Reduction in Caregiver-Identified Problem Behaviors in Patients With Alzheimer Disease Post-Hearing-Aid Fitting

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Studies and clinical procedures related to patients with Alzheimer disease (AD) largely have ignored the hearing ability of either the patient or caregiver. Yet the majority of treatment and investigation depends on or presupposes communication ability. Further, caregiver complaints often center around communication-based issues. Hearing deficits may be the most frequently unrecognized condition in patients with AD because patients either communicate adequately in quiet or the impairment is masked by other behavioral symptoms of AD. The current investigation identified individuals with AD with perceived and measured hearing impairment, provided amplification management, and evaluated the impact of treatment on caregiver-identified problem behaviors believed to be related to hearing status. Specifically, treatment compliance (hearing-aid use) and treatment efficacy (reduction in perceived hearing handicap and problem behaviors) were measured in the current investigation. A multiple-baseline design across individuals with multiple dependent variables was used to evaluate the reduction of problem behaviors post-hearing-aid treatment. Eight participants were included and 1 to 4 problem behaviors were significantly reduced for each patient after hearing-aid treatment. All participants were able to complete the necessary evaluation for hearing-aid fitting and wore their hearing aids between 5 and 15 hours per day by the end of the study. This investigation employed novel methodology in the areas of on-site hearing evaluation and hearing-aid selection, advanced hearing-aid technology, and primary data recording of caregiver-identified problem behaviors by caregivers.

KEY WORDS: problem behaviors, Alzheimer disease, hearing aids, caregivers

D iseases can interact to make a pair of diseases much more disabling than either one would be alone, and this may be the relationship between Alzheimer disease (AD) and hearing impairment associated with aging. Unmanaged hearing loss will most likely interrupt the processing of spoken messages regardless of other pre- or co-existing conditions. Therefore, one must consider hearing management in the patient with hearing loss and AD.

The auditory systems of patients with AD have been studied in order to identify any differences in these patients compared with aging peers. There do not appear to be physiological abnormalities of the peripheral,

subcortical, or primary cortical pathways, as measured by evoked potentials (Grimes, Grady, & Pikus, 1987). Some authors have suggested that the long-latency potentials (e.g., P300) demonstrate abnormalities associated with the disease (e.g., Fenton, 1986). These later potentials are believed to be more cognitively based than the short-latency potentials. Strouse, Hall, and Burger (1995) found that although 10 AD patients performed similarly to matched individuals on peripheral hearing tasks, the AD patients performed significantly worse on four of five central auditory tests. Sinha, Hollen, Rodriquez, and Miller (1993) reported a consistent pattern of deterioration in the central auditory nuclei of the auditory system. This is in contrast to degeneration generally seen peripherally in the cochlea or auditory nerves in typically aging adults who demonstrate high-frequency hearing sensitivity loss. Even if there are central difficulties, the patient must have an audible signal before the central system makes use of the signal.

Patients with AD traditionally have been considered difficult or impossible to test. At least two studies related to hearing evaluation do not support this belief. Uhlmann, Rees, Psaty, and Duckert (1989) used an audiometric screening of 40 dB HL with 34 demented and 31 nondemented individuals and found them to produce reliable (repeatable) hearing thresholds. Durrant, Gilmartin, Holland, Kamerer, and Newall (1991) performed full audiometric test batteries on 10 patients with AD without notable difficulty. The same hearing evaluation methods used for normal functioning adults could be employed with aging adults with AD. In addition, both groups exhibited comparable pure tone thresholds. Although some patients with AD complained about being tested, at most they required reinstruction, encouragement, and gentle prodding. Much of the hearing test battery is based on repeating what is heard, and the AD patients did not have difficulty with this type of task. Repetition of auditory stimuli has been reported as an easy task for AD patients previously (Holland, Boller, & Bourgeois, 1986). The ability to reliably evaluate hearing sensitivity in this group is essential before hearing management can be realistically considered.

The incidence of hearing loss among aging individuals with organic mental syndromes is generally twice as frequent as among aging individuals with normal mental capacity (Hodkinson, 1973; Kay, Beamish, & Roth, 1964; Uhlmann, Larson, Rees, Koepsell, & Duckert, 1989). Uhlmann and colleagues (1989) found that hearing sensitivity was correlated with severity of cognitive dysfunction and therefore concluded that unmanaged hearing loss contributed to cognitive decline. These data support the notion that a large percentage of patients with AD seeking health care are experiencing communication difficulties that are related to hearing loss as well as to the primary disease itself.

Peters, Potter, and Scholer (1988) followed individuals with dementia (various etiologies, including one group with AD) with and without hearing loss. The authors reported a decline in cognitive function at follow-up in the group with unmanaged hearing loss. Although hearing loss is continually reported in the AD population, studies regarding management of the loss have not been reported.

The similarities between the psycho-social literature describing the impact of hearing impairment on life activities and reactions, and the literature describing the impact of AD, are notable. There is no doubt that the Alzheimer disease process gravely impacts communication. Hearing loss may exaggerate these communication difficulties. Among individuals without dementia, hearing loss has been attributed to eliciting feelings of helplessness, depression, passivity, and negativism (Herbst & Humphrey, 1980; Weinstein & Ventry, 1982). Among individuals with dementia of various etiologies, hearing loss has been associated with an accelerated and rapid cognitive decline (Peters, et al. 1988; Uhlmann, Larson, & Koepsell, 1986; Uhlmann, Larson, et al., 1989). Hearing loss may appear to contribute to cognitive dysfunction indirectly through associated social isolation (Norris & Cunningham, 1981; Thomas, 1981; Weinstein & Ventry, 1982), disorientation (Ohta, Carlin, & Harmon, 1981), and depression (Eastwood, Corbin, & Reed, 1985; Herbst & Humphrey, 1980; Jones, Victor, & Vetter, 1984; Thomas & Herbst, 1980). Birren (1964) notes that the loss of auditory contact may actually adversely affect an individual's ability to adjust to all life situations. The individual's sensory environment is being changed, and normal interpersonal relations as well as social contacts may change drastically.

Considering these psycho-social consequences of hearing loss, Mulrow, et al. (1990) investigated quality of life changes as a function of amplification use by a group of aging adults with significant hearing loss. Individuals who were matched on the basis of hearing thresholds either received a hearing aid or were put on a waiting list for the duration of the 4-month study. At the 6-week follow-up, significant change in social and emotional function, as measured by the Hearing Handicap Inventory for the Elderly (Ventry & Weinstein, 1982), was documented, as were significant changes in communication function, cognitive function, and depression. Although this population is not the same as an AD patient population, the final results and time line for significant change are very encouraging.

The sensory deficits associated with hearing loss in patients with AD may be related to a variety of problem behaviors, such as repetitive questioning, arguments, and activity disturbances. It is likely that undetected/unmanaged hearing loss could aggravate any of these reported conditions and that management of hearing

loss might alleviate some of the difficulty directly related to communication. An alleviation of problem behaviors would be viewed positively for both the caregiver and the patient with AD; therefore, reduction of problem behaviors may be a useful outcome measure for any treatment a patient with AD might receive, including hearing-loss management through amplification.

Bourgeois, Burgio, and Schulz (1992) reported preliminary findings for a group of spouse caregivers of AD patients who were counting problem behaviors while undergoing one of three treatments (behavior management training, self-management training, or support). These data revealed that caregivers are able to identify problem behaviors in their spouses with AD and count them reliably. Also, the authors ranked the problem behaviors that have been identified to date, and it is evident that 50% of the top 10 problem behaviors potentially can be linked to hearing ability.

Currently, there are data illustrating a high incidence of hearing loss in the AD population. In addition, there are some data indicating overlapping communication difficulties (e.g., asking for repetition, searching, forgetting) that may be caused by AD, hearing loss, or a combination of these conditions. The current literature indicates that hearing status in AD patients can be documented accurately. However, Durrant et al. (1991) reported that 1 out of 10 AD patients with hearing loss had hearing aids, whereas 6 out of 10 hearing-loss matched individuals used amplification, although self-perceived hearing handicap was very similar in both groups. Nevertheless, there is a paucity of empirical data and/or clinical reports related to the management of hearing loss in this population. For the aging patient with AD, there appear to be several major barriers to hearing impairment management: lack of medical referral, belief that testing is difficult, lack of efficacy data, use of inappropriate technology, and lack of access to ongoing care. This investigation was developed in order to quantify the impact of managing hearing loss through the provision of hearing aids in individuals with AD. Data collected were treatment compliance (number of hours of hearing-aid use) and reduction of the rate of problem behaviors, as reported by the caregivers of these individuals. Such data may provide methods for collection of efficacy data, which in turn could impact medical referral. Audiologists may be more willing to provide accessible care, and patients and their families may be motivated to access care, if the use of hearing aids decreases the rate of problem behaviors.

Design and Method
Design

A multiple-baseline design across individuals with multiple dependent variables was used to evaluate the effects of hearing-aid intervention on the problem behaviors of individuals with AD and hearing loss. This is a pre/post-treatment design with differential lengths of baseline and treatment phases (McReynolds & Kearns, 1983). Differential phase length allows the demonstration that the behavior does not change with the passage of time, but only changes at the point of intervention. During baseline, caregivers counted the frequency of one to four "hearing-related" problem behaviors on a daily basis. Baseline data (pre-hearing-aid treatment) were collected for 1.5 to 2.5 months in order to accumulate a representative sample of the participants' behaviors. After this time period, the hearing-aid intervention began (hearing-aid treatment phase). Caregivers continued to collect daily data on the problem behaviors for approximately 2 months post-treatment. Introduction of the hearing-aid intervention was staggered across individuals according to the multiple baseline design.

A single-subject design methodology was chosen to evaluate treatment effects, allowing individuals to be their own controls, and thereby making a control group unnecessary. Considering the varied data regarding the auditory systems of patients with Alzheimer disease and the varied stages of the disease, it is unlikely that an appropriate control group could be defined.

Participants

Participants were recruited from the Alzheimer Disease Research Center, University of Pittsburgh; the Benedum Geriatric Center, University of Pittsburgh; the Alzheimer Association of Pittsburgh; and the Aging Research and Education Center of Lutheran Affiliated Services. Recruitment consisted of chart review and the subsequent mailing of invitations to participate in the study. Caregivers of AD patients living at home were provided with a telephone number and were invited to contact us if they were interested in participating in the investigation. Participants consisted of 10 subject/caregiver dyads. All individuals had a diagnosis of AD (provided by a physician) and were living at home with either a spouse ($n = 7$) or child ($n = 3$) caregiver. Age and gender of participants were not controlled for the purpose of this study. This information was used for descriptive purposes only.

Participants were included in the study if they met the following criteria: (a) a primary medical diagnosis of AD, (b) Mini Mental State Evaluation (MMSE; Folstein, Folstein, & McHugh, 1975) scores between 12 and 24, (c) a significant other's version of the Hearing Handicap for the Elderly (HHIE; Ventry & Weinstein, 1982) revealing scores of >18%, (d) a bilateral sensorineural hearing loss appropriate for the range of amplification provided by the Multifocus hearing aid (Oticon, Inc.), and (e) living at home with a spouse or

child caregiver. The first 10 dyads meeting these requirements were accepted into the study. One exception was made, and an individual with an MMSE of 5 was entered into the study in order to see if problem behaviors could be impacted through amplification at this lower level of cognitive function. For the purpose of this investigation, individuals needed MMSE scores severe enough to indicate problem behaviors that may be impacted, while not so severe that subtle changes would be masked. On the basis of Morris et al.'s (1992) data relating MMSE scores (with standard deviations) and severity of impairment, this criterion allowed inclusion of at least 4 individuals with mild impairment (mean of 19.2, standard deviation of 5.6). Individuals with a significant history of alcohol abuse, schizophrenia, Parkinson disease, head trauma, stroke, and language other than English as a first language were not included in the investigation. This information was obtained from individual records and/or caregiver interview.

Table 1 provides descriptive data for the eight subject/caregiver dyads who completed the investigation. Two dyads were withdrawn from the study prior to treatment data collection because both individuals with AD became residents of nursing homes, and behavior could not be tracked consistently. There were 5 male and 3 female participants with AD, 6 female caregivers, and 2 male caregivers. Of the caregivers, there were 5 spouses, 2 daughters, and 1 son.

Five of the participants were taking donepezil (brand name: Aricept), a medication specifically for AD. Participants 1, 3, and 6 started taking Aricept on day 38, 10, and 14 of baseline data collection, respectively, and baseline was continued for another 23, 63, and 49 days, respectively, to ensure that the impact of the Aricept would not mask the impact of hearing-aid treatment. Participants 2 and 8 entered the study having already taken Aricept for several months, so the standard 2-month baseline data collection was considered sufficient. The effect of the Aricept is best controlled for by the design of the study, which includes the requirement of

stable baseline data (no abrupt or gradual improvement due to medication) prior to implementation of treatment. In addition, the immediate impact of treatment can be viewed for each individual and is started at different time periods across participants in order to separate the experimental treatment from any other confounding treatments (e.g., medication).

Procedure

Telephone contact was used to introduce caregivers to the purpose of the study. The significant other's version of the HHIE, which asks the caregiver's opinion of the prospective participant's social and emotional reactions to hearing disability, was administered over the telephone. If the individual and caregiver were interested in participating in the study and the individual passed the above mentioned inclusion/exclusion criteria, the first home visit was scheduled. During the first home visit, the study was explained again, and both the caregiver and patient (when possible) provided informed consent.

Weinstein and Amsel (1986) reported that unidentified/uncorrected hearing loss influences performance on tests that are administered in a face-to-face interview. To ensure that hearing status at the time of interviewing and testing did not impact our results, a personal amplification device (Williams Sound Pocketalker) was used by the patient and/or caregiver with hearing loss for communication purposes whenever necessary. The volume control on the personal amplification device was controlled by the user during its use.

Audiometric Evaluation

At the start of the first home visit, a standard audiometric evaluation was conducted for the individual and caregiver. This was made possible by a portable audiometer (Beltone 120) and immittance system (Storz MCX Diagnostic Center), with the use of insert earphones (ER3A) for sound attenuation in a less than ideal

Table 1. Participants' descriptive data.

| Dyad | Subject | | | | | Caregiver | | | |
	Gender	Age	MMSE	PTA	Medication	Gender/type	Age	MMSE	PTA
1	m	78	18	56.6	Aricept	f/spouse	73	28	38.0
2	f	89	15	50.0	Aricept	f/daughter	66	27	08.3
3	m	71	5	21.7	Aricept	f/spouse	66	29	26.7
4	f	79	12	40.0		m/spouse	79	30	22.0
5	f	82	15	53.3		f/daughter	46	26	10.0
6	m	78	14	28.3	Aricept	f/spouse	70	26	13.3
7	m	76	12	25.0		f/spouse	75	29	20.0
8	m	84	18	48.3	Aricept	m/son	56	30	11.6

Note. PTA = pure tone average (500, 1000, and 2000 Hz). f = female. m = male.

audiometric testing environment (ANSI, 1977). The insert earphones created approximately 30 dB of sound attenuation (Wilber, Kruger, & Killion, 1988). The evaluation included otoscopic examination, and assessment of pure tone air conduction thresholds (ANSI, 1978) and bone conduction thresholds. These were considered the minimal data required to attempt an appropriate hearing-aid fitting. An immittance screening was conducted (ASHA, 1990). A standard vision screening (Snellen Chart) also was conducted because speechreading ability is an essential component of communication strategies. All participants passed the vision screening with 20/20 vision, either corrected or uncorrected. General dexterity and mobility of the caregiver were evaluated using a model hearing aid that was inserted into a plastic ear model. The passing criteria included the caregiver placing a battery in the hearing aid and the hearing aid into the model ear. None of the caregivers had difficulty with this task.

Table 1 contains the pure tone averages (500, 1000, and 2000 Hz) for the individuals with AD and their caregivers. Figure 1 provides the pure tone results as a function of frequency for the individuals with AD. All of the individuals with AD had mild-to-moderately-severe hearing losses. All of these individuals had bilateral, symmetrical sensorineural hearing losses, so only the audiometric results for the ear that was aided in the investigation are provided in Figure 1. Air and bone conduction results were within 10 dB across frequencies for all participants, and all participants passed the

immittance screening (ASHA, 1990). Five of the caregivers, including 1 child caregiver, had hearing loss severe enough to impact daily communication. None of these caregivers had pursued amplification. Unremediated hearing loss in the caregiver could affect the behaviors that can be successfully impacted by remediating hearing loss in the individual with AD. For the purpose of this investigation, hearing loss was not remediated for the caregivers, but appropriate referrals were provided.

Cognitive Status

The caregiver and individual with AD completed the MMSE during the first visit (range: 0–30, normal). For the purpose of this investigation, caregivers were required to have an MMSE of 26 or greater (normal function). In single-subject design, generalizability to a group of similar individuals (similar cognitive status) is established through direct replications of an outcome (McReynolds & Kearns, 1983). A direct replication means that data collection is conducted with similar individuals. Participants were considered similar in the current investigation if their MMSE scores were in the same range (Morris et al., 1992). Herzen and Barlow (1977) suggest three direct replications (4 individuals, total) to ensure generalizability. Direct replication was accomplished in this investigation by including 4 individuals with MMSE levels indicating mild impairment (mean of 19.2, standard deviation of 5.6; Morris et al., 1992, see Table 1). Three individuals with MMSEs lower than

Figure 1. Audiograms of ears that received the hearing aid for 8 participants in the current investigation.
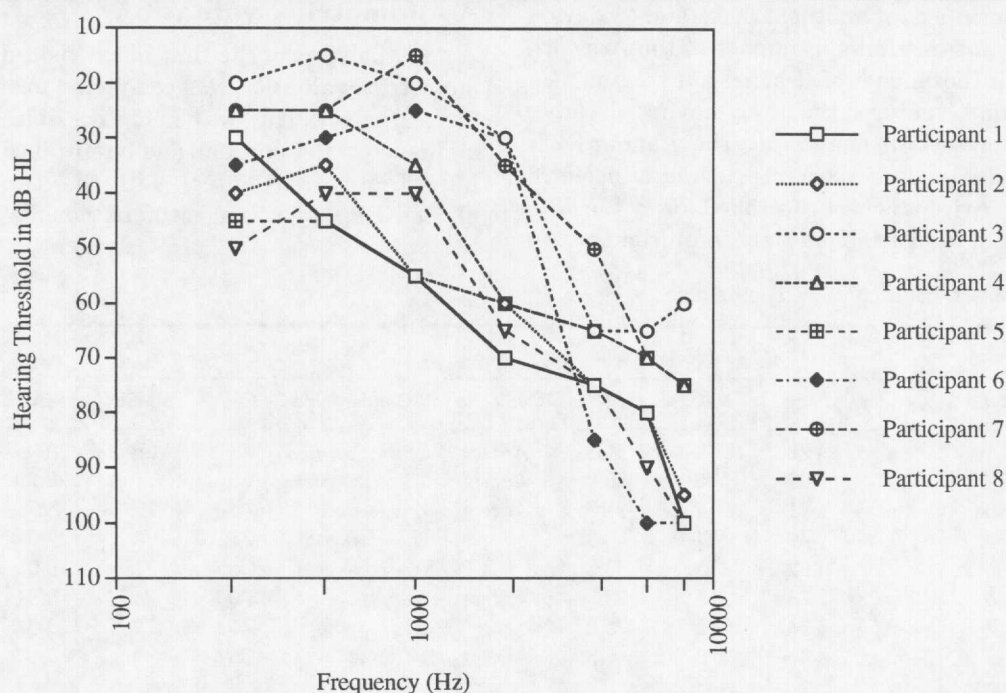
13.6 were included in order to examine problem behavior reduction in individuals with more severe dementia.

Behavior Documentation

If a hearing loss was documented for the individual with AD, the Behave-AD inventory (Reisberg, et al., 1987) was administered to identify one to four spouse- or child-identified problem behaviors. The Behave-AD provides a list of questions that document 30 behaviors commonly associated with AD. Since it was the goal of the current investigation to impact behaviors that are associated with AD and could possibly be linked to hearing loss, this provided an appropriate interview technique. See Appendix A for sample Behave-AD questions. The four most frequent and upsetting behaviors as determined by this questionnaire were used for tracking purposes. If no behaviors were identified, the dyad was not included in the current project but was supplied with written information describing communication strategies that may improve the communication environment and was provided with a referral for independent hearing health care. Behaviors were identified for every dyad tested for the study, so this criterion did not exclude any dyads.

A second visit the next week was scheduled in order to start baseline data collection. The HHIE (Ventry & Weinstein, 1982; Weinstein, 1984) was administered to the individual with AD to measure the individual's perception of his/her hearing difficulty. Davis and Robbins (1989) investigated the results of interview questionnaires with aging adults with and without cognitive impairment. Based on similar rank order of symptoms between groups and reliability for a 1-year interval, the authors concluded that interviewing aging individuals with cognitive impairment is a useful method for discovering concurrent disorders that may be remediable. Four of the 8 individuals with AD who completed the current investigation were able to respond to the HHIE. The purpose of administering the HHIE to both the spouse/child caregiver and individual with AD was to provide a pretest specifically designed to investigate perceived hearing handicap, with which a posttest could be compared after hearing-aid intervention.

During this visit, caregivers were trained to count the one to four problem behaviors that were identified previously. The caregiver was expected to count behaviors on a behavior counting record sheet each day, during three preset time periods per day, each lasting 5 hours, for the duration of the study. The total number of occurrences of a particular behavior, observed during these periods, was tallied for each day. During the first 2 months of the study (*baseline* period), the research associate visited with the caregiver and patient weekly to collect the data sheets. During each visit (including the monthly visits during the 4th and 5th months) the research associate counted the problem behaviors displayed by the individual with AD in order to verify the reliability of the caregiver's documentation. The reliability consisted of comparing the research associate's count to the caregiver's count during a particular time period. If discrepancies were found, the research associate reinstructed the caregiver in the counting protocol. None of the caregivers required reinstruction during this investigation.

Hearing-Loss Management

Earmold impressions were taken from the individuals with AD for hearing-aid fitting purposes after medical clearance was obtained (during 3rd week). The treatment phase began when participants received their hearing aids. Individuals received their hearing aids at either the 6th, 7th, 8th, 9th, or 10th week, depending on the staggered entry into treatment.

A two-channel (high and low frequency) adaptive compression instrument was used in this investigation (Multifocus by Oticon, Inc.). The hearing-aid gain and compression ratio are dictated by the input signal's frequency composition and level. The response is based on a set of compression ratios determined by average hearing losses at a particular level. The hearing-aid response is adequate for individuals with mild-to-moderately-severe hearing losses. This technology provides a convenient way to select a hearing aid on the basis of the threshold data for each individual. The adaptive signal processing automatically adjusts the volume control in all listening situations to ensure enough volume without allowing the hearing aid to become uncomfortably loud. With this new technology, the user (or caregiver) only has to learn how to insert the battery into the hearing aid and the hearing aid into the ear. There are no complicated instructions about volume wheel manipulation. A volume control can be a problem because of confusion, touch sensitivity, and dexterity.

Monaural hearing-aid fittings were used to reduce potential use/insertion confusion that might be created by having two very similar looking hearing aids in a binaural fitting. The ear to be aided was based on audiometric results and patient/caregiver preferences. Ear selection potentially could create a processing advantage, but this was not controlled for in the current investigation. An in-the-ear style was chosen for the individuals in this study because of the ease of insertion for the caregiver and comfort while wearing eyeglasses. Battery insertion and hearing-aid insertion were demonstrated and practiced until the caregiver was comfortable with the process. Written material about use and care of the hearing aids was provided and explained. A battery tester and a supply of batteries were provided.

The research associate visited with the caregiver and patient once per week during the 2nd and 3rd months of the study in order to continue hearing-aid training/ trouble shooting. Information concerning personal-safety assistive technology, such as smoke detector signals also was provided during this time. Behavior data record forms were collected from caregivers at weekly meetings during the 2nd and 3rd months of the study. Caregivers also reported the number of hours per day and days per week of amplification use by the individual with AD.

Posttest Evaluation

Caregivers continued to count problem behaviors during the 4th and 5th months, and the research associate made monthly visits during this time period. Reliability of counting the behaviors was checked during each monthly visit. During the final visit (5th month) a follow-up evaluation was conducted. The HHIE and MMSE were administered to the individual with AD and to the caregiver. Caregivers also were given a social validity questionnaire, developed for this investigation, which asked specific questions related to the caregiver's impressions of the hearing aid during the final visit.

Results
Hearing-Aid Compliance

Table 2 reports the average number of hours per day that the hearing aids were worn by the individuals with AD, as reported by the caregivers. Participants wore their hearing aids between 4 and 13 hours per day, with all but 1 individual wearing his/her hearing aid for 7 or more hours per day. Data from individuals, shown in Figures 2–9, also indicate the daily hours of hearing-aid use.

Primary Data
Reliability

Point-by-point interobserver response agreement (reliability) for the caregiver and research associate was calculated by comparing the two observers' recorded observations for a reasonable sample of the home visits (33%). The number of agreements was divided by the total number of observed behaviors and multiplied by 100 to create a percentage. The point-by-point interobserver response agreement results are displayed in Table 2 and ranged from 87–100%. This was considered adequate reliability, and the results are therefore presented below.

Problem-Behavior Modification

Figures 2–9 display the single-subject data. The horizontal axis presents the days on which the individual

Table 2. Data related to hearing-aid use, problem behavior identification and change, and reliability.

Subject	Average hours of hearing-aid use	Number of behaviors identified	Number of behaviors changed	Average reliability (%)
1	12	3	3	100
2	13	4	4	89
3	11	3	1	97
4	10	2	2	90
5	7	3	2	87
6	4	3	2	97
7	8	4	3	100
8	8	4	1	97

was enrolled in the investigation. The top portion of each figure contains the number of hours of hearing-aid use, with 0 hours throughout the baseline phase, gradually increasing hours at the time of hearing-aid fitting, and the number of hours of use per day throughout the hearing-aid treatment phase. The baseline and treatment phase are separated by a vertical dashed line. Each portion of the figure below the "hours of hearing-aid use" portion is labeled with the problem behavior chosen individually from the Behave-AD evaluation and tracked by the caregiver (e.g., forgetting, searching, asking for repetition, etc.). There were between one and four problem behaviors tracked for each participant; therefore, the number of individual graphs per figure varies. For reporting purposes, the data from the three data recording periods have been added together to provide the frequency of each problem behavior on each day. The data to the left of the dashed vertical line indicate the number of problem behaviors in any given category that a patient displayed (counted by the caregiver) prior to hearing-aid use. The data to the right of the dashed vertical line indicate the number of problem behaviors posthearing-aid fitting. Because these are problem behaviors, a decrease in observed behaviors is considered a positive result. For instance, in Figure 8 hearing-aid treatment starts on day 79, and within 8 days (coinciding with full hearing-aid use) a decrease (to almost 0) is evident in "Hearing things that are not there."

Table 3 provides the Wilcoxon Signed Ranks Test (Z) results, which were used to establish whether a significant change in number of behaviors per day was achieved after hearing-aid treatment. Results revealed either significant reduction in problem behaviors after hearing-aid treatment or no change. There were no cases in which problem behaviors increased significantly. Only significant results are graphed (Figures 2–9) for each participant and reported in Table 3. Table 2 provides data related to nonsignificant findings. Caregivers identified between two and four problem behaviors (see Table 2). For 3 of the participants, all of

Figure 2. Baseline and treatment data for Participant 1.
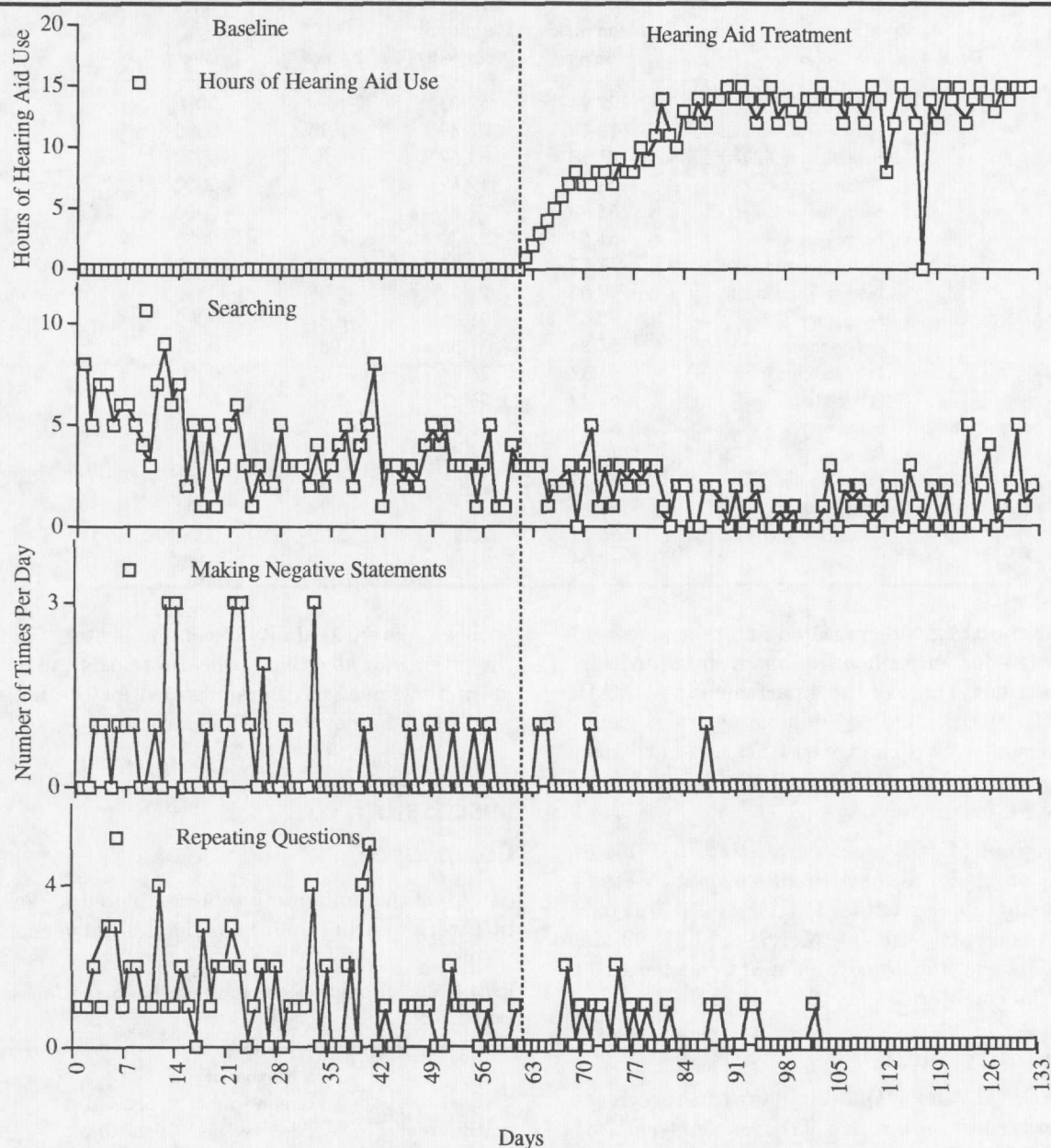
the identified problem behaviors changed significantly after hearing-aid treatment. For 3 of the participants, all but one of the identified behaviors changed signficantly after hearing-aid treatment, and for 2 of the participants, only one of the three or four problem behaviors changed significantly.

Table 4 provides the results as a function of the type of behavior identified. Of the 30 questions on the Behave-AD, from which these behaviors were identified, 11 behaviors were found to be troublesome. For all but two of the identified behaviors, at least some dyads had significant reduction of the problem behavior. For the behaviors "won't stop talking" and "too few interactions,"

no significant change was noted for the individual identified with this problem.

Related Data

Perceived Hearing Handicap

The difference between the HHIE administered prior to hearing-aid fitting and post-hearing-aid fitting for each caregiver and individual with AD is graphed in Figure 10. A difference of 18.7 points for the total score in two face-to-face administrations of the HHIE (Weinstein, Spitzer, & Ventry, 1986) is considered meaningful for an individual patient (95% critical difference).

Table 3. Wilcoxon Signed Ranks Test (Z) results ($p \leq .05$ indicates a significant change).

Dyad #	Behavior	Mean rank baseline	Mean rank treatment	Z score	2-tailed p
1	Searching	127.91	58.73	-8.94	.0000
	Negative statements	113.14	72.42	-7.15	.0000
	Repeating questions	121.48	64.69	-7.85	.0000
2	"I can't hear you"	58.41	19.69	-7.46	.0000
	Negative statements	55.98	22.51	-6.63	.0000
	Forgetting	51.51	27.70	-4.61	.0000
	TV/radio too loud	57.33	20.95	-7.34	.0000
3	Negative statements	40.03	24.42	-2.48	.0132
4	Forgetting	72.61	25.85	-8.34	.0000
	Acts restless	57.36	39.58	-3.89	.0001
5	TV/radio too loud	64.37	26.54	-5.88	.0000
	"I can't hear you"	64.43	26.35	-5.68	.0000
6	Forgetting	82.16	40.97	-6.29	.0000
	Pacing	70.66	55.55	-2.35	.0189
7	"Hearing things"	57.19	17.45	-5.87	.0000
	Forgetting	56.32	20.57	-5.28	.0000
	Negative statements	56.22	20.93	-5.22	.0000
8	Forgetting	47.26	36.06	-2.12	.0340

Nearly all of the caregivers indicated that they perceived a significant reduction in hearing handicap after hearing-aid treatment. Three of the 4 participants with AD, for whom the HHIE could be administered, also exhibited a significant positive change post-hearing-aid fitting.

Cognitive Changes

The original MMSE scores are listed in Table 1. MMSE was stable for all participants over the 5- to 6-month investigation, except for Participant 8. This participant revealed a significant (Morris et al., 1992) decrease in score classification, from mild to moderate, in MMSE by the end of the study (from 18 to 9).

Social Validity Data

For the Social Validity Questionnaire, the caregivers were encouraged to use a range of responses ("yes," "for the most part," "at times," "to some degree," "not really," "no"), but they also could elaborate. Six of the 8 caregivers reported that the individuals with AD had adapted to wearing the hearing aids, and the remaining 2 caregivers indicated that the individuals adapted "at times" or "for the most part." All of the caregivers indicated that they were comfortable putting the battery into the hearing aid and inserting the hearing aid into the individual's ear. The social validity questionnaire asked caregivers directly if they felt that the hearing-aid treatment had reduced the occurrence of identified problem behaviors. Six of the 8 caregivers were sure that the hearing aids had accomplished this, whereas 2 were less sure. One of the questions relates directly to perceived hearing disability: "Do you feel that wearing a hearing aid has improved your spouse's (parent's) ability to communicate?" Six of the 8 caregivers indicated that the hearing aid had accomplished an improvement in communication for the individuals with AD, whereas 2 were less sure.

Discussion
Compliance

All of the individuals who completed the investigation were wearing their hearing aids between 4 and 12

Table 4. Caregiver-identified problem behaviors and subsequent modification.

Behavior categories[a]	Number of caregivers that identified the behavior	Showed significant* improvement	No improvement
Searching	3	1	2
Negative statements	4	4	0
Repeating questions	1	1	0
Forgetting	6	4	2
"I can't hear you"	2	2	0
TV/radio is too loud	2	2	0
Acts restless	1	1	0
Pacing	3	1	2
Hearing things not there	2	1	1
Won't stop talking	1	0	1
Too few interactions	1	0	1

[a]Behaviors from the Behave-AD (Reisberg et al., 1987).
*$p \leq .05$, using a Mann-Whitney U–Wilcoxon Rank Sum W test.

Figure 3. Baseline and treatment data for Participant 2.
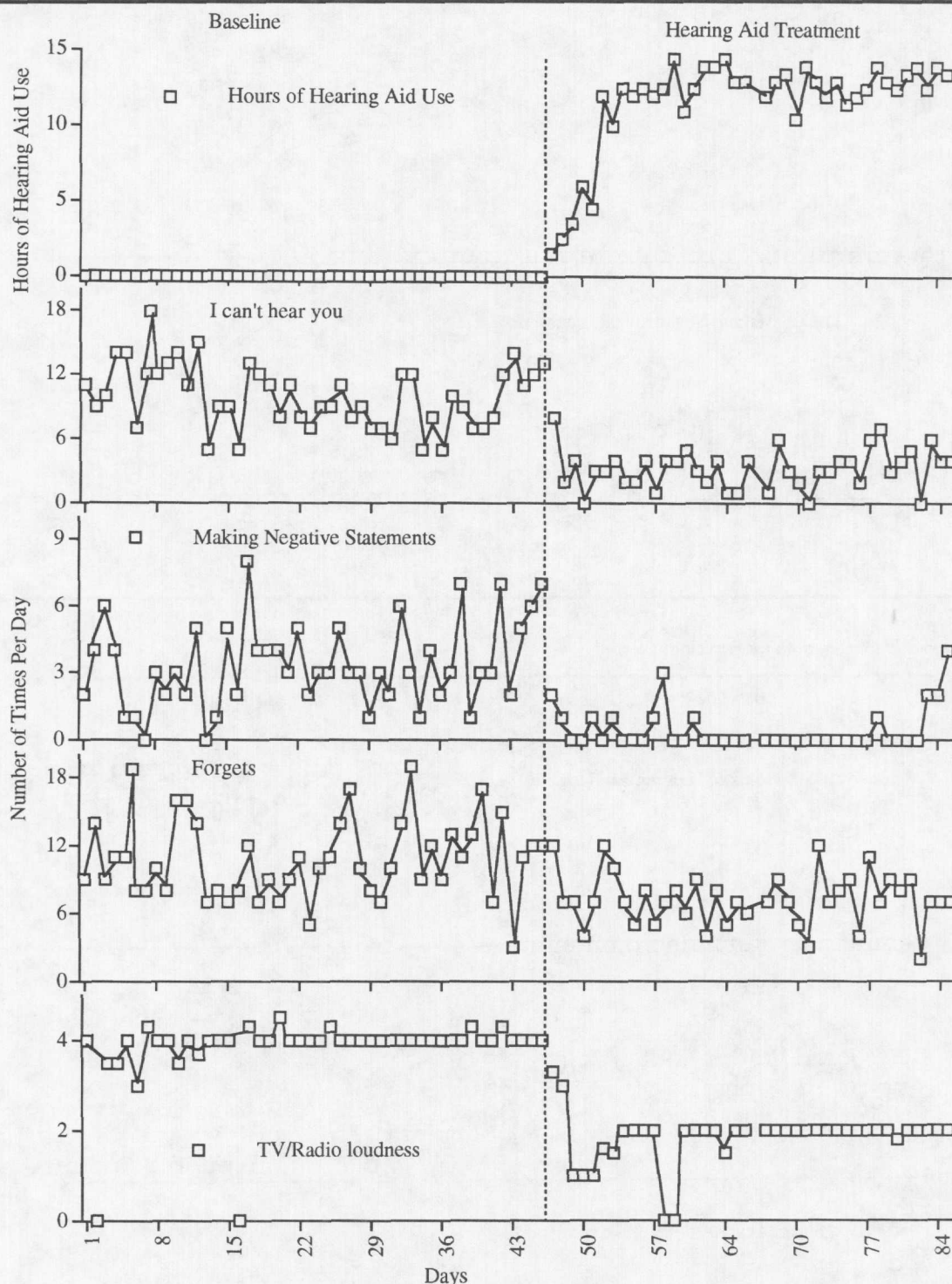
hours per day, on average, by the end of the study. Figures 2–9 illustrate that the hearing aids were introduced gradually, increasing use by approximately an hour per day. Participant 6 had the shortest wearing time of approximately 4 hours per day. The caregiver of Participant 6 was the only caregiver to report that her spouse may not have adapted to using the hearing aid completely, yet two of the three identified problem behaviors for Participant 6 were reduced significantly after hearing-aid fitting.

Two individuals (Participants 2 and 5) indicated that the hearing aid was too loud and noisy when first fit.

Figure 4. Baseline and treatment data for Participant 3.
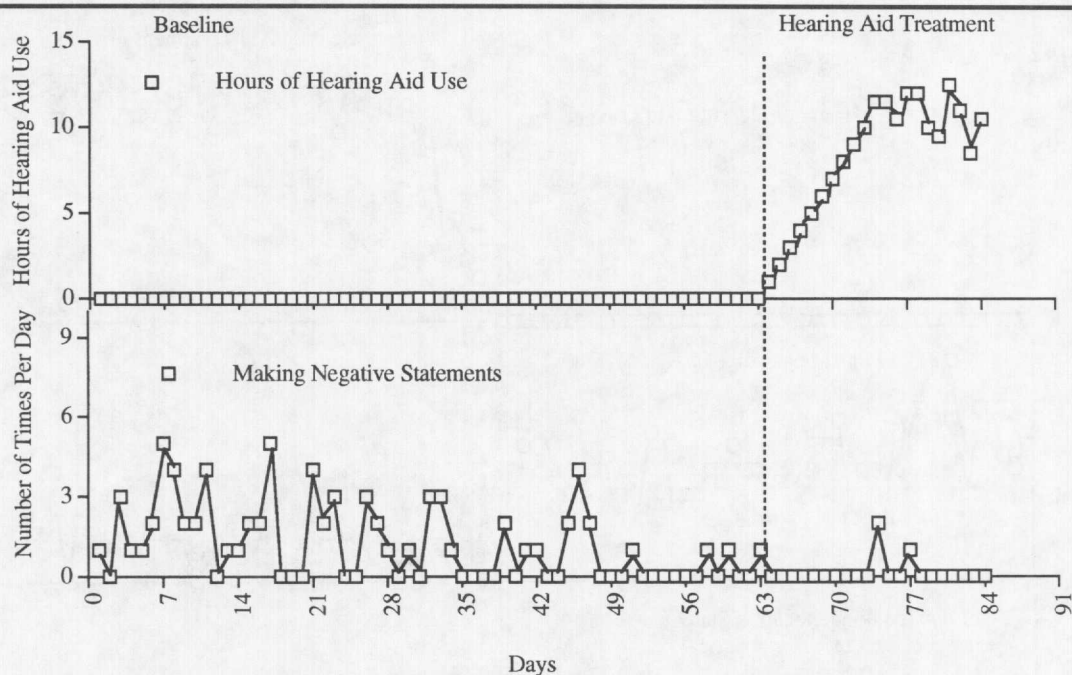
Figure 5. Baseline and treatment data for Participant 4.
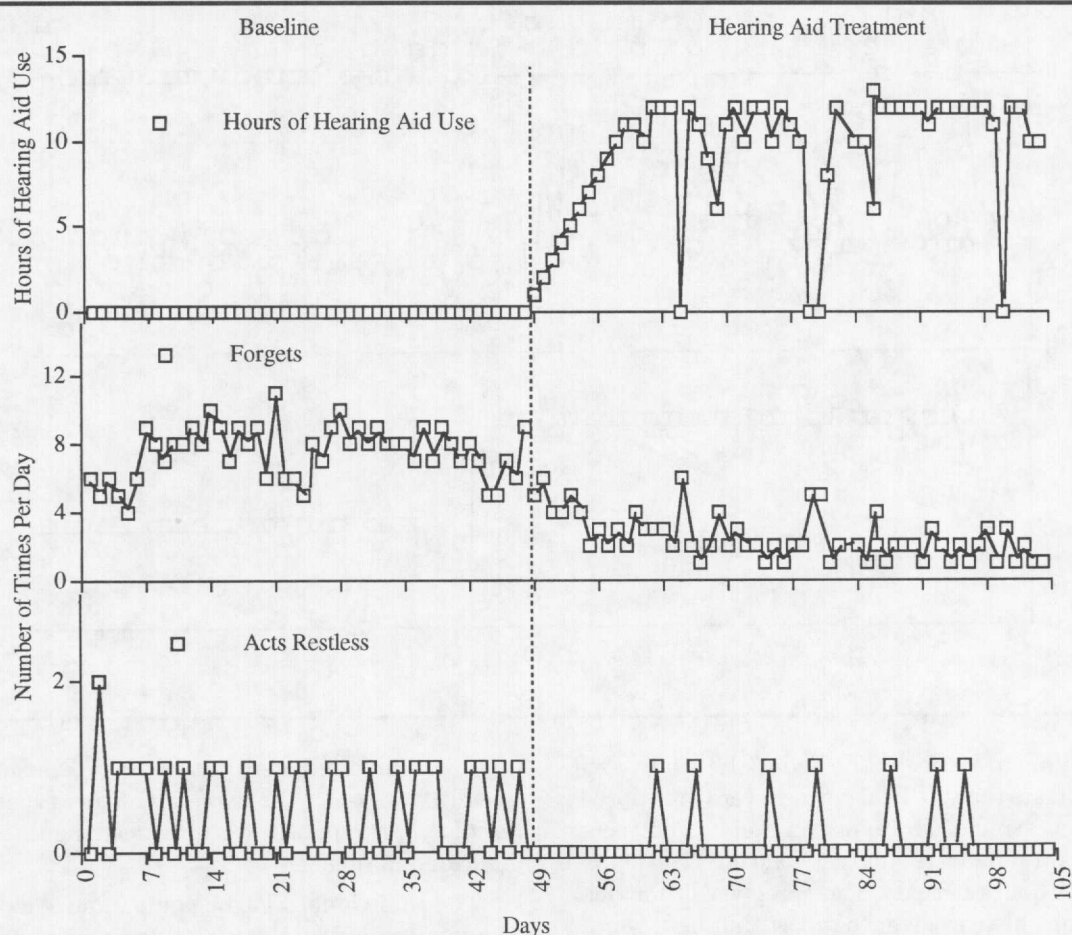
Figure 6. Baseline and treatment data for Participant 5.
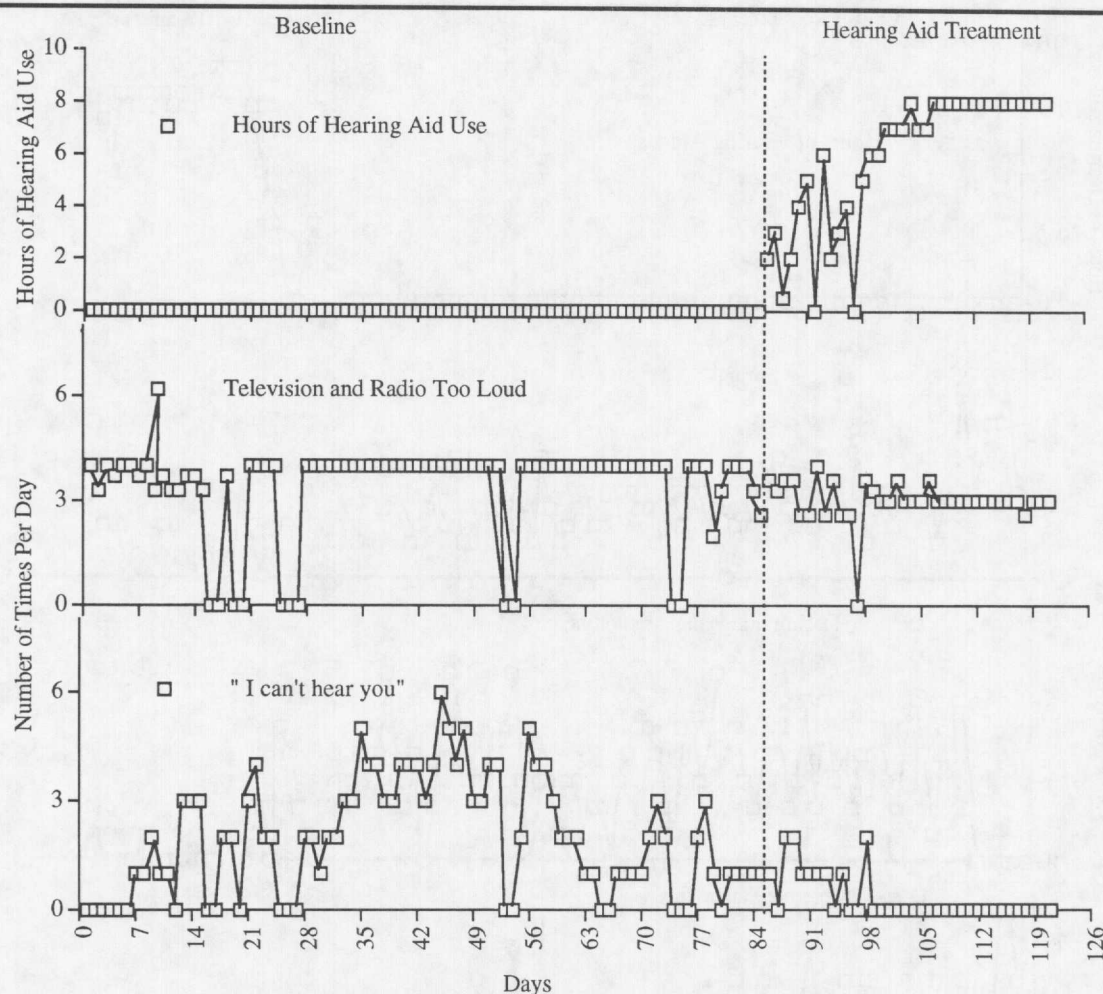
Both individuals indicated that they would not wear the hearing aid. The participants were counseled by the research associate and caregiver to go ahead and give it a try, and both agreed. By the 2nd week of hearing-aid use, both individuals were wearing the devices full time (13 and 7 hours) and did not repeat the complaints. Participant 5, however, continued to complain about her own voice sounding hoarse (which it was), indicating that all other sounds were "good and clear."

Three of the individuals (Participants 5, 6, and 8) were able to remove their hearing aids without assistance, although occasionally they misplaced the hearing aids. Five of the 8 participants did not attempt to remove their hearing aids, nor did they lose their hearing aids.

Problem Behaviors

Between one and four caregiver-identified problem behaviors were impacted positively for all 8 participants who completed this investigation. Thus, caregiver tracking of problem behaviors appears to be a worthwhile

outcome measure to assess the benefit of amplification in a population of individuals with AD who are living at home and displaying mild-to-moderate cognitive impairment.

In the current study, the top four behaviors of each individual were used for tracking purposes and are listed in Table 4. The first nine appear to be related to hearing loss in that they were modified significantly after hearing-aid treatment. The last two behaviors ("won't stop talking" and "too few interactions") also appear to have a potential link to hearing, yet no change was noted. These two problem behaviors were identified for Participant 8 who only showed significant change for one behavior (forgetting) and revealed a significant decrease in MMSE by the end of the study (from 18 to 9). The caregiver for this individual noted that he was unsure if the participant adapted to the hearing aid and whether the hearing aid reduced any problem behaviors.

The caregiver for Participant 3 also was not sure that the hearing aid had reduced the occurence of any problem behaviors when asked directly. Participants 8

Figure 7. Baseline and treatment data for Participant 6.
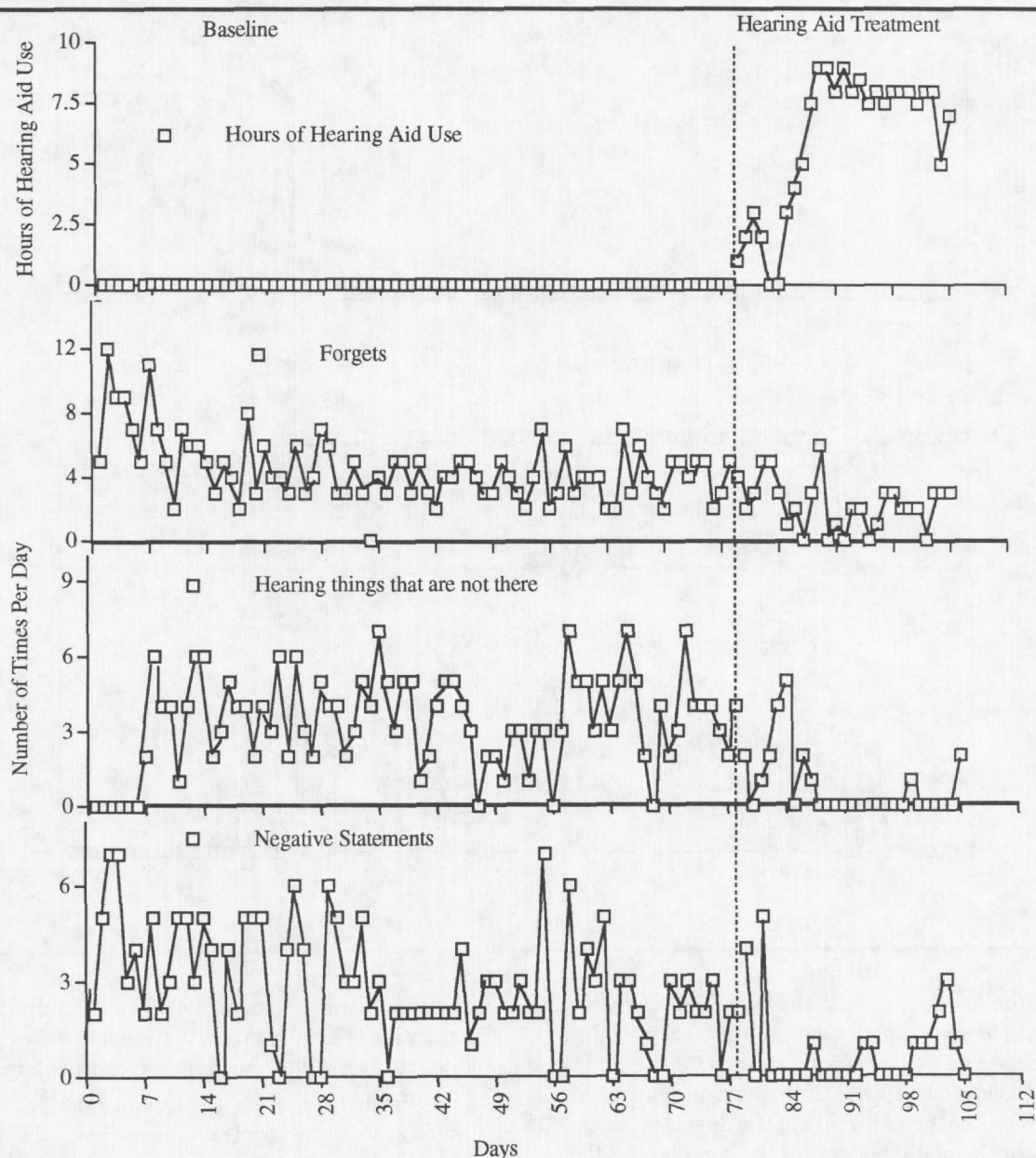
and 3 displayed the least amount of problem behavior reduction in terms of the number of identified problems that were reduced after hearing-aid treatment (1 of 4 and 1 of 3, see Table 1). The caregivers' reports were in good agreement with the data and statistical analysis. These two individuals (Participants 8 and 3) had the lowest final MMSEs of the individuals included in this investigation, suggesting that the introduction of amplification for individuals with severely impaired cognitive function may have a minimal impact on reduction of problem behaviors.

The change in problem behaviors documented in the treatment phase of the study does support the contention that management of hearing loss can reduce several problem behaviors typically identified by caregivers of individuals with mild-to-moderate AD.

Perceived Hearing Handicap

For the purpose of documenting change in hearing handicap, it was most effective to use the significant other's version of the HHIE in the current investigation. Nearly all (7/8) of the caregivers documented a significant change in their perception of their spouse's or parent's hearing handicap. Two of the caregivers (Dyad 3 and 8) responded "not sure" and "to some degree" to the

Figure 8. Baseline and treatment data for Participant 7.
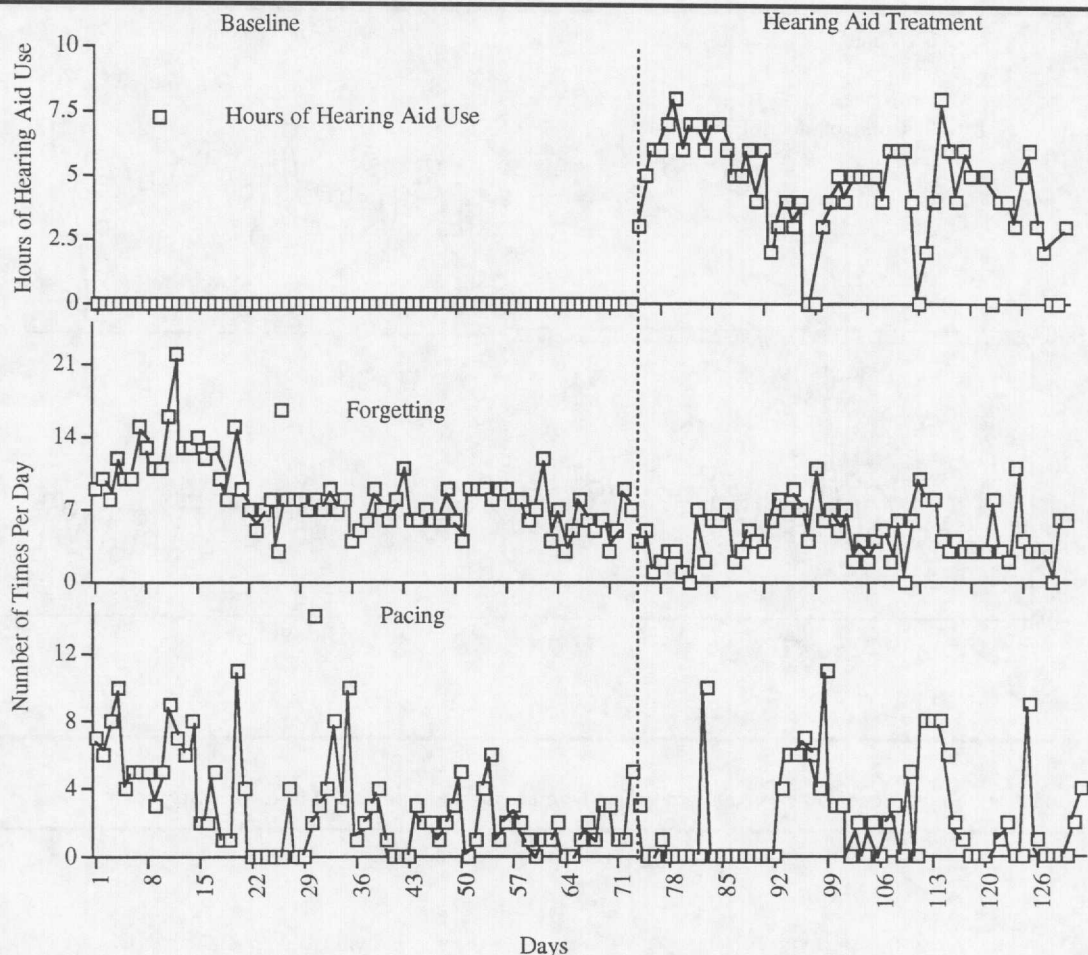
question "Do you feel that wearing a hearing aid has improved your spouse's (parent's) ability to communicate?" These two caregivers showed the least amount of change on the pre- and post-HHIE, as compared to the other caregivers. The 2 participants with AD receiving care from these individuals also had the least number of changed behaviors and the lowest final MMSEs, indicating lower cognitive function than the other participants.

Fifty percent (4/8) of the individuals with AD were able to complete both the pre- and posttest of the HHIE, and 3 of these 4 indicated significant reduction in hearing handicap (see Figure 10). Participant 8 was able to complete the pre-HHIE without difficulty but was unable to complete the posttest. This participant's MMSE decreased from 18 to 9 from the beginning to the end of the investigation, which may explain this subsequent difficulty. Participant 3 was not able to complete either the pre- or post-HHIE, but verbally reported that the hearing aid was "good" and "made all the sounds clear." None of the caregivers or participants indicated increased hearing handicap over the course of the investigation.

Although Davis and Robbins (1989) reported that interview questionnaires were appropriate to use with individuals with cognitive impairment, they did not report how many of the group with cognitive impairment that made up their data set actually were able to complete the questionnaire successfully. Durrant et al. (1991) indicated that all of their participants ($N = 10$) were able to complete the HHIE in an interview format, but a measure of cognitive status (e.g., MMSE scores) was not available for this group, so it is difficult to compare them to the current participants. Considering the results of the individuals who were able to complete the HHIE task (4/8), it appears worthwhile to attempt administration of this type of hearing handicap measure in order to provide outcome data specifically reported by the individual with AD.

Items Not Measured by the Instruments Included in This Investigation

Caregivers were provided with a diary in which to record thoughts and comments generated by themselves or their spouses/parents after hearing-aid treatment.

Figure 9. Baseline and treatment data for Participant 8.
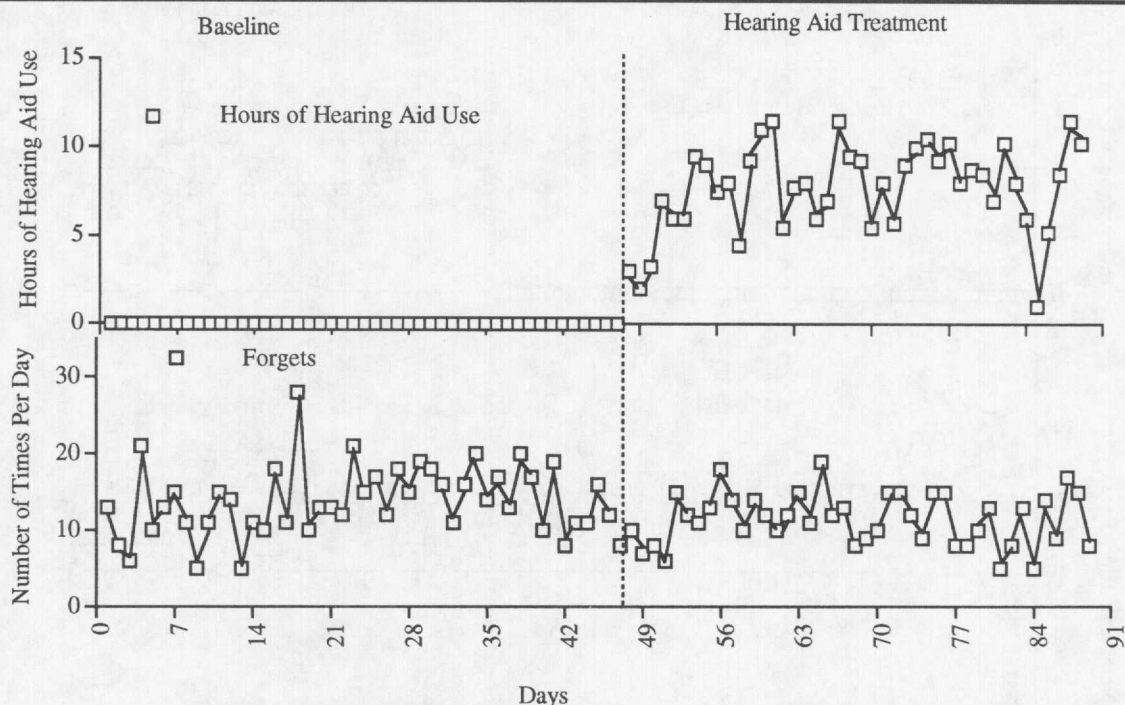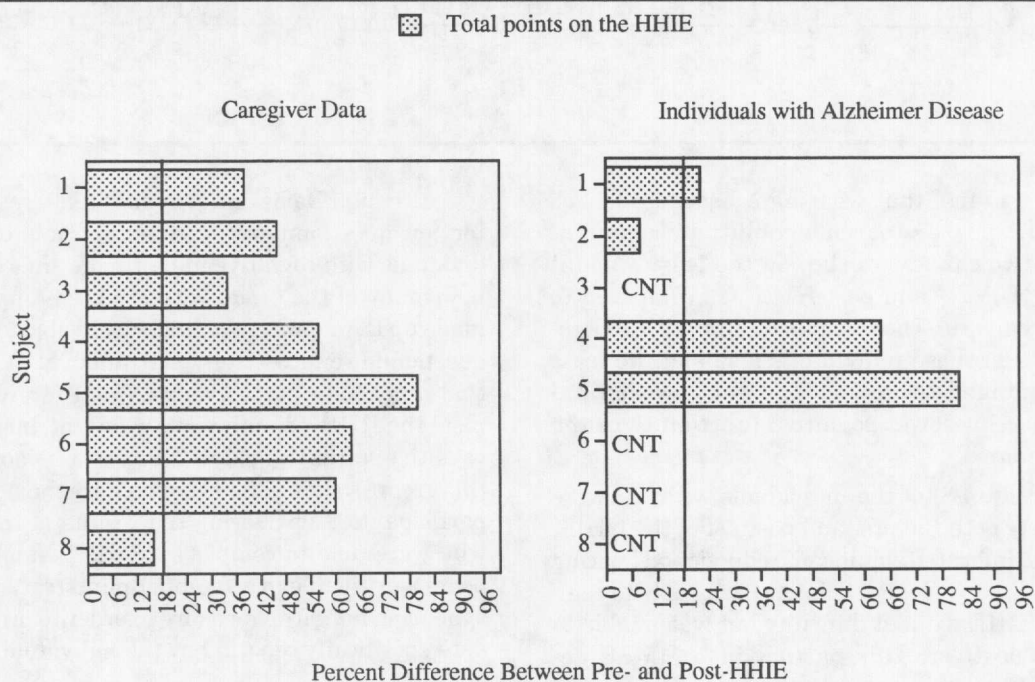

Figure 10. Pre- and Post-Hearing Handicap Inventory for the Elderly results for participants and their caregivers.

Some of these comments illustrate positive changes that were not captured by the instruments employed in this investigation. Caregivers reported that some of the individuals requested that the hearing aid be placed in their ear each morning and made positive comments about the way the hearing aid made the world sound. Caregivers reported increases in the following behaviors by their parents/spouses: engaging in conversation,

engaging in interactions, awareness of environmental sounds (car blinker, birds, air conditioner, the mail being delivered, etc.), paying attention to TV, and general alertness. Because most of these items represent an absence of a certain behavior (e.g., not tuning into the environment or not having conversations), they were not captured as problem behaviors. However, these items could easily be adapted for future measures of behavior modification following hearing-aid management.

Summary

Eight caregiver/subject dyads were able to complete this investigation and one to four problem behaviors were significantly reduced for all of the participants after hearing-aid treatment. In addition, nearly all of the caregivers indicated that hearing handicap had been significantly reduced, according to the significant other's version of the HHIE. All participants were able to complete the necessary evaluation for hearing-aid fitting and wore their hearing aids between 4 and 13 hours per day by the end of the study. The participants with the lowest cognitive functioning at the end of the investigation (Participants 3 and 8) appeared to receive the least benefit from hearing-aid remediation as measured by the HHIE, number of problem behaviors reduced, and direct questioning of the caregivers.

The methodology presented in this investigation is novel in the areas of on-site evaluation, on-site hearing-aid selection, and use of caregiver-identified problem behaviors as a measure of treatment effects. With some modification, these methods could be used in clinical situations for managing hearing loss in patients with AD. Anecdotal reports suggest that hearing-aid remediation for the hearing loss of the individual with AD living at home with a caregiver may actually benefit the caregiver at least as much as the patient. Therefore, outcome measures may be appropriately directed toward both the caregiver and the individual who is using the new hearing aid. Future investigations should include varying degrees of cognitive status, remediation of caregiver hearing loss, binaural hearing-aid fittings in order to capture the positive benefits of binaural listening, and inclusion of behaviors that caregivers would like to see increase.

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Appendix A. Sample questions on the Behave-AD.

1. Does your spouse ever mention that someone is hiding or stealing things?

   No 0 = Not present.

   Yes 1 = Does he mention people are hiding or stealing?

   2 = Does he ever say people are coming into the house to hide or steal things?

   3 = Does he ever talk or listen to imaginary people coming into the house to hide or steal things?

2. Does your spouse forget what you've told him?

   No 0 = Not present.

   Yes 1 = He forgets what I've told him.