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Impact of Central Auditory Processing Disorder and Cognitive Deficit on the Self-Assessment of Hearing Handicap in the Elderly

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Abstract

We studied the impact of central auditory processing disorder (CAPD) and cognitive deficit (CD) on the self-assessment of hearing handicap in 122 elderly subjects. Self-assessment was quantified by means of the Hearing Handicap Inventory for the Elderly (HHIE). Results showed that cognitive impairment exerted no significant effect on the self-assessment of hearing handicap. Subjects with CAPD, however, rated themselves as significantly more handicapped than non-CAPD subjects. Furthermore this difference did not interact with degree of loss. It was present even in subjects without significant peripheral sensitivity loss. These results support the conclusion that CAPD status is a relevant dimension in the evaluation of the elderly subject with or without peripheral hearing loss.

Key Words: Central auditory processing disorder (CAPD), cognitive deficit (CD), aged, Hearing Handicap Inventory for the Elderly (HHIE), auditory diseases, central

It is becoming increasingly clear that the hearing problems of the elderly may be more complex than one would predict from their pure-tone audiograms (Davis, 1980; Hayes, 1984; Stach et al, 1985; Lutman et al, 1987; Bergman, 1988; Spretnjak et al, 1988; Jerger et al, 1989). For a review of recent research on the hearing problems of the elderly, the interested reader is referred to Salomon (1986). The total auditory deficit in an elderly individual may reflect, in varying proportion, at least two components, termed peripheral and central impairments. The peripheral component is reflected in the frequency-specific sensitivity loss revealed by the conventional pure-tone audiogram. The central component is typically reflected in scores on specific speech audiometric measures of central processing ability (Orchik and Burgess, 1977; Jerger and Hayes, 1977; Bergman, 1980; Shirinian and Arnst, 1982; Arnst, 1982; Otto and McCandless, 1982; Dubno et al, 1984). The hearing problems of the elderly may also be complicated by the decline in cognitive functions (Uhlmann et al, 1986; Jerger et al, 1989; White 1989), especially changes in memory, attention, and speed of mental processing (Cohen, 1979).

To what extent do the factors of central auditory processing disorder (CAPD) and cognitive deficit (CD) affect the elderly person's perception of handicap? In other words, is self-

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perceived handicap governed entirely by the peripheral component; or is it influenced, over and above the peripheral component, by CAPD and/or cognitive deficits? The answer to this question could have important consequences for rehabilitative intervention strategies. Conventional hearing aids, for example, focus primarily on the peripheral component. Indeed, emphasis on the selective amplification approach to hearing aid fitting in the elderly targets the audiometric frequency contour almost exclusively. To the extent, however, that factors other than the pure-tone threshold affect the elderly person's perception of his hearing problem, an alternative intervention strategy (e.g., an assistive listening device with remote microphone) may be indicated.

It is of interest to ask, therefore, whether the presence of CAPD and/or CD affects the elderly individual's estimate of his handicap, over and above the extent to which that estimate is governed by peripheral hearing loss. In the present study we asked whether elderly subjects with CAPD or with CD assess their handicaps differently from elderly subjects unimpaired in these dimensions.

METHOD

Subjects

All subjects were paid volunteers who responded to advertisements soliciting participation in a study on auditory aging. We required that subjects be in good general health, speak English as their native language, and be free of signs of pathologic aging. In addition we established audiometric criteria designed to exclude individuals with severe or substantially asymmetric hearing sensitivity loss. Specific exclusion criteria were as follows:

1. History and physical examination
   a) Evidence or history of systemic disease
   b) Evidence or history of neurologic disease
   c) Evidence or history of cerebrovascular accident (CVA)
   d) Evidence of active middle ear disease
   e) Native language not English
2. Neuropsychological examination
   a) Evidence of dementia
   b) Evidence of psychiatric disorder
3. Audiometric examination
   a) PTA_1 greater than 60 dB HTL on either ear
   b) Interaural PTA_1 difference greater than 20 dB

From an initial pool of 143 subjects we excluded 21 subjects on the basis of the criteria listed above. The final sample consisted of a total of 122 elderly subjects (46 males and 76 females). Subjects ranged in age from 50 to 91 years. The average age was 69.8 years with a standard deviation of 7.8 years.

In general, audiometric contours were of the classic presbyacusic configuration–showing bilateral high-frequency sensorineural hearing loss. Average pure-tone sensitivity (PTA) for the frequency range from 500 through 2000 Hz (PTA_1) ranged from 0 to 55 dB HL for the right ear (RE) and from 0 to 58 dB HL for the left ear (LE). Average PTA_1s were 24 dB HL for the RE and 22 dB HL for the LE. Average pure-tone sensitivity for the frequency range from 1000 Hz through 4000 Hz (PTA_2) ranged from 3 to 73 dB HL for the RE and from 0 to 78 dB HL for the LE. Average PTA_2s were 32 dB HL for the RE and 31 dB HL for the LE.

Only 7 of the 122 subjects were hearing aid users. Thus the sample is not representative of individuals who typically seek help from an Audiology Center. It is probably more typical of the elderly population in general. The low prevalence of hearing aid use in the group may be related to at least two factors; first, the relatively mild degree of sensitivity loss characterizing most members of the group, and, second, the fact that subjects were recruited, not from patients being evaluated for hearing aid use, but as volunteers from the population at large.

We did not regard the low prevalence of hearing aid use in our subjects as a limitation of the study, since our purpose was to examine the effects of CAPD and CD on the self-perception of handicap in the unaided condition.

Results of immittance audiometry were within normal limits in 117 of the 122 subjects. For the remaining 5 subjects, immittance results (tympanogram and/or acoustic reflex thresholds) suggested some middle ear abnormality. Conventional manual pure-tone audiometry, however, failed to demonstrate a substantial air-bone gap in any subject.

Materials and Procedures

This project was part of a larger study in which subjects were tested for two consecutive days on a battery of audiologic and neuropsy-

chologic tests. Measures relevant to the present project included pure-tone audiometry, immittance audiometry, speech audiometry, and a questionnaire for the self-assessment of communication handicap.

Conventional pure-tone audiograms by air conduction were obtained on each ear of all subjects at octave frequencies from 250 to 8000 Hz. Immittance testing included tympanograms, static compliance measurement, and both crossed and uncrossed acoustic reflex thresholds (ARTs). For crossed ARTs, test frequencies were 500, 1000, 2000, and 4000 Hz. For uncrossed ARTs, test frequencies were 1000 and 2000 Hz. If immittance audiometry indicated the possibility of middle ear disorder, conventional bone-conduction audiometry was carried out at 500, 1000, 2000, and 4000 Hz. Four speech measures were employed: (1) The phonemically-balanced (PB) word test; (2) the synthetic sentence identification (SSI) test; (3) the speech perception in noise (SPIN) test; and (4) the dichotic sentence identification (DSI) test. The subjects' thresholds for the multitalker babble of the SPIN test were determined for each ear separately. The presentation level for PB, SSI, and SPIN testing was 50 dB above the babble threshold of each ear. Thus, test sensation level was held constant at 50 dB for all monaural test conditions. The DSI test sentences were presented at 50 dB HL unless the subject reported difficulty in hearing the sentences. In that case, the intensity was increased 10 or 20 dB.

The Hearing Handicap Inventory for the Elderly (HHIE), developed by Ventry and Weinstein (1982), was administered to all subjects. The HHIE consists of 25 items designed to measure the self-perceived hearing handicap in elderly subjects. The HHIE contains two subscales: an emotional subscale, measuring the subject's emotional response to his hearing difficulties, and a social/situational subscale, assessing the subject's perceived effects of his hearing difficulties in various communication situations.

All subjects completed the HHIE questionnaire during a break from audiometric testing. The questionnaire was self-administered in a paper-pencil format. Each subject was asked to complete the questionnaire according to its printed instructions. Subjects were required to answer all questions. The HHIE requires the subjects to answer either YES, NO, or SOMETIMES in response to 25 questions. A score of 4 was given for a YES, 2 for a SOMETIMES, and 0 for a NO answer. The scoring system results in a possible outcome between 0 and 100 percent. The higher the score, the greater the self-perceived handicap due to hearing difficulties. Weinstein and Ventry (1983) have reported a cut-off of 18 percent of the HHIE as a significant self-perceived handicap.

The complete neuropsychologic test battery is described in detail in a previous report (Jerger et al, 1989). The test battery included: Minnesota Multiphasic Personality Inventory, Wechsler Adult Intelligence Scale-Revised, Wechsler Memory Scale, Boston Naming Test, Spatial Orientation Memory Test, Buschke Selective Reminding Test, Simple Auditory Reaction Time Test, Simple Visual Reaction Time Test, and the 4-Choice Visual Reaction Time Test. The various standardized tests were administered by an experienced neuropsychologist according to established procedures.

Scoring and Categorization

Speech audiometric results were categorized as either "normal" or "consistent with CAPD," according to the following criteria:

1. The SSI test was scored as abnormal if the difference between the PB score and the SSI score (PB-SSI) exceeded 20 percent on either ear (Jerger and Hayes, 1977).
2. The SPIN test (Kalikow et al, 1977) was scored according to the nomograph supplied with the manual for the revised SPIN test. This nomograph defines a region of normalcy based on the joint outcome of the high- and low-context subtests. The SPIN test result was categorized as abnormal if the subject's position on the nomograph, on either ear, fell two steps below the normal acceptance region. In general this occurred when the high-context score was reduced to a relatively greater extent than the low-context score. The exact cut-off score varied according to basic performance on the low-context items.
3. The DSI test (Fifer et al, 1983) was scored as abnormal if the difference between individual ear scores exceeded 16 percent, provided the PTA_1 was less than 40 dB HL in both ears. If, however, PTA_1 exceeded 40 dB HL in at least one ear, then the criterion of ab-

normality was a difference greater than 37 percent. A third criterion of abnormality was invoked if the best absolute ear score fell below the criterion of individual ear score abnormality specified in Figure 3 of Fifer et al (1983).

Subjects were categorized as CAPD if performance on any one of the three speech measures was abnormal.

The neuropsychologic examination was scored and interpreted, according to established criteria, by an experienced neuropsychologist (FP) who had no knowledge of either the audiologic or medical history. On the basis of the neuropsychologic evaluation, subjects were placed into one of the following categories:

1. Normal
2. Evidence of cerebral dysfunction limited to the right hemisphere.
3. Evidence of cerebral dysfunction limited to the left hemisphere.
4. Evidence of bilateral cerebral dysfunction.

Subjects were categorized as cognitively impaired (i.e., CD) if there was evidence of cerebral dysfunction, either mild or moderate, in one or both hemispheres.

Finally, statistical significance was evaluated at an alpha level of 0.05.

RESULTS

Subjects were categorized according to degree of peripheral hearing loss. Three categories, based on PTA_1, were defined:

1. NO HL, if $PTA_1 < 20$ dB HL in both ears
2. MILD HL, if $PTA_1 < 40$ dB HL in both ears
3. MODERATE HL, if $PTA_1 \geq 40$ dB HL in either ear

CAPD Versus Non-CAPD

Within each hearing loss category we formed two subgroups, one with CAPD and one without CAPD. Table 1 shows the mean age and standard deviation for each of the six groups. Inevitably the groups with some hearing loss are slightly older than the normal hearing group. Within each of the three loss groups, however, average age did not differ by more than 6 years. Figure 1 shows the mean handicap scores, and their standard errors, for HHIE as a function of degree of hearing loss and CAPD status. A two-factor analysis of variance performed on these data revealed that the main effects of degree of hearing loss ($p < 0.001$) and CAPD status ($p = 0.004$) were statistically significant, but that there was no significant interaction between degree of loss and CAPD status ($p = 0.98$). The fact that the main effect for degree of loss was significant is not, of course, surprising. It simply reaffirms that self-assessed handicap scores increase systematically with degree of hearing sensitivity loss (Lutman et al, 1987; High et al, 1964; Speaks et al, 1970; Schow and Tannahill, 1977; Tyler and Smith, 1983). The fact that the main effect for CAPD status was significant, however, sug-

Table 1 Mean Ages and Their Standard Deviations in Subjects with Normal Hearing, Mild and Moderate Hearing Loss as a Function of CAPD Status

		Age	
Group	*N*	*Mean*	*SD*
No HL			
CAPD	10	66	7.4
Non-CAPD	43	65	6.8
Mild HL			
CAPD	37	74	6.2
Non-CAPD	15	72	6.6
Moderate HL			
CAPD	12	76	5.4
Non-CAPD	5	70	4.4

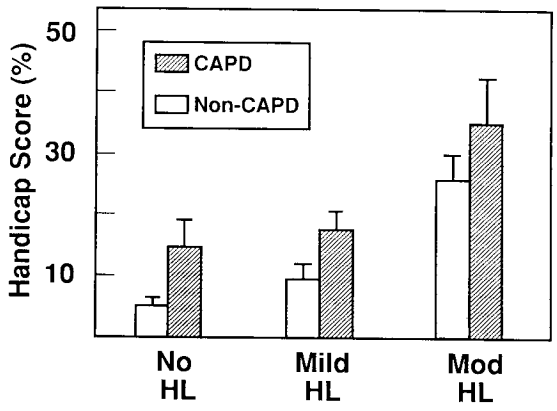

Figure 1 Means and standard errors of handicap scores for HHIE as functions of degree of hearing loss for subjects with and without CAPD.

gests that subjects with symptoms of CAPD rated themselves as more handicapped, on average, than their non-CAPD counterparts. This was true irrespective of degree of hearing loss.

CD Versus Non-CD

For this analysis, we formed two subgroups within each of the three categories of hearing loss, one with cognitive deficit (CD) and one without cognitive deficit (non-CD). Table II shows the mean age and standard deviation for each of the six groups. Within each sensitivity category no mean age difference was greater than 5 years. Figure 2 shows the mean HHIE handicap scores, and their standard errors, as functions of degree of hearing loss and cognitive status. A two-way analysis of variance, performed on these data, revealed that only the main effect of hearing loss was significant ($p < 0.001$). Cognitive status was not statistically significant ($p=0.43$), nor was there a significant interaction between hearing loss and cognitive status ($p=0.18$).

DISCUSSION

The present results suggest that cognitive status does not necessarily affect hearing handicap ratings. Elderly subjects with mild or moderate cognitive deficit did not rate themselves as more hearing-handicapped than elderly subjects with unimpaired cognitive function. The present results do suggest, however, that, in the elderly, central auditory processing disorder may influence the self-assessment of handicap, over and above that explained by peripheral hearing loss. Elderly subjects with symptoms of CAPD rated themselves as more handicapped, on average, than subjects without symptoms of CAPD. This finding demonstrates the importance of CAPD symptomatology in planning intervention strategies for the elderly. If the elderly person's perceived handicap depends solely on the degree of peripheral hearing loss, then the presence of CAPD need not be considered a relevant variable in the total aural rehabilitation program. But, if the perceived handicap is influenced by the presence of CAPD, then it is possible that common intervention strategies, such as conventional hearing aids, may not be ideal. An alternative intervention strategy (e.g., assistive listening device with remote microphone) might be more efficacious.

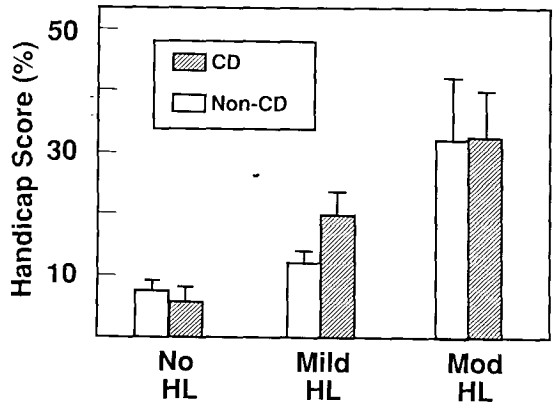

Figure 2 Means and standard errors of handicap scores for HHIE as functions of degree of hearing loss for subjects with and without CD.

Table 2 Mean Ages and Their Standard Deviations in Subjects with Normal Hearing, Mild and Moderate Hearing Loss as a Function of Cognitive Status

		Age	
Group	*N*	*Mean*	*SD*
No HL			
CD	18	66	6.6
Non-CD	35	64	7.0
Mild HL			
CD	23	76	6.0
Non-CD	29	71	6.1
Moderate HL			
CD	8	77	5.1
Non-CD	9	72	5.7

The extent to which the CAPD component does, in fact, impact the use of conventional hearing aids remains controversial. Studies of the extent to which symptoms of CAPD actually influence the elderly subject's rating of successful hearing aid use have yielded conflicting findings. Kricos et al (1987), for example, found no relation between perceived hearing aid benefit and central auditory function. McCandless and Parkin (1979), however, have reported that as site of lesion moves centrally, successful hearing aid use declines. Moreover, Stach et al (1985) reported a longitudinal study of a single elderly subject over a 9-year period. As symptoms of CAPD increased, there was a concomitant decline in the perceived benefit from amplification.

It may be, of course, that perception of hearing handicap and perception of successful

hearing aid use are not necessarily related in the elderly. Thus, when the elderly subject is asked to assess his overall handicap irrespective of hearing aid use, he or she may give considerable weight to the problems generated by the central processing component. When asked to assess successful hearing aid use, however, the subject may give greatest weight to those problems that the hearing aid seems to address most directly.

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REFERENCES

Arnst DJ. (1982). Staggered Spondaic Word Test performance in a group of older adults: a preliminary report. *Ear Hear* 3:118-123.

Bergman M. (1980). *Aging and the perception of speech.* Baltimore, MD:University Park Press.

Bergman M. (1988). Speech discrimination in the elderly. *Adv Audiol* 5:88-97.

Cohen G. (1979). Language comprehension in old age. *Cogn Psychol* 11:412-429.

Davis AC. (1980). Hearing disorders in the population: first phase findings of the MRC National Study of Hearing. In: Lutman ME, Haggard MP, eds. *Hearing science and hearing disorders.* London:Academic Press, 35-60.

Dubno JR, Dirks DD, Morgan DE. (1984). Effects of age and mild hearing loss on speech recognition in noise. *J Acoust Soc Am* 76:87-96.

Fifer RC, Jerger JF, Berlin CI, Tobey EA, Campbell JC. (1983). Development of a dichotic sentence identification test for hearing-impaired adults. *Ear Hear* 4:300-305.

Hayes D. (1984). Hearing problems of aging. In: Jerger J, ed. *Hearing disorders in adults.* San Diego: College-Hill Press, 311-337.

High WS, Fairbanks G, Glorig A. (1964). Scale for self-assessment of hearing handicap. *J Speech Hear Dis* 29:215-230.

Jerger J, Hayes D. (1977). Diagnostic speech audiometer. *Arch Otolaryngol* 103:216-222.

Jerger J, Jerger S, Oliver T, Pirozzollo F. (1989). Speech understanding in the elderly. *Ear Hear* 10:79-89.

Kalikow DN, Stevens KN, Elliott L. (1977). Development of a test of speech intelligibility in noise using sentence materials with controlled word predictability. *J Acoust Soc Am* 61:1337-1351.

Kricos PB, Lesner SA, Sandridge SA, Yanke RB. (1987). Perceived benefits of amplification as a function of central auditory status in the elderly. *Ear Hear* 8:337-342.

Lutman ME, Brown EJ, Coles RRA. (1987). Self-reported disability and handicap in the population in relation to pure-tone threshold, age, sex, and type of hearing loss. *Br J Audiol* 21:45-58.

McCandless GA, Parkin JL. (1979). Hearing aid performance relative to site of lesion. *Otolaryngol Head Neck Surg* 87:871-875.

Orchik DJ, Burgess J. (1977). Synthetic sentence identification as a function of the age of the listener. *J Am Aud Soc* 3:42-46.

Otto VC, McCandless GA. (1982). Aging and auditory site of lesion. *Ear Hear* 3:110-117.

Salomon G. (1986). Hearing problems and the elderly. *Dan Med Bull Suppl* 3.

Schow RL, Tannahill C. (1977). Hearing handicap scores and categories for subjects with normal and impaired hearing sensitivity. *J Am Aud Soc 3*:134-139.

Shirinian MJ, Arnst DJ. (1982). Patterns in the performance-intensity functions for phonetically balanced word lists and synthetic sentences in aged listeners. *Arch Otolaryngol* 108:15-20.

Speaks C, Jerger J, Trammell J. (1970). Measurement of hearing handicap. *J Speech Hear Res* 13:768-776.

Spretnjak ML, Stach BA, Jerger JF. (1988). *The prevalence of central presbyacusis in a clinical population.* Paper presented at the Annual Convention of the Speech, Language and Hearing Association, Boston.

Stach BA, Jerger JF, Fleming KA. (1985). Central presbyacusis: a longitudinal case study. *Ear Hear* 6:304-306.

Tyler RS, Smith PA. (1983). Sentence identification in noise and hearing-handicap questionnaires. *Scand Audiol* 12:285-292.

Uhlmann RF, Larson EB, Koepsell TD. (1986). Hearing impairment and cognitive decline in senile dementia of the alzheimer's type. *J Am Geriat Soc* 34:207-210.

Ventry IM, Weinstein BE. (1982). The hearing handicap inventory for the elderly: a new tool. *Ear Hear* 3:128-134.

Weinstein BE, Ventry IM. (1983). Audiometric correlates of the Hearing Handicap Inventory for the Elderly. *J Speech Hear Dis* 48:379-384.

White K. (1989). Hearing impairment and cognitive decline among aging nursing home patients. *Hear J* 42:17-20.