which occurred in the presence of a symmetric pure-tone hearing loss, might be the result of auditory deprivation from three years of unilateral amplification, the audiologist provided KB with bilateral amplification. Auditory deprivation from unilateral amplification has been demonstrated in children (Boothroyd, 1993; Gelfand and Silman, 1993; Hattori, 1993). After nine months of bilateral amplification, KB's mother sought a second opinion regarding the hearing-aid fitting because of the academic and social problems that KB experienced after the addition of the second hearing aid. The audiologic findings of the objective second opinion supported binaural interference as evidenced by the following: significantly asymmetric unaided word-recognition scores under phones (which remained stable following the addition of the second hearing aid); significantly asymmetric unilateral-aided scores; and aided word-recognition scores that were substantially poorer in the bilateral condition than in the better-ear unilateral condition. If the auditory input to the left (worse) side did not influence word-recognition performance under the bilateral-aided condition, then the score in the bilateral-aided condition would be identical, or nearly identical, to that of the right (better-ear) aided score (i.e., 90%). The observed bilateral aided score of 56%, however, suggests that the effect of auditory input to the left side went beyond no effect to an adverse effect on bilaterally aided performance. The author submits that this case represents a behavioral binaural interference phenomenon for aided word recognition after three years of unilateral amplification. The academic and behavioral difficulties following the bilateral fitting probably represent further evidence of binaural interference. This case report suggests that binaural interference is a phenomenon that can occur not only in adults (especially older adults) but also in children.

Because KB was only 4.6 years of age at

the time of the bilateral fitting, he was less able to outright reject an unsatisfactory amplification outcome by refusing to wear the second hearing aid than an adult might have been. Hurley (1993) reported that four of nine subjects who were initially fitted unilaterally, and who then experienced auditory deprivation effects in the unfitted ear, rejected the second aid after a short period of bilateral amplification. The academic and psychosocial problems exhibited by KB after the addition of the second hearing aid may reflect lack of tolerance or discomfort with the distorted auditory perception due to binaural interference and perhaps a juvenile form of amplification rejection. The improved academic and psychosocial performance following the change in amplification status from two hearing aids to one hearing aid suggests resolution of binaural interference.

The findings in this case emphasize the importance of comparing speech-recognition performance in the bilateral-aided condition with both unilateral-aided conditions when considering bilateral fittings. It is interesting that KB, who had markedly asymmetric word-recognition scores under phones, despite the symmetric pure-tone configuration, also demonstrated binaural interference with bilateral amplification. Perhaps the risk of binaural interference is greater when asymmetric word-recognition performance is obtained under phones or in the unilateral-aided conditions. Significant interaural asymmetry in unaided word-recognition performance under phones was demonstrated in three of four cases of binaural interference reported by Jerger and colleagues (1993) and in the case of an adult with binaural interference during an active phase of multiple sclerosis (Silman, 1995). It is important to investigate the possibility of binaural interference when bilateral hearing aid fittings are considered, regardless of whether the unilateral-aided speech-recognition scores or unaided speech-recognition scores under phones are asymmetric.

Without confirmatory performance data under the bilateral-aided versus the separate unilateral-aided conditions, it cannot be established that KB's improved tolerance of bilateral amplification during the aural habilitation program reflects decreased binaural interference. Such objective data would confirm that the observed behavioral improvements (increased attention and fewer negative actions) reflect remediation of binaural interference through gradually increasing periods of bilateral amplification. If the binaural interference effect emerged from auditory deprivation due to unilateral amplification, then recovery in the word-recognition performance of the poorer ear might be expected with continued tolerance and use of bilateral amplification. Boothroyd (1993) presented a case study of a child with bilateral, symmetric, severe-to-profound sensorineural hearing loss, who rejected bilateral amplification at age 10 years after five years of unilateral amplification, but who later (at about 24 years of age) accepted bilateral amplification following a sudden "event" (characterized by tinnitus and loss of speech clarity) in the initially aided ear. In Boothroyd's reported case, the individual's speech-recognition performance in the initially unaided ear improved over time, with phoneme-recognition scores increasing to about 75% from about 40%, supporting recovery of speech-recognition performance after prolonged auditory deprivation. If KB's binaural interference effect emerged from auditory deprivation due to unilateral amplification, then recovery in the word-recognition performance of the poorer ear might be expected with continued tolerance of amplification in that ear as reported by Boothroyd and others (Silverman and Silman, 1990; Silman et al, 1992; Boothroyd, 1993; Hurley, 1993; Silverman and Emmer, 1993).

Given the recognized advantages of binaural hearing, particularly for the recognition of speech in noise (see Libby, 1980; and Byrne, 1981; for a review), the standard treatment for patients with binaural hearing loss is the use of bilateral hearing aids; this is probably even more true for children than for adults. If, as this case suggests, binaural interference can occur in children, then clinicians should take this possibility under consideration when planning treatment. Speech-recognition performance in separate unilateral-aided conditions and in the bilateral-aided condition should be compared to determine whether a bilateral fitting is truly beneficial. And audiologists should consider persons with asymmetric unaided word-recognition scores under phones to be at risk for possible binaural interference. In addition to the traditional measures of binaural interference discussed earlier, binaural interference also may be evaluated according to the protocol recommended

by Ching (2005). In her discussion of binaural-bimodal fittings (bilateral input through a cochlear implant in one ear and a hearing aid in the other), she suggested comparing word recognition in noise performance at 0° azimuth for the cochlear implant-aided ear alone against that for the cochlear implant-aided ear and hearing aid-aided ear together as a means of testing for suspected binaural interference.

Although most of the literature supports the current practice among audiologists for bilateral amplification, several case studies (Jerger et al, 1993; Silman, 1995; Chmiel et al, 1997; Carter et al, 2001; Holmes, 2003) and the recent report of Walden and Walden (2005) suggest that some individuals are unsuccessful or unsatisfied with bilateral amplification or do more poorly on speech-recognition tasks with bilateral amplification than better-ear unilateral amplification. Therefore, it behooves us to investigate the possibility of binaural interference using peripheral and central measures (Jerger et al, 1993; Silman, 1995: Chmiel et al, 1997) on our patients, including children, whenever considering the use of bilateral amplification, particularly in the presence of significantly asymmetric word-recognition performance.

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