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The Relationship Between Self-Perceived Benefit as Measured by the APHAB, COSI and CPHI and the Presence of APD in an Elderly Population

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(ABSRTACT)

The self-perceived hearing aid benefit of 38 participants was examined. Of the 38 subjects, 8 were found to have an auditory processing disorder as measured by the Dichotic Sentence Identification (DSI). When compared to the non-APD subjects, there were essentially no significant differences on the APHAB or COSI outcome measures. However, two of the 5 scales of the CHPI did show significant differences. In conclusion, these results do not support the notion of APD having a negative effect on hearing aid benefit. No finding in this study was robust and although there were several trends supporting that APD may impede an individual from receiving their full potential of benefit, this finding is not necessarily so.

INTRODUCTION

It is well known that as individuals age many will exhibit difficulty understanding speech, particularly in background noise. Much of this difficulty can be attributed to peripheral hearing loss. Research studies reviewed by Humes, Christopher and Cokely (1992) suggest that 70-95% of the systematic variance in speech understanding by older individuals can be attributed to differences in peripheral hearing sensitivity. Peripheral hearing loss results from damage to the sensory receptors in the cochlea, the auditory neurons, or any structures involved in the functioning processes of the inner ear (e.g., Gelfand,1997; Humes, 1996; Stach, Loiselle & Jerger, 1991). For individuals with peripheral hearing loss, the use of hearing aids appears to be an efficacious treatment option (e.g., Chmiel & Jerger, 1996; Givens, Arnold & Hume, 1998; Kricos, Lesner, Sandridge & Yanke, 1987). There are older individuals, however, who appear to have limitations in the benefit they receive from hearing aids. One possible explanation for this is that some of these older individuals might exhibit a central hearing loss or an auditory processing disorder (APD). Indeed, Givens, Arnold and Hume (1998) hypothesized that APD is one of two major contributing factors responsible for dissatisfaction with hearing aids among the elderly. The other factor they identified was cognitive dysfunction.

APD results from changes in the structural or functional auditory pathways of the brainstem or the auditory portions of the cortex (e.g., Humes, 1996). The central auditory system is responsible for many functions. Its pathways are the routes by which information presented to each ear is carried to the brain. Furthermore, the central system contributes to functions of the peripheral system, such as frequency and intensity discrimination (Gelfand, 1997). The central auditory system also has a major role in the temporal processing of acoustic stimuli. Since speech cues, such as frequency and intensity, vary rapidly over time, one's temporal processing ability could theoretically be important for speech understanding. Additionally, one's ability to understand a spoken message being conveyed in background noise is dependent on the central auditory system's ability to process the speech signal in the presence of noise (e.g., Baran & Musiek, 1999). As the site of hearing loss moves from peripheral to more central regions, hearing aids become less beneficial (Kricos et al., 1987). That is, hearing aids simply increase audibility and this does not always help individuals who have difficulty with frequency and intensity discrimination, temporal processing or separating speech from noise.

As noted previously, cognitive dysfunction may also play a role in the lack of satisfaction or continued difficulty that older individuals have with hearing aids (Chmiel et al., 1997; Givens et al., 1998; Stach et al., 1991). Kaplan, Sadock and Grubb (1994) define cognition as the process of obtaining, organizing, and using intellectual knowledge. Although, the capacity to learn new information is unaffected by age, the speed of learning does decline with age as do the strategies used for the retrieval of stored information. With increasing age, more time is required for the transmission of sensory information to be processed. However, the acoustic changes, which provide information for understanding speech, occur rapidly in time. (Salthouse, 1994; Wingfield, 1996). Therefore, it is not surprising that cognitive dysfunction may have an effect on the benefit obtained from hearing aids.

In a recent study, Carter, Noe and Wilson (2001) attempted to separate the role of APD from cognitive functioning in the ability of older individuals to use amplification. The subjects in this study appeared to exhibit what has been termed by Jerger, Silman, Lew and Chmiel (1993) as binaural interference (BI). Binaural interference occurs when input to both ears results in poorer speech recognition than input into the better ear alone. It is hypothesized that the interference is likely caused by input to the left ear since the right ear is believed to have an advantage (right-ear advantage; REA) for verbal signals. This is to say that the majority of information coming from right ear goes directly to the left hemisphere, which for the greater part of the population is the hemisphere responsible for processing speech. Although there is a small amount of information that comes from the ipsilateral ear, it is suppressed by the information traveling from the contralateral ear. The information coming from the left ear is delayed since it travels first to the right hemisphere and then crosses the corpus callosum to the left hemisphere (Jerger, Chmiel, Allen & Wilson, 1994).

Carter et al. (2001) evaluated four subjects between the ages of 52 and 79 years old who reported preferring monaural to binaural amplification after a minimum of two years of experience. All participants were required to recall series of digits presented in one of three conditions: free recall (FR), directed-recall left (DR-L) and directed-recall right (DR-R). In the free-recall condition, the listener reports which digit was heard in each ear. In the directed-recall condition pre-cued to the left-ear (DR-L), the listener reports only the digit heard in the left ear and vice versa for the directed-recall condition pre-cued to the right ear (DR-R). The authors reported that decreasing the cognitive load of the task (i.e., changing from the FR condition to DR) did not improve the performance of any of their subjects. That is, performance binaurally or to the left-directed ear was poorer than the right-directed performance. This was interpreted to suggest a primarily central auditory problem, since even binaural performance was worse than performance of the right ear alone. Furthermore, the results suggest that these patients not only lacked a binaural advantage, but the binaural input actually degraded their performance. This could be the reason why some patients reject binaural amplification. Data such as these highlight the importance of considering APD status in hearing aid fittings. In fact, there is controversy in the literature about the benefit that a person with APD can gain through the use of amplification even when fit monaurally.

Support for a negative effect of APD on hearing aid use comes from the work of Chmiel and Jerger (1996). They examined 115 elderly subjects, each of whom was monaurally fit. Subjects were separated into two groups based on their performance on the dichotic sentence identification (DSI) test, an APD group and a non APD group. After six weeks of hearing aid use, the APD patients rated themselves as being significantly more handicapped by their hearing loss on the Hearing Handicap Inventory in the Elderly (HHIE):(Ventry & Weinstein, 1982) than those with only peripheral hearing loss.

Contrary to the results of Chmiel and Jerger (1996), Kricos et al. (1987) did not find a relationship between APD status and hearing aid outcome measures. To determine whether or not a subject had APD, a battery of tests was administered including: 1) performance-intensity functions for NU#6 half word lists, and; 2) the Synthetic Sentence Identification test (SSI) (Speaks & Jerger, 1965). Although 14 out of their 24 older adult subjects were found to exhibit a central component to their hearing loss, there was no relationship between this finding and their self-reported hearing aid benefit as determined by the Hearing Aid Performance Inventory (HAPI) (Walden, Demorest & Hepler, 1984). The authors concluded that questions remained regarding the incidence of APD in the elderly population and its potential effects of APD on the benefit of hearing aids.

Given the controversy in the literature, it appears that further examination of the possible influence of APD on hearing aid outcome measures is warranted. Thus, the purpose of this study was to determine the effect, if any, of APD on several outcome measures, including: 1) the Client Oriented Scale of Improvement (COSI) (Dillion, James & Ginis, 1997); 2) the Communication Profile of Hearing Impaired (CPHI) (Demorest & Erdman, 1987), and; 3) the Abbreviated Profile of Hearing Aid Benefit (APHAB) (Cox & Alexander, 1995).

METHOD

Participants

Thirty-eight veterans currently enrolled in an ongoing research study (protocol #2148) concerning the cost-utility of receiving hearing aids alone or in conjunction with an aural rehabilitation program, at the Department of Veteran Affair Medical Center, Bay Pines, Florida, were recruited to participate in this study. Subjects willing to participate in the current research met the following inclusion criteria: 1) interaural pure tone threshold differences less than 15 dB at 500, 1000 or 2000 Hz; and 2) age-dependent passing score on the Mini Mental Status Exam (Folstein, Folstein & McHugn, 1979); 3) pure tone average greater than 49 dB HL at 500, 1000 and 2000 Hz (Fifer, Jerger, Berlin, Tobey & Campbell, 1983); 2) no active middle ear or outer ear disease; and 3) no known neurological or psychiatric disorders.

All participants were wearing Starkey hearing aids issued to them during the start of their participation in the other research protocol (#2148). Hearing aids were fit utilizing the National Acoustics Laboratory-Revised (NAL-R) prescriptive formula (Bryne & Dillon, 1986). The participants included 22 males and 16 females. The males ranged in age from 60 to 85 years old with a mean age of 75.4 years. The females ranged in age from 66 to 91 years old, with a mean age of 78.7 years.

Diagnostic Groups

Participants were divided into two groups depending on their performance on the Dichotic Sentence Identification (DSI) test (Fifer et al., 1983). The DSI was chosen for its diagnostic utility in measuring a participant's central auditory processing ability. The DSI consists of 30 randomized dichotic presentations of six sentences. The same 30 items are repeated in three conditions: free-recall (FR), directed-recall pre-cued left (DR-L), and directed-recall pre-cued right (DR-R). The participant held a placard displaying the six sentences as a reference for reporting their responses. They were instructed to listen to each dichotic presentation and to repeat back the sentences in either a free-recall or a directed-recall condition. In the free-recall condition, the listener reports which sentence was heard in each ear and to which ear it was presented. In the directed-recall condition pre-cued to the left ear (DR-L) the listener reports only the sentence heard in the left ear. The opposite occurs for the directed-recall condition pre-cued to the right ear (DR-R), such that the listener reports only the sentence heard in the right ear. The sentences were be presented to both ears at a fixed level of 75 dB HL (Strouse, Noe & Wilson, 2000) under ER-3A insert earphones and took approximately 30-45 minutes to administer.

For the purpose of this study, the groups will be referred to as the auditory processing disorder (APD) diagnostic group or the normal diagnostic group. Participants were divided into these groups based on their DSI score. More specifically, subject's with ear difference scores that exceeded 16 %, with a PTA less than 40 dB HL or 37% with a PTA greater than 40 dB HL were categorized as APD (Fifer et al., 1983). The APD group consisted of three females and five males. Seven of the APD participants had received the 4-week post hearing aid fitting aural rehabilitation (AR) therapy and one did not. The normal diagnostic group consisted of 13 females and 17 males. Sixteen of these participants received AR therapy, while 14 did not. The AR program was designed to help patients learn communication strategies and tips for helping them communication more successfully.

Figures 1 and 2 show the mean thresholds at the audiometric frequencies between 250 and 8000 Hz for the APD group and the normal diagnostic groups, respectively. As can be seen, there is essentially no difference between ears within the groups. When comparing figures 1 and 2, the normal diagnostic group had slightly worse thresholds at 2000, 3000, 4000 and 8000 Hz in both the right and the left ears. The biggest difference being 8 dB at 8000 Hz in both ears.

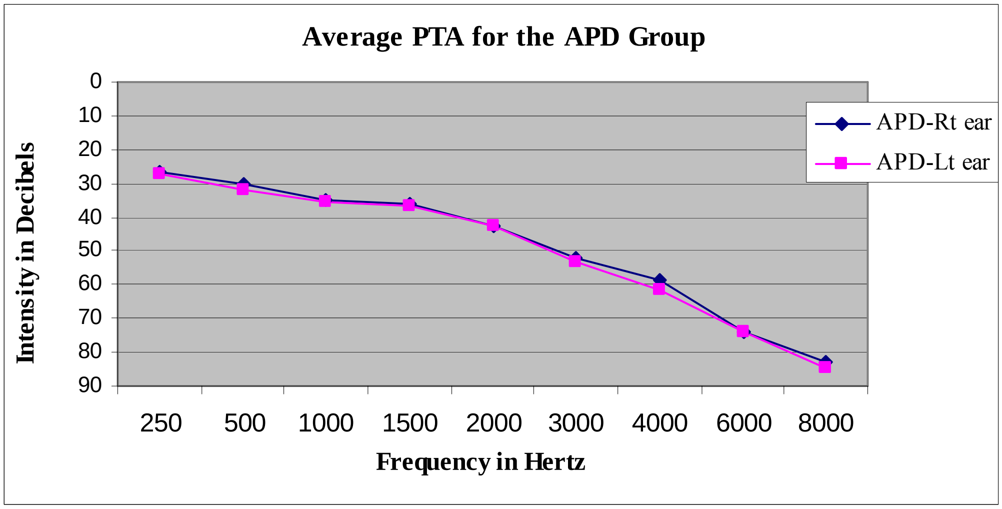

Figure 1. Average PTA for the APD Group.

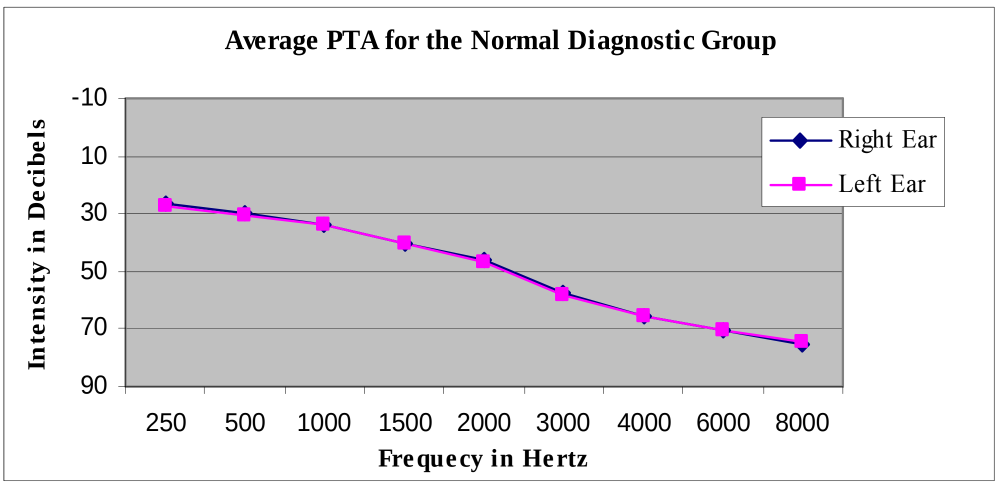

Figure 2. The average PTA for the normal diagnostic group.

Table 1 summarizes other relevant demographic variables for each group. These include age, average root mean square (RMS) differences between the NAL-R target and measured insertion gain, and the maximum output of the hearing aids. RMS differences were calculated for each ear for each participant as recommended by Byrne and Dillon (1986). As can be seen from Table 1, between group t-test comparisons failed to yield differences between the two groups on any of the demographic variables analyzed.

Table 1

Comparison of other relevant characteristics pertaining the participants in both diagnostic groups.

	APD	Normal		
Characteristic	Mean (SD)	Mean (SD)	*t*	*p*
Age	76.87 (8.90)	76.59 (5.62)	0.11	0.91
RMS-Rt ear	5.61 (4.07)	9.12 (7.99)	-0.54	0.59
RMS-Lt ear	5.63 (2.59)	6.02 (5.20)	-0.2	0.84
Output-Rt ear	100.13 (7.61)	99.15 (8.13)	0.3	0.76
Output-Lt ear	102.63 (3.66)	101.19 (8.46)	0.46	0.65

An inspection of the mean RMS data suggests that the normal groups hearing aid settings deviated further from target than the APD group. It should be noted that following the initial fit to target, fine tuning adjustments were completed in accordance with patient subjective responses at follow-up. There was essentially no difference between the overall output of the hearing aids between the APD and normal diagnostic group.

Outcome Measures

The abbreviated profile of hearing aid benefit (APHAB) (Cox & Alexander, 1995). This instrument contains 24 items used to measure self-perceived benefit from hearing aid use. Administration requires 10 minutes or less. Four subscales are obtained: Ease of Communication (EC), Reverberation (RV), Background noise (BN) and Aversiveness of Sounds (AV). For purposes of analysis, the benefit score (i.e., difference between aided and unaided) for each subscale was utilized. In addition, global scores, which are calculated by taking the average of the three communication subscale scores (i.e., EC, RV and BN) were examined. Finally, APHAB results were examined in terms of the number of participants in each diagnostic group who did or did not exhibit “clinical significance” benefit at the 90% confidence interval. For benefit to be considered clinically significant at this level, the “benefit” scores on each of the three communication subscales needs to be five or more points.

The communication profile for the hearing impaired (CPHI) (Demorest & Erdman, 1987). This inventory consists of 145 items, which are divided into 25 subscales. The subscales fall into five primary categories: Communication Importance, Communication Performance, Communication Environment, Communication Strategies, and Personal Adjustment. High scores signify that the patient has little or no problem in the specified area. Low scores indicate that this area is problematic for the patient. The above is true for every subscale with the exception of denial. A high score in this subscale would suggest that the patient has a lot of denial issues concerning their hearing loss. Low score would denote the patient is not in denial. In the analysis, the scores for each subscale, pre- and post- intervention were utilized. Administration of this test is approximately 30-45 minutes.

The client oriented scale of improvement (COSI) (Dillion, James & Ginis, 1997). This self-report scale allows the patient to identify, prior to intervention, 1-5 specific listening situations that they would like to have improved with amplification. Unlike other scales, the COSI allows the participants to decide for themselves their most difficult listening situations. At a later appointment, the participant rates the degree to which amplification resolved their identified problems according to 1) how much better (or worse) they function with their aids in each situation and 2) their final ability to function in that situation from "never" (0%) to "almost always" (95%).

Procedure

Participants who had previously completed or were in the process of concluding research protocol #2148 were contacted via telephone and informed about the current study. Individuals who met subject inclusion criteria and agreed to participate signed an informed consent approved by the Institutional Review Board (IRB) and completed the DSI and APHAB during follow-up visits for research protocol #2148. If time did not permit during those follow-up visits, additional appointments were scheduled. COSI and CPHI data had been obtained during participation in research protocol # 2148.

RESULTS AND DISCUSSION

Benefit obtained from hearing aid intervention was examined using the three outcome measures, APHAB, CPHI and COSI, as a function of diagnostic group and treatment group. Although treatment group, referring to participation in AR, was considered a variable in the initial analyses for each outcome measure, it will be recalled that only one of the eight APD subject did not participate in AR therapy, while almost half (14 of 30) in the normal diagnostic group did not participate in AR therapy. Thus it seemed that examining the interaction between diagnostic group and treatment group was questionable. Thus the data for only those who received AR were examined in additional analyses. Results obtained are presented below as a function of each measure.

Abbreviated Profile of Hearing Aid Benefit (APHAB)

Subscale scores for all participants. The APHAB subscale data were subjected to a repeated measures analysis of variance (ANOVA) with two between group factors (i.e., diagnostic group and treatment group) and one within groups factor (i.e., subscale score). The results are shown in Table 2.

As can be seen, the only significant finding was the main effect of subscale. This finding is not surprising since three subscales (EC, BN and RV) are in the positive direction and one (AV) is in the negative. Neither the main effect of treatment group nor any interactions with treatment group were significant. This suggests that for this group of subjects as a whole, AR treatment did not provide any additional benefits over receiving hearing aids alone. Perhaps the most important result to consider is the interaction between diagnostic group and subscale as illustrated in Figure 3.

Table 2

Analysis of Variance for APHAB Benefit Scores

Source	df	MS	F	P	
Dx Group (G)	1	949.43	1.80	.19	
error	34	527.01			
Tx Group (M)	1	529.27	1.00	.32	
error	34	527.01			
Subscale (S)	3	6334.89	13.76	.00	**
error	102	460.50			
M x G	1	819.88	1.56	.22	
error	34	527.01			
M x S	3	109.38	0.24	.87	
error	102	460.50			
G x S	3	628.98	1.37	.26	
error	102	460.50			
M x G x S	3	107.83	0.23	.87	
error	102	460.50			

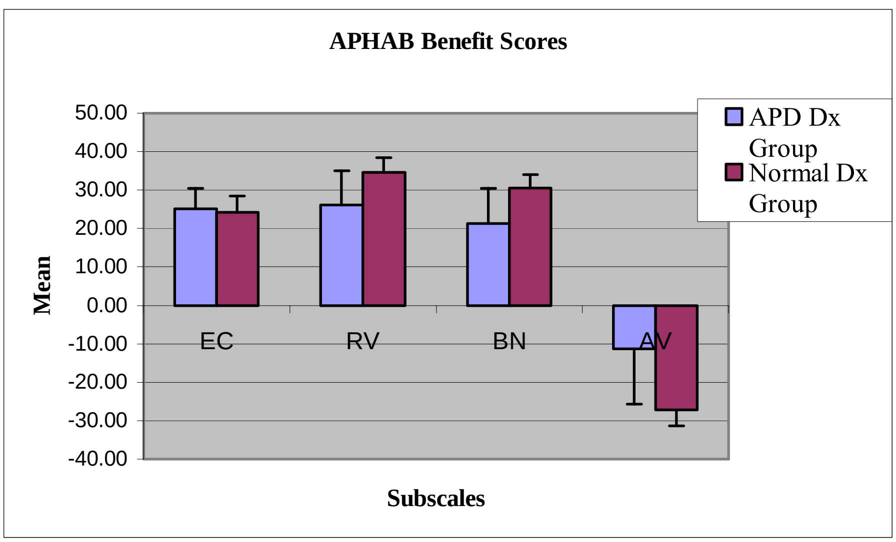

Figure 3: Mean APHAB subscale (+/- 1 SE) as a function of diagnostic group.

Although there were no statistically significant differences as a function of diagnostic group in any APHAB subscale benefit score, visual inspection of Figure 3 suggests that the APD participants perceived less benefit on both the reverberation and background noise subscales. In addition, the APD group appeared to have less of a negative effect in terms of aversiveness of amplified sound. Indeed, the proportion of variance accounted for by diagnostic group is (pv)= .04, which indicates that the interaction effect is "real," but small (Murphy & Myors, 1998). In other words, the small number of participants in this study may have precluded finding a statistically significant results (i.e., or increased the likelihood that a Type II error is being made) (Murphy & Myors, 1998). It is also important to note that the variability in performance for the eight participants with APD was much larger than for the 30 participants with normal auditory processing as indicated by the much larger standard error for the former group.

Subscale scores for AR participants. It is of interest to note that similar results were obtained when examining the results of only those participants who received AR. Table 3 shows the results of the ANOVA when only data for participants who received AR are considered. Mean subscales scores and standard deviations (SD) as a function of diagnostic group are shown in Figure 4.

Table 3

ANOVA for APHAB Benefit Scores for Those Who Received Aural Rehabilitation

Source	df	MS	F	P	
Dx Group (G)	1	49.22	.08	.77	
error	21	594.81			
Subscale (S)	3	9701.43	16.77	.00	**
error	63	577.54			
G x S	3	430.76	.74	.53	
error	63	577.54			

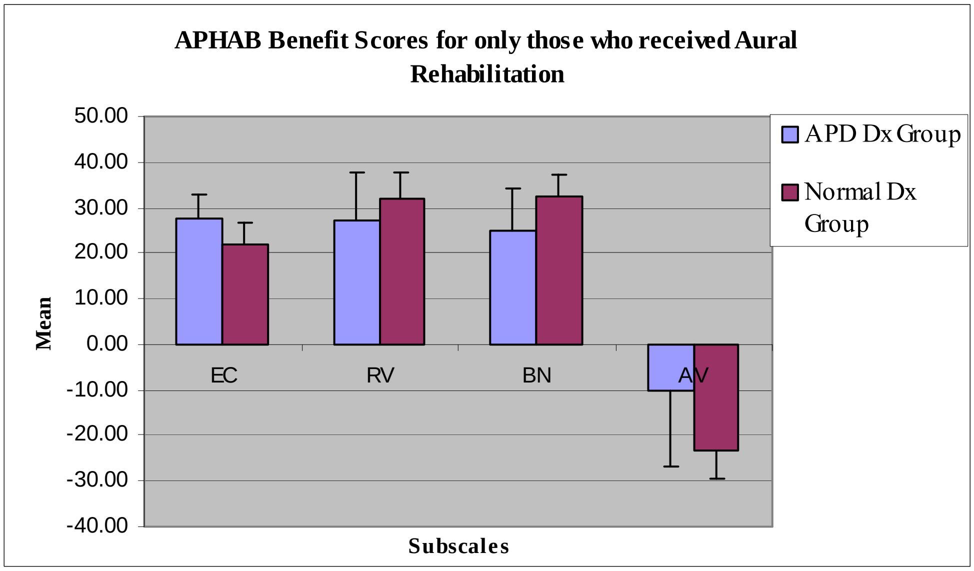

Figure 4: Mean APHAB subscale (+/- 1 SE) as a function of diagnostic group for only those whom were part of the Aural Rehabilitation program.

As in the larger analysis, it can be seen that, on average, APD participants who received AR perceived less benefit on the RV and BN subscales than the normal group. However, they perceived more benefit on the EC subscale. Again, the APD participants appeared to perceive less of a negative effect in terms of aversiveness of amplified sound.

Examination of clinically significant benefit. Another way to examine the APHAB scores is by determining the number of participants in each group demonstrating "clinically significant benefit" which is defined for a 90% confidence interval as an improvement score of 5 or more points on all three communication subscales (EC, RV and BN) (Cox, 1997). Based on this criteria, three of the eith participants with APD, and five of the 30 without APD demonstrated clinically significant benefit. The difference in proportions showing and not showing benefit as a function of diagnostic group was not statistically significant (χ^2 (1) = 1.65, p= .33, Fischer Exact). When only the data for participants who received aural rehabilitation were examined a similar pattern emerged. Two of the seven participants with APD and three of the 16 without APD, failed to demonstrate clinically significant APHAB increase in benefit and the difference in proportions was not statistically significant (χ^2 (1) = .28, p = .49, Fisher Exact).

Global APHAB scores for all participants and AR-only participants. An APHAB "global" score was calculated for each diagnostic group as a whole and for the subset of participants in each diagnostic group who had participated in the AR program. The global score is the average of the three communication subscales (EC, RV, BN). The means and standard errors of the global score are illustrated in Figure 5. While mean global scores were slightly lower for the APD group, the difference in scores for all the participants as a function of diagnostic group (t (36) = .77, p = .45) and for only those receiving aural rehabilitation (t (21) = .26, p = .79) were not significant.

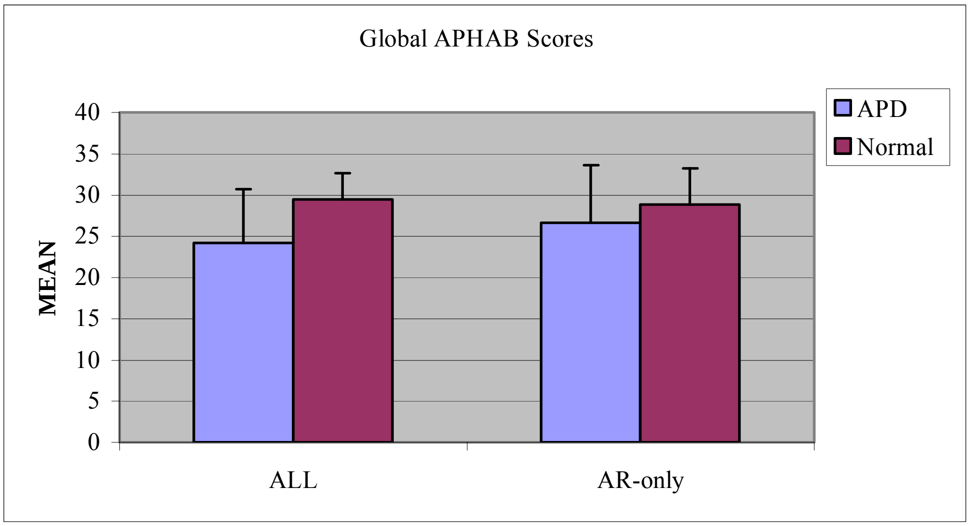

Figure 5: Mean global APHAB scores (=/- 1 SE) for all the subjects and for those who participated in the aural rehabilitation program.

Summary of APHAB outcomes. Statistical analyses failed to support reliable differences as a function of the presence or absence of APD for APHAB outcomes among 1) subscale scores for all subjects; 2) subscale scores for AR only participants; and 3) global APHAB scores for all and for AR only participants.

Communication Profile for the Hearing Impaired (CPHI)

CPHI Outcome for all participants. The CPHI data were calculated for each of the 25 subscale scores for both pre and post treatment, for each participant in each group. These data were subjected to a repeated measures ANOVA with two between groups factor (i.e., diagnostic group and treatment group) and two within groups factor (i.e., test time and subscale). The results are shown in Table 4.

It can be seen that the main effects of time and subscale were significant. However, neither of the group effects (diagnostic group or treatment group) was significant. In terms of the main effect of time, mean scores of all the subscales improved from 3.44 to 3.51, thus supporting the efficacy of hearing aid intervention for all participants. The significant main effect of subscale was not surprising, as it would be highly unlikely that the effects of hearing loss would be consistent across all areas for any subject group. In addition to a lack of finding a significant main effect of treatment group, it is important to note that none of the interactions with treatment group were significant. This suggests that for this group of subjects as a whole, AR treatment did not provide any additional benefits over receiving hearing aids alone as measured by the CPHI.

An important significant interaction that was found is that between test time and subscale scores. This interaction was further examined using the Tukey HSD post-hoc test (Statistica, 1999). Results revealed significant differences at $p < .01$ in mean scores for the subscales illustrated in Figures 6. These differences were seen amongst the subscales in only two primary categories, Communication Performance (CP) and Personal Adjustment (PA). Within these categories, the specific subscales showing significant improvement with intervention included: Social Situations (CP1), At Work (CP2), At Home (CP3), Average Conditions (CP4), Adverse Conditions (CP5), Self-Acceptance (PA1), Acceptance of Loss (PA2), Discouragement (PA6), Stress (PA7), and Withdrawal (PA8). The mean score for Denial (PA9) decreased, which is a positive finding. These findings are perhaps not surprising as previous studies have shown benefits of hearing aid intervention in terms of improvement in psycho-social and emotional functioning (e.g., Weinstein, 2000) and self-reported communication performance (see, for example, Mulrow et al., 1990).

Table 4

Analysis of Variance for CPHI Scores

Source	Df	MS	F	p	
Dx Group (G)	1	.34	.12	.73	
error	34	2.82	.21		
Tx Group (M)	1	.59	.21	.65	
error	34	2.81			
Time (T)	1	17.83	20.25	.00	**
error	34	.88			
Subscale (S)	24	3.73	5.48	.00	**
error	816	.68			
M x G	1	4.09	1.45	.24	
error	34	2.81			
M x T	1	.00	.00	.97	
error	34	.88			
G x T	1	.04	.04	.84	
error	34	.88			
M x S	24	.59	.87	.65	
error	816	.68			
G x S	24	.27	.40	.99	
error	816	.68			
T x S	24	1.71	7.14	.00	**
error	816	.24			
M x G x T	1	.33	.37	.55	
error	34	.88			
M x G x S	24	.66	.97	.51	
error	816	.68			
M x T x S	24	.28	1.17	.26	
error	816	.24			
G x T x S	24	.68	2.83	.00	**
error	816	.24			
M x G x T x S	24	.31	1.30	.15	
error	816	.24			

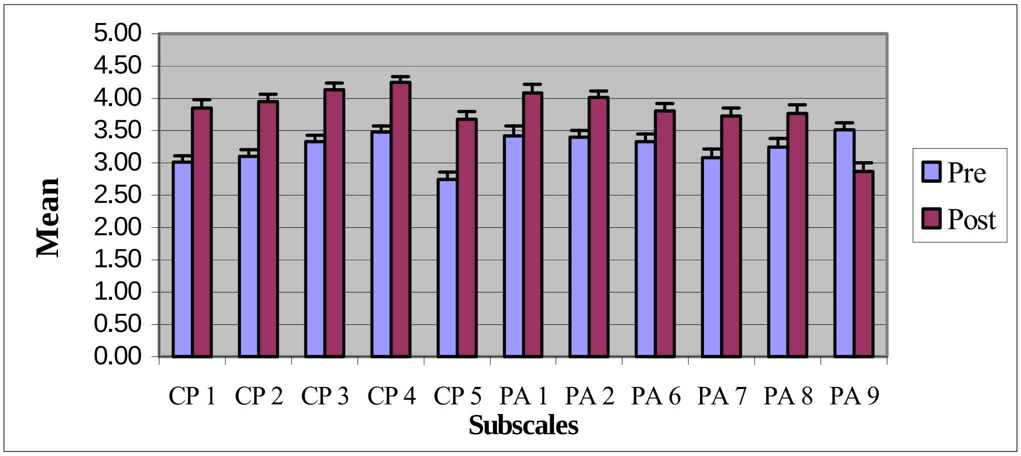

Figure 6: Mean scores (+/- 1 SE) for all subjects on the CPHI subscales showing a significant difference between pre and post test.

As noted, the differences pre and post treatment among any of the Communication Importance or Environment subscales were not significant. This finding is not surprising, as hearing aids do not alter the environment per se. Further, it is likely to be the case that individuals who choose to pursue hearing aid intervention would be likely to place a high level of importance on communication. Perhaps disappointing, however, is the finding that although many of the subjects (n=23) participated in an aural rehabilitation program no difference was shown in use of Communication Strategy subscales either overall or as a function of treatment group.

For the purposes of this investigation perhaps the most important finding to consider is the significant interaction between diagnostic group, time, and subscale. Figures 7 and 8 show the mean change scores for each diagnostic group (+/- 1 SE) for each of the subscales demonstrating significant overall improvement as a function of time (see, also, Figure 9). It can be seen that mean difference scores for the APD subjects were higher than for the normal diagnostic group for Communication Performance in Social Situations (CP 1), At Work (CP 2), and in Adverse Conditions (CP 5) and essentially equal for Communication Performance At Home (CP 3) and in Average Conditions (CP 4). The biggest differences were in the subscales CP 2 and CP 5. The fact that At Work (CP 2) showed a large difference is an interesting finding since most of the participants were reportedly no longer working. Upon a closer examination of the questions used to

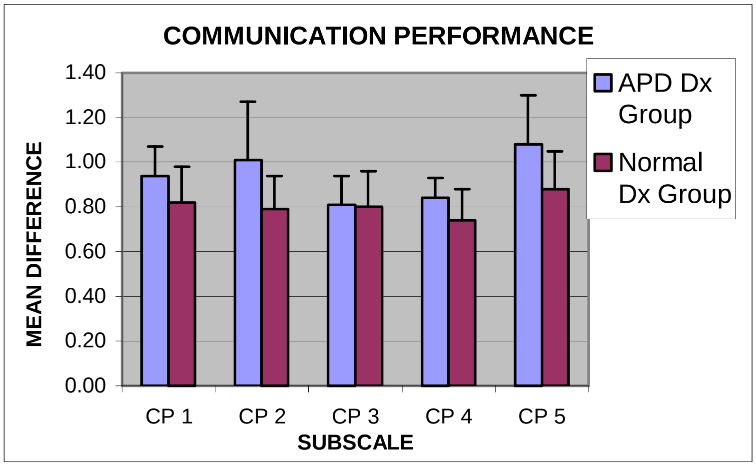

Figure 7: Mean difference scores from Pre- to Post-testing (+/- 1 SE) in the category of Communication Performance. Subscales revealing significant differences include: Social Situations (CP 1), At Work (CP 2) and Adverse Conditions (CP5).

comprise the CP 2 subscales, only one of the questions specifically states "at work", the others deal with issues that can occur in an office or anywhere when trying to get instructions to perform a task, which retired individuals can encounter, considering that many of the participants perform volunteer work or are active in social and community organizations. Perhaps this accounts for the finding.

The Adverse Conditions (CP 5) subscale shows a large mean difference, with APD subjects indicating more improvement than the normal diagnostic group. This finding can also be interpreted to mean that the APD subjects were communicating better the normal group since the pre test mean for the APD group was 2.70 and increased to 3.78, while the normal group had a pre test mean of 2.76 and increased only to 3.64 (see Appendix A). This finding suggests that the APD group received a greater improvement in listening in adverse conditions than the subjects without APD. This result seems somewhat inconsistent with the APHAB finding for the BN and RV subscales. Recall that for these subscales on the APHAB, the mean scores for the normal diagnostic group were higher than for the APD group. The CPHI incorporates concepts such as distance and performing a task while another person is trying to communicate with you. For example, one question asks the listener to rate their ability when, "you're at a social gathering with music or other noise in the background." The BN subscale of the APHAB is geared more towards multi-talker babble. For example, a question from the BN subscale is, "I can understand conversations even when several people are talking". Further, the RV subscale of the APHAB asks questions such as, "I have trouble understanding dialogue in a movie or at the theater". The difference in findings between the two instruments may be attributed to the wording of the questions.

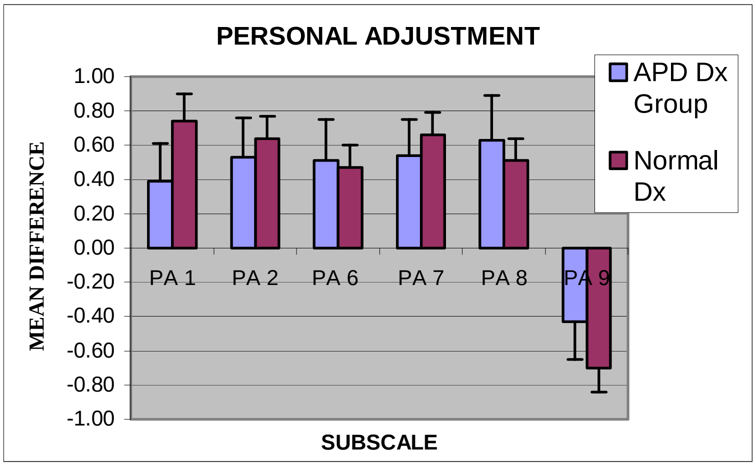

Figure 9: Mean difference scores from Pre- to Post-testing in the scale of Personal Adjustment. Subscales include: Self-Acceptance (PA 1), Acceptance of Loss (PA 2), Discouragement (PA 6), Stress (PA 7), Withdrawal (PA 8), and Denial (PA 9).

Figure 9 illustrates the mean difference scores for the Personal Adjustment subscale. The mean difference scores were better for the normal diagnostic group in the PA subscale of Self-Acceptance (PA 1), and Denial (PA 9). This finding could be due to the observation that even with amplification, APD listeners appear to be having more difficulty understanding speech, as indicated by their lower mean APHAB scores for reverberation and background noise. However, it should be noted that the post test means for this subscale were very similar between the two groups, with 4.09 for the normal group and the 4.04 for the APD group, indicating essentially equivalent attitudes in this subscale.

The mean scores for the Denial (PA 9) subscale show the normal group had greater issue with denial regarding their hearing prior to receiving hearing aids. The pre test mean for the normal group was 3.55 and 3.36 for the APD group. However, the post test means proved the normal group to be in less denial (2.86) as compared to the APD group (2.94).

The APD group mean difference scores showed more improvement in the Withdrawal (PA 8) subscale. This finding that the APD participants had greater improvement may be attributed to fact that all but one of the APD subjects received aural rehabilitation therapy while only approximately half of the normal diagnostic group did.

While it is difficult to interpret this complex pattern of results, the findings do suggest that the APD and normal diagnostic groups can both benefit from the use of hearing aids. Although there are likely to be some individual differences in both groups, the overall benefit is apparent.

<u>CPHI scores for only the AR participants.</u> Due to the fact that some subjects received aural rehabilitation therapy while others did not, it is important to interpret the data examining the effects of aural rehabilitation. Again seven of the eight APD participants received the four-week post hearing aid fitting AR therapy, while only 16 of the 30 normal diagnostic group participants did. Thus, Table 5 shows the CPHI data for only the AR participants. The most important finding is that the interaction between diagnostic group, time and subscale remained significant. Thus differences between the diagnostic groups in the main analysis are most likely not due to participation in the aural rehabilitation program.

First consider the significant interaction between time and subscale. Table 6 summarizes the subscales where there was a statistically significant (as denoted by "**") interaction between time and subscale for the group as a whole and for only those who received aural rehabilitation. As can be seen, all but two of the subscales as a function of time remained significant when the aural rehabilitation subjects were examined alone. These subscales were Self-Acceptance (PA1) and Discouragement (PA 6). When data for all participants were considered, the mean score for Self-Acceptance (PA 1) increased from 3.50 to 4.07 and for Discouragement (PA 6) from 3.29 to 3.77. For the AR participants, PA 1 increased from 3.54 to 4.10, while PA 6 increased from 3.31 to 3.87 (see Appendix B). Thus, there were increases in scores, even though not statistically significant, for these two subscales for the AR only participants. The fact that these subscales failed to reach significance is most likely due to a lack of adequate power, as there were fewer participants who received aural rehabilitation therapy.

Table 5

ANOVA for CPHI of Only Those Participants Who Received Aural Rehabilitation Therapy.

Source	df	MS	F	P	
Dx Group (G)	1	10.52	3.70	.07	
Error	21	2.85			
Time (T)	1	28.12	29.78	.00	**
Error	21	0.94			
Subscale (S)	24	6.36	9.03	.00	**
Error	504	0.70			
G x T	1	0.23	0.24	.63	
Error	21	0.94			
G x S	24	0.50	0.71	.84	
Error	504	0.70			
T x S	24	1.65	6.85	.00	**
Error	504	0.24			
G x T x S	24	0.41	1.72	.02	**
Error	504	0.24			

Table 6.

Subscales Showing Statistically Significant Interactions Between Time and Subscale

	Significant interaction between time and subscale	
Subscale	All Subjects	AR-only
CP 1	**	**
CP 2	**	**
CP 3	**	**
CP 4	**	**
CP 5	**	**
PA 1	**	
PA 2	**	**
PA 6	**	
PA 7	**	**
PA 8	**	**
PA 9	**	**

As with the analyses for the participants as a whole, perhaps the most important finding is the significant three-way interaction between diagnostic group, time and subscale. The subscales that showed significant improvement from pre to post test for all of the AR participants can be further examined through visual inspection of Figure 10. It can be seen that the APD subjects who received aural rehabilitation therapy showed more improvement in the subscales of Communication Performance in Social Situations (CP 1), At Work (CP 2) and in Adverse Conditions (CP 5). Closer examination of these subscales shows that when compared to the APD subjects as a whole (refer to Figure 7), the results are essentially the same. This finding seems understandable since only one APD subject did not receive AR therapy.

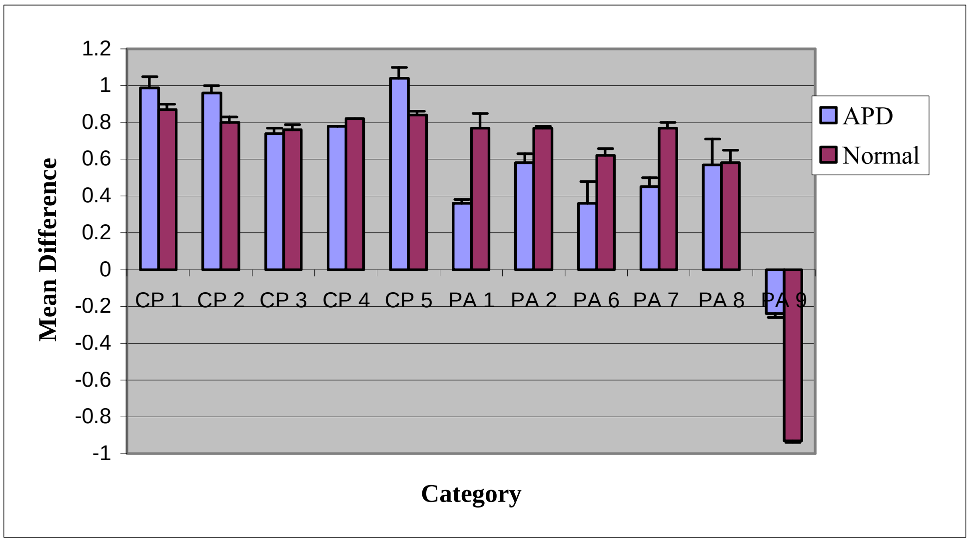

Figure 10. Mean difference scores (+/- 1 SE) on the CPHI subscales when examining only those participants whom received AR.

The normal diagnostic group showed more improvement in the Personal Adjustment subscales of Self-Acceptance (PA 1), Acceptance of Loss (PA 2), Discouragement (PA 6), Stress (PA 7) and Denial (PA 9). Compare to Figure 8, in which the normal subjects were analyzed as a whole, the AR subjects showed more improvement in the subscales of Acceptance of Loss (PA 2), Discouragement (PA 6) and Stress (PA 7). The PA 2 subscale improved from 3.39 to 4.16 for the AR-only subjects and from 3.41 to 4.06 for the normal subjects as a whole. A similar finding was seen for the Discouragement (PA 6) subscale in which the APD group's score increased from 3.41 to 4.03 and the normal group as a whole improved from only 3.37 to 3.83 and for the stress subscale (PA 7) which increased from 3.22 to 3.99 for the APD participants and

3.09 to 3.76 for the entire normal diagnostic group. The AR participants started with similar feelings of discouragement and stress than their non-AR counterparts. However, those that did receive AR appear to have come to terms with these issues more so than those who did not receive AR therapy, demonstrating the efficacy of aural rehabilitation for any individual with hearing loss.

Summary of CPHI outcomes. Analysis of the CPHI data showed statistically significant results for 11 of the 25 subscales. Only subscales of the Communication Performance (CP) and the Personal Adjustment (PA) scales showed significant improvement with hearing aid intervention. Overall, these findings support the efficacy of hearing aid intervention whether or not an individual exhibits signs of APD or not since all subjects improved. Interestingly, however, is the finding that the post intervention scores for the CP scale showed very mixed results between the two groups. On the other hand, when the PA scales were examined by mean scores, the normal diagnostic group showed much greater improvement over that of the APD subjects. Perhaps this difference could be attributed to the aspect of "functioning" that is being examined. The CP scale is a measure of disability, while the PA scale is a measure of handicap.

Client Oriented Scale of Improvement (COSI)

Finally, the COSI data were analyzed. Recall that prior to receiving amplification, each participant identified 3-5 specific listening situations that they had difficulty communicating in and wanted to have improved with the use of amplification. Table 7 shows the number of subjects in each diagnostic group who had a problem in each category regardless of whether it was identified as the first, second or third problem. It can be seen that the most common categories to which "problems" were assigned, were number 5 (listening to television/Radio at normal volume), followed by number 1 (conversations with one or two in quiet). This was true for both diagnostic groups.

Table 7

The Number of Subjects in Each Diagnostic Group Who Had a Problem in Each Category.

	COSI CATEGORY															
Ss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
APD	6	2	1	1	6	1	0	0	0	0	0	0	0	0	4	0
Normal	20	12	5	7	23	8	1	0	0	0	0	0	0	0	10	3
Total	26	14	6	8	29	9	1	0	0	0	0	0	0	0	14	3

It is of interest to note that many categories were not selected at all, more specifically, categories 8-14. Figure 11, presented below, shows mean reported final ability for each category as a function of diagnostic group.

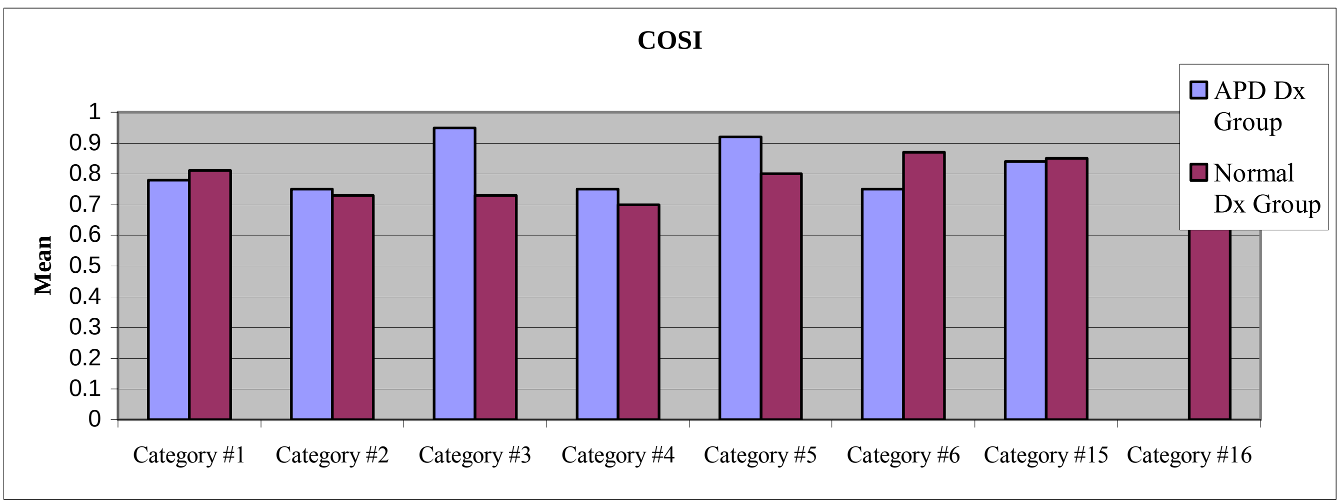

Figure 11: Mean reported final ability for those categories reported to be a problem area. Missing categories were eliminated since no patients listed them as a problem area. Conversations with 1 or 2 in quiet (Category #1), Conversations with 1 or 2 in noise (Category # 2), Conversations with group in quiet (Category # 3), Conversations with group in noise (Category # 4), Television/Radio @ normal volume (Category # 5), Familiar speaker on phone (Category # 6), Church or meeting (Category # 15) and Other (Category # 16).

The majority (7 of 8) of categories selected by participants in the Normal group were also selected by those in the APD group. It should be noted that for four of the categories, results are based on only one subject's response (e.g., 3, 4, 6, 7). Visual inspection of Figure 11, for example, shows the APD group rated themselves as having received higher benefit in category 3 (conversations with groups in quiet); however these results are deceiving since it is based on only one subject. The same can be seen for category 6 (familiar speaker on phone), in which the normal diagnostic group appears to have received higher benefit. The available data for each category were subjected to an independent t-tests which revealed no statistically significant group differences. Thus the APD subjects self-reported final functioning ability with hearing aids appears essentially equivalent to that of non-APD individuals.

Summary of COSI outcomes. In summary, hearing aid outcomes as measured by the COSI showed very little difference between the APD group and the normal diagnostic group.

Overall summary of results. In summary, the effect of APD on the three outcome measures used in this study were:

1. APHAB: APD subjects received less benefit, but none statistically significant, on the RV and BN subscales; however they reported having less aversiveness to amplified sounds then the normal diagnostic group.
2. CPHI: Results suggest that the APD subjects showed greater improvement that the normal subjects in the subscales of Communication Performance in Social Situations (CP 1), At Work (CP 2) and in Adverse Conditions (CP 5) and Withdrawal (PA 8).
3. COSI: The final functioning ability of all the subjects was essentially equivalent regardless of diagnostic group.

In conclusion, these results do not support the notion of APD having a negative effect on hearing aid benefit. No finding in this study was robust and although there were several trends supporting that APD may impede an individual from receiving their full potential of benefit, this finding is not necessarily so. The subjects in both diagnostic groups showed improvement even if the differences were not statistically significant. Therefore the results support the efficacy of hearing aid intervention regardless of whether an individual has APD or not. Caution must be taken with this interpretation, however, due to the small number of participants and the high variability among those with APD. Had more subjects been recruited, the trends may have been more apparent.

SUMMARY AND CONCLUSIONS

The purpose of this study was to examine the possible influences of APD on hearing aid outcome measures since this has been an issue in the literature. The data of this current study failed to find a statistically significant effect of APD on the APHAB or COSI. The results of these two measures are consistent with those of Kricos et al. (1987) but differ from the results of Chmiel and Jerger (1996).

There are several possible reasons to account for these conflicting results. One explanation being that the present study examined a total of 38 participants, eight of whom were determined to have APD. Chmiel and Jerger (1996) investigated 115 individuals, 33 of which were classified as APD according to their Dichotic Sentence Identification (DSI) scores. It seems reasonable to assume that had more subjects been recruited, the results of this study may have become significant. However, since the study is underpowered, enough information could not be obtained to rightfully reject the null hypothesis, which lends itself to make a type II error.

There seems to be some indication that patients with APD do not do as well on some outcome measures as they did on others. As was eluded to earlier, perhaps the aspect of functioning being measured is the key factor when looking for benefit. For example, when examining disability (i.e., what a person can and cannot do) as the CP scale of the CPHI does, there are no differences in outcomes between the APD and non-APD subjects. This finding is consistent with Kricos et al. (1987) who had similar findings. They used the HAPI outcome measure, which also measures disability. If however, handicap or the psychosocial aspects of hearing impairment are being examined, as the PA scale of the CPHI does, then those without APD have better outcomes then those with APD. This finding is consistent with Chmiel and Jerger (1996) who used the handicap measure, HHIE to determine their subjects outcomes. In general, there does not appear to be an effect of APD in terms of self-reported disability, that is communication abilities. However, there does appear to be an effect in terms of self-reported handicap, which are the social and cultural consequences of hearing loss.

Clinically, the findings of this study do not warrant the necessity of adding APD tests to the traditional diagnostic battery. Clearly these results do not address whether binaural or monaural amplification is more appropriate for individuals with APD. More research is needed on this topic.

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APPENDIX A. CPHI Mean Raw Data For All Participants

Subscale	Normal PRE	Normal POST	APD PRE	APD POST
CP 1	3.02	3.84	2.94	3.88
CP 2	3.14	3.93	2.93	4.00
CP 3	3.35	4.14	3.29	4.10
CP 4	3.51	4.25	3.35	4.19
CP 5	2.76	3.64	2.70	3.78
CP 6	4.12	3.53	3.88	3.68
CE 1	2.52	2.49	2.98	2.29
CE 2	3.11	3.34	3.58	2.73
CE 3	3.67	4.19	3.75	3.83
CE 4	3.63	4.03	3.95	3.84
CS 1	3.90	4.39	4.09	4.34
CS 2	3.00	2.84	2.44	2.93
CS 3	3.73	3.61	3.09	3.76
PA 1	3.35	4.09	3.65	4.04
PA 2	3.41	4.06	3.33	3.85
PA 3	3.22	3.70	3.06	3.20
PA 4	3.06	3.13	2.70	2.63
PA 5	2.82	3.16	2.81	3.15
PA 6	3.37	3.83	3.20	3.71
PA 7	3.09	3.76	3.05	3.59
PA 8	3.26	3.77	3.15	3.78
PA 9	3.55	2.86	3.36	2.94

APPENDIX B. CPHI Mean Raw Data For Only AR Participants

	Normal		APD	
Subscale	PRE	POST	PRE	POST
CP 1	3.03	3.90	2.90	3.89
CP 2	3.13	3.93	3.01	3.97
CP 3	3.41	4.17	3.33	4.07
CP 4	3.48	4.30	3.36	4.14
CP 5	2.82	3.66	2.76	3.80
CP 6	4.04	3.46	3.87	3.71
CE 1	2.64	2.76	2.94	2.47
CE 2	3.23	3.56	3.57	2.83
CE 3	3.76	4.33	3.74	3.97
CE 4	3.62	4.12	3.96	3.94
CS 1	4.01	4.52	4.10	4.39
CS 2	3.05	2.83	2.44	2.70
CS 3	3.53	4.30	3.04	3.66
PA 1	3.53	4.30	3.54	3.90
PA 2	3.39	4.16	3.23	3.81
PA 3	3.25	3.79	3.03	3.11
PA 4	3.09	3.08	2.54	2.46
PA 5	2.82	3.39	2.76	3.00
PA 6	3.41	4.03	3.20	3.56
PA 7	3.22	3.99	2.99	3.44
PA 8	3.46	4.04	3.13	3.70
PA 9	3.49	2.56	3.37	3.13

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