Asymmetric Suprathreshold Speech Recognition and the Telephone Ear Phenomenon

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Abstract
We compared interaural suprathreshold speech recognition scores in 62 adults with sensorineural hearing loss. Subjects were tested at two sites, 25 at the Baylor College of Medicine, Houston, TX and 37 at Brooklyn College, Brooklyn, NY. Ears were categorized according to telephone usage. Results showed, at both sites, a small but significant difference in speech understanding scores between the ear habitually used on the telephone and the opposite, nontelephone ear. The average speech recognition score was approximately 5 percent better on the telephone ear. Results are interpreted in relation to the theories of auditory deprivation and auditory acclimatization.

Key Words: Auditory deprivation, speech recognition, telephone usage

Abbreviations: NTE = ear not used on the telephone, PTA = pure-tone average, SSRS = suprathreshold speech recognition scores, TE = ear used on the telephone

Late-onset auditory deprivation has been described in adults with bilateral sensorineural hearing impairment who have been aided in only one ear (Silman et al., 1984; Gelfand et al., 1987; Silverman and Silman, 1990; Hurley, 1993). It is a phenomenon characterized by asymmetry in suprathreshold speech recognition. If only one ear has been aided, gradual deterioration in suprathreshold speech recognition occurs in the unaided ear but not in the aided ear. This deterioration has been attributed to interaural asymmetry in auditory stimulation resulting from long-term lack of amplification in the unaided ear.

Recent clinical observations have suggested to us the possibility of another source of such asymmetry in suprathreshold speech understanding. We have observed that, in persons with mild bilateral sensorineural loss who have never been aided in either ear, suprathreshold speech recognition is often slightly better in the ear habitually used on the telephone.

The purpose of the present study was to attempt a more systematic study of this apparent “telephone ear” (TE) effect. We sought to determine whether habitual use of the telephone in a single ear is, indeed, associated with asymmetry in suprathreshold speech understanding.

METHOD

Subjects

Data were collected at two sites: the Audiology Service of The Methodist Hospital, Baylor College of Medicine, Houston, TX and Brooklyn College, Brooklyn, NY. Data were collected retrospectively at Baylor and prospectively at...
Brooklyn College. There were 25 subjects at the Baylor site and 37 subjects at the Brooklyn site. Specific inclusion criteria were as follows: (a) reported onset of hearing impairment in adulthood consistent with presbyacusis or noise-induced hearing impairment; (b) all bone-conduction thresholds within 10 dB of their respective air-conduction thresholds; (c) interaural difference in pure-tone average (PTA) for 500, 1000, and 2000 Hz not exceeding 5 dB bilaterally; (d) tympanometric peak pressure within -100 daPa for a 226-Hz probe tone bilaterally (Jerger, 1970); (e) contralateral acoustic-reflex thresholds for the 226-Hz probe tone consistent with cochlear pathology bilaterally; and (f) negative history of amplification. Of the total of 62 subjects, 34 were men and 28 were women. The sex ratio was approximately equivalent at the two sites. At each site, each subject was queried as to the ear habitually used on the telephone. Potential subjects were asked which ear was habitually used for telephone communication. Individuals were excluded as subjects if the telephone was alternated between ears. Eighteen subjects identified the right ear as the TE. The other 44 identified the left ear as the TE. Throughout the remainder of this paper, the opposite ear is designated as the nontelephone ear (NTE). Subjects ranged in age from 23 to 87 years. The average age was 66.7 years.

Procedure

Within the context of routine clinical audiological evaluation, suprathreshold speech recognition scores (SSRS) were obtained with recorded word lists, either the 50-word CID W-22s presented at a sensation level of 40 dB relative to the spondee recognition threshold (Brooklyn) or half-list versions of the PAL PB-50 word lists, presented at two or three suprathreshold levels (60, 80, and 100 dB SPL), to define the maximum of the performance versus intensity function (Baylor). The possibility that ear differences in SSRS could be explained by differences in effective presentation levels of the speech stimuli is countered by the fact that sensation level was held constant at the Brooklyn site, and that maximum SSRS scores were defined at levels as high as 100 dB SPL at the Houston site. At both sites, conventional pure-tone, speech, and acoustic-immittance assessment was carried out in a sound-treated audiometric test booth meeting standard criteria for background noise in audiometric rooms (ANSI, 1977). Pure-tone and speech tests were administered through a dual-channel diagnostic audiometer. Speech audiometric materials were delivered by means of a dual-channel magnetic tape recorder/playback system using commercially available recordings. Conventional acoustic-immittance measures were obtained using an Amplaid, model 720 instrument (Baylor) or GSI-33 (version 2) acoustic-admittance meter (Brooklyn). All instrumentation was routinely calibrated according to ANSI standards (ANSI, 1987, 1989). Statistical significance was evaluated at an alpha error level of 0.05.

RESULTS

For each subject, we computed the difference between the SSRS of the TE and the SSRS of the opposite or NTE. Figure 1 plots this TE–NTE difference as functions of three variables: (1) subject gender (male vs female), (2) telephone ear (right ear vs left ear), and (3) site (Baylor vs Brooklyn). Across all three variables, the TE–NTE difference varied between 4 and 6 percent. To evaluate the possibility that the TE–NTE difference was contaminated by one or more of these three factors, we carried out a simple analysis of variance with the difference, TE–NTE, as the dependent variable and test site, gender, and TE as the independent variables. There were no significant interactions among the independent variables and no significant main effects. We felt justified, therefore, in collapsing the difference data across site, gender, and TE. In this total group (n = 62), the average SSRS on TE and NTE ears were 74.1 percent and 69.0 percent, respectively. Thus, the TE–NTE difference was 5.1 percent. A paired t-test revealed

![Figure 1](image-url)
sensorineural hearing impairment. RL habitually used the telephone in her right ear. At the initial evaluation, PTAs were 39 dB HL bilaterally. The SSRS were 84 percent and 72 percent for the right and left ears, respectively, yielding a TE–NTE difference of 12 percent. Binaural amplification was recommended but RL declined the use of any amplification. Six years later, at age 61, both ears had PTAs of 70 dB HL and both SSRS had declined to 62 percent, yielding a TE–NTE difference of 0 percent. The TE effect was present when RL had a borderline moderate degree of hearing impairment. It then apparently dissipated when the magnitude of hearing impairment became borderline severe and attenuated telephone usage. At the re-evaluation, RL stated that approximately 2 years earlier, she had become an infrequent telephone user (although telephone use was still habitually restricted to the right ear) because of her "embarrassment" over her difficulty with telephone communication.

**DISCUSSION**

These findings suggest the following tentative hypothesis: in unaided adults with mild bilateral, symmetric sensorineural hearing impairment, long-term habitual use of the telephone in a single ear results in much greater auditory stimulation of the TE than of the NTE. Such restriction of telephone use to one ear under these conditions appears to result in asymmetric SSRS, similar to the asymmetric SSRS observed in auditory deprivation from long-term monaural hearing-aid use. That is, over time, the SSRS for the NTE declines more than the SSRS for the TE, resulting in the TE effect. On the other hand, in unaided adults with moderate or severe, bilateral, symmetric, sensorineural hearing impairment, the TE phenomenon appears to be attenuated. Perhaps the moderate or greater degree of hearing impairment adversely affects telephone communication to a degree that is sufficient to result in infrequent telephone usage. Accordingly, habitual restriction of telephone communication to a single ear does not lead to substantially greater auditory stimulation in the TE than in the NTE in the monotic condition over time. Thus, asymmetric SSRS are not observed.

Some studies have demonstrated acclimatization (Gatehouse, 1992, 1993) or increase in hearing aid benefit (Cox and Alexander, 1992) in monaurally fitted adults with bilateral, symmetric, sensorineural hearing impairment.
as evidenced by slightly but significantly improved SSRS in the aided but not unaided condition during the 3- to 4-month postfitting period. It is relevant to ask whether these effects are based on the same phenomenon underlying the telephone ear effect.

Gatehouse (1993) and Cox et al. (1996) have noted that their acclimatization and hearing aid effects emerged only after sufficient high-frequency amplification had been provided. But telephones are manufactured with limited frequency responses that sharply filter out high frequencies above approximately 3300 Hz when the telephone exchange is involved (personal communication, Harry Levitt). Furthermore, the subjects in the present study typically had downwardly sloping audiometric configurations. Therefore, restricted high-frequency responses for telephones as well as unaided subjects with sloping audiometric configurations probably resulted in lack of substantial high-frequency stimulation. Thus, the present observations on telephone use seem inconsistent with the apparent need for high-frequency stimulation posited by Gatehouse and Cox et al. It may be, however, (Gatehouse, personal communication) that improvement in speech identification ability occurs in a manner that is closely coupled to the frequency regions for which audibility has been materially improved by the provision of either amplification or telephone stimulation. Gatehouse (1993) draws a parallel, in this connection, with the work on neural plasticity of auditory cortex reported by Rencanzone et al. (1993). Within this conceptual framework, the present results are not inconsistent with the previous observations of improved performance only after high-frequency stimulation.

It is of further interest to note the results of a study of dichotic listening in 144 Greek telephone operators by Kapranis and Tzavaras (1993). These investigators found that telephone operators who coupled their earpiece to the left ear had a significantly smaller right-ear advantage, on a dichotic digits test, than operators who coupled the earpiece to the right ear. Kapranis and Tzavaras concluded that the extraordinary verbal stimulation of the left ear over many years had affected functional cerebral organization in such a way that the right-ear-to-left-hemisphere pathway no longer enjoyed its normal advantage over the left-ear-to-right-hemisphere pathway in the dichotic paradigm. Whether this effect resulted from acclimatization of the left ear or deprivation of the right ear is open to question, but the effect of prolonged, high-intensity verbal stimulation of one ear over many years was striking.

An alternative explanation of the TE effect is that asymmetry of speech understanding ability is the cause, rather than the effect, of the choice of ear to be used on the telephone. In this scenario, inherent asymmetry in speech understanding dictates which ear the individual will choose for habitual telephone usage. The TE effect derives from this inherent asymmetry. The individual chooses, as the ear to be used habitually on the telephone, the ear with intrinsically better speech recognition ability. Arguing against this possibility, however, is the undoubted fact that, in right-handed individuals, keeping the right hand free for writing is a strong determinant of which hand is used to hold the telephone receiver. In the present sample, for example, 44 of the 62 subjects (71%) held the receiver in the left hand. Another counter argument is illustrated in Figure 2. As degree of loss increases, the effect tends to diminish. If the choice of ear to be used on the telephone resulted from intrinsic asymmetry in speech understanding ability, such asymmetry ought to remain constant as loss increases.

Further research on a larger sample is needed to substantiate the TE phenomenon. Research also is needed to investigate the possible relations between monaural versus binaural amplification and frequent versus infrequent habitual telephone use that is restricted to one ear.

Acknowledgments. This project was partially supported by VA grant #C0845R. The authors would like to thank the following for their contribution for data collection and comments: Michael Bergen, Olga Lis, and Pamela Marx.

REFERENCES


