CHAPTER TWENTY-FIVE

Evidence for the Use of FM Systems in Older Adults

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Introduction

Despite recent advances in hearing aid technology, the deleterious effects of distance, noises, and reverberation, in combination with the effects of cognitive aging, continue to result in older adults with hearing loss experiencing significant difficulties understanding speech in noise. A particularly effective method for improving speech understanding in noise and/or understanding at a distance is the use of an FM system, or as Dr. Mark Ross (2004) refers to it, "listening with a third ear". Ross (2004) described several situations in which he, personally, finds having a "third ear" to be particularly helpful, including: (a) having a conversation with his wife in a noisy restaurant; (b) socializing with another couple in a restaurant; (c) conversing while driving a car; (d) communicating in noisy group situations; and, (e) while watching television with his wife.

Results from several previous studies demonstrate that the use of FM systems by adults improves laboratory measures of speech understanding in noise (e.g., Jerger, Chmiel , Florin, Pirozzolo, & Wilson, 1996; Lewis, Crandell, Valente, & Enrietto, 2004). Further, with the provision of systematic counseling, coaching, and instruction focused on the use of FM systems to meet individualized communication goals, adults experience many subjective benefits, both short-term and after 1 year of FM use (Chisolm, Noe, McArdle & Abrams, 2007). Although available data support the use of FM systems by adults, the potential influence of age on outcomes has not been systematically examined. Indeed, aging effects related to memory and cognitive status, visual function, manual dexterity, and/or other health conditions are important considerations in developing audiological rehabilitation approaches for older adults, including the use of FM systems and other hearing assistive technologies (Kricos, 2009). To best develop the most effective intervention approaches, it is thus important to explore the potential effects of age on the outcomes of FM use by older adults.

In the present study report, data collected by Dornton (2009) who investigated the effects of the use of an FM system in veterans utilizing custom-fitted hearing aids, were re-examined as a function of age, to address two specific questions:

1) Can older adults with hearing loss benefit from the use of FM systems in conjunction with the use of hearing aids: and,
2) Does age influence the outcomes of FM use by older adults with hearing loss?

Methods

Participants

Thirty-six male veterans were recruited from the Audiology and Speech Pathology Service at the Bay Pines VA Healthcare System (VAHCS). All procedures were approved by the Bay Pines VAHCS Institutional Review Board. Participants were experienced users of bilateral custom-fit hearing aids. Individualized goals for amplification for all participants included situations in which FM systems can improve outcomes (e.g., *listening in a restaurant, listening in a car, watching television,* etc.).

Initially, half of the participants were randomly assigned to the experimental treatment group, utilizing FM systems in addition to their hearing aids (i.e., HA+FM), and the other half served as a control group,

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utilizing their current hearing aids alone (i.e., HA-Alone). The 36 participants ranged in age from 53 to 85 years old. The mean age of participants in the HA+FM and HA-Only groups was 72.5 years old (sd = 6.8 years) and 76.6 years old (sd = 9.5 years), respectively. The results of a between groups t-test revealed that the difference in age between the two groups was not statistically significant (t (34) = 1.47; p = .15).

In order to examine potential effects of age on the outcomes of FM use, the 36 participants were divided into three age groups: (a) < 70 years old (n = 8); (b) 70–79 years old (n = 16); and, (c) ≥ 80 years old (n = 12). Within the < 70 year old group, 3 of the participants were in the HA-Alone group and 5 were in the HA+FM group. Seven of the participants in the 70–79 year old group were assigned to the HA-Alone group, with the remaining 9 were in the HA+FM group. Finally, in the oldest group, 8 participants were in the HA-Alone group and 4 in the HA+FM group.

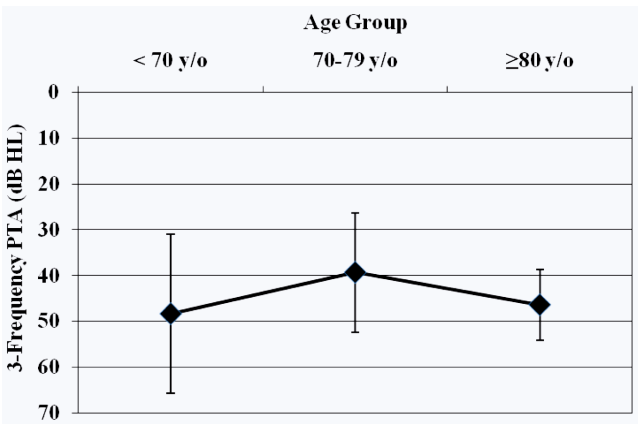

Figure 1. Mean (+/–1 SD) 3-frequency pure tone averages (PTAs) at 500, 1000 and 2000 Hz, collapsed across ears, as a function of the three age groups.

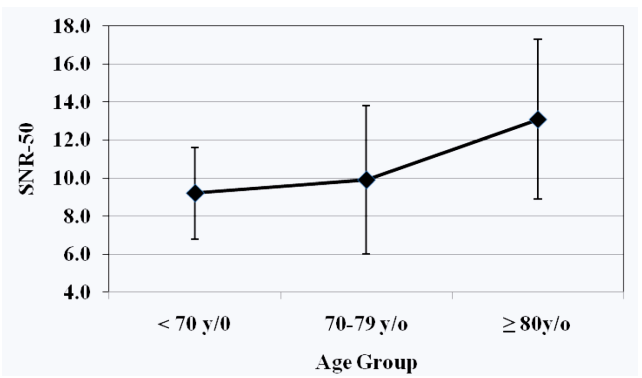

Figure 2. Mean (+/–1 SD) 50% correct binaural speech recognition in noise (SNR) thresholds as a function of the three age groups.

No specific audiometric criteria were set for inclusion in the study, except that participants were required to exhibit essentially symmetrical bilateral sensorineural hearing losses which could be fitted with custom-fit hearing aids. Given the criterion of hearing loss for which custom fit hearing aids were appropriate, perhaps it is not surprising that the mean 3-frequency pure tone averages (PTAs) for 500 Hz, 1000 Hz, and 2000 Hz were not statistically significantly different across the three groups (F (2,33) = 2.79, p = .075) as illustrated in Figure 1.

In addition to considering pure tone thresholds, binaural 50% correct speech recognition in noise thresholds as measured, clinically, with the QuickSIN procedure (Killion, Niquette, Gudmundsen, Revit, & Banerjee, 2004) were available for the majority of participants and were thus examined as a function of the three age groups. The results, shown in Figure 2, demonstrated poorer speech recognition in noise abilities as Age Group increased, although the effect of Age Group failed to reach statistical significance (F (2,29) = 2.88, p = .072). The finding of a visually apparent decrease in speech recognition in noise abilities as Age Group increased, despite a lack of systematic declines in average pure tone hearing losses, is not surprising given that cognitive performance, which in general decreases as age increases, as well as audibility factors, are believed to influence speech understanding abilities in older adults (e.g., Pichora-Fuller & Singh, 2006; Humes, 2007).

Hearing Aids and FM Systems

The hearing aids worn by study participants were all digital custom-fit instruments with adaptive directional microphone technology and t-coils. All hearing aids were current VA issued devices from a variety of manufacturers as shown in Table 1. Hearing aids were fitted according to clinical protocol to NAL-NL1 prescriptive targets with verification performed using the Frye Fonix 7000 Hearing Aid Test System. In addition, the Fonix 7000 was used to assure that hearing aid telecoil strength was within specifications. For participants randomized to the HA+FM group, bilateral Phonak MyLink™ FM receivers were utilized with the Phonak ZoomLink™ transmitter.

Outcome Measures

Client Oriented Scale of Improvement (COSI; Dillon, James, & Ginis, 1997). Individualized goals for hearing aid intervention are routinely obtained as a part

Make	Model	Number
INTERTON		
	INSTINCT NS30 ITC	1
	INSTINCT NS40 HS 4	4
	INSTINCT NS60 FS	1
MICRO-TECH		
	RADIUS 12 HS 4	4
	RADIUS 12 ITC	1
	RADIUS 12 ITE 3	3
	RADIUS 16 HS 2	2
	RADIUS 16 ITE 3	3
PHONAK		
	CLARO HS	1
	PERSEO 23 DAZ HS 3	3
	SAVIA 33 DSZ FS 3	3
SIEMENS		
	ARTIS ITC	1
	ARTIS HS	1
	MUSIC D FS	1
	TRIANO HS	1
	TRIANO ITC	1
	TRIANO ITE 3	3
STARKEY		
	DESTINY 1600 ITE	1
UNITRON		
	EVO FS	1
	Total	36

Table 1. Makes and models of hearings aids worn by study participants.

of clinical protocol at the Bay Pines VAHCS using the COSI procedure. In the present study, COSI goals were re-established for hearing aid use for the HA-Alone participants and established for FM use for the HA+FM participants. For each participant, one to three individualized goals were established. Each of the goals was assigned to one of the 16 COSI categories (e.g., listening to one or two in noise, listening to groups in noise, listening to radio or TV, etc.) described by Dillon et al. (1997). The two COSI ratings ("Degree of Change" and "Final Ability") were used to assess changes from baseline performance, which was defined as performance with current custom-fit bilateral hearing aids at the beginning of the study protocol, to performance at the end of the protocol with either hearing aids alone (i.e., HA-Alone group) or for use of FM devices with hearing aids (i.e., HA+FM group).

Hearing Device Satisfaction Survey

(Kochkin, 1990; Humes, Ahlstrom, Bratt & Peek, 2009). Satisfaction with devices (hearing aids and/or FM systems) was assessed utilizing selected items from the MarkeTrak survey instrument (Kochkin, 1990). The items selected provide an assessment of satisfaction with hearing aid features as well as satisfaction in specific listening situations. As discussed by Humes et al. (2009), in their series of studies examining the outcomes of hearing aid use by older adults, responses to the MarkeTrak hearing aid features and specific listening situations can be averaged to provide a general satisfaction rating, which ranges from 1, indicating very unsatisfied, to 5 indicating very satisfied. In Humes et al.'s work, the use of the MarkeTrak survey items utilized in this manner is referred to as providing a Hearing Aid Satisfaction Survey (HASS) measure. In the present study, the same approach was utilized to assess satisfaction with hearing aids and/or FM systems and is referred to as the Hearing Device Satisfaction Survey (HDSS).

The Speech, Spatial and Qualities of Hearing Questionnaire

(SSQ; Gatehouse & Noble, 2004). The SSQ was designed to assess the influences of cochlear function on auditory disability and handicap. Version 3.1.1 of the SSQ, which consisted of 50 questions, was utilized in the present study. Fourteen of the SSQ items assessed hearing for speech in a range of contexts; 17 items assessed classical components of spatial hearing, involving directional and distance judgments; and the remaining 19 items assessed "other" qualities of hearing, such as segregation of sounds, recognition, clarity/naturalness and listening effort. For each item, the participant responds using a scale which ranges from 0 to 10, with 0 indicating the poorest performance and 10 indicating the best performance. Respondents are also allowed to indicate if they would not hear in a certain situation or if a situation is not applicable. Scores can be reported in terms of: (a) individual items; (b) Speech, Spatial, and Qualities scores; or, in terms of 10 pragmatic scale scores as recommended by Gatehouse and Akeroyd (2006). There are four pragmatic Speech scales: *Speech-in-Quiet, Speech-in-Noise, Speech-in-Speech Contexts,* and *Multiple Speech-Stream Processing & Switching;* two Spatial scales: *Localization* and *Distance & Movement;* and, four Qualities scales: *Sound Quality & Naturalness, Iden-*

tification of Sound & Objects; Segregation of Sounds, and *Listening Effort.* In the present study, the data were examined as a function of the pragmatic scale scores.

Procedures

The study protocol consisted of two visits and one interim phone call. An additional research visit was completed if the participants reported experiencing any difficulties during the interim phone calls. The total duration from baseline to post-intervention assessment ranged from four to eight weeks, depending on the necessity of the interim research visit.

All participants were consented approximately one to two weeks prior to Visit 1 and randomized into the HA-Alone or HA+FM group. The first step in Visit 1 was to (re-)establish COSI goals for hearing aid and/or FM use. Participants were then required to complete the HDSS and SSQ, via paper-and-pencil administration. The order of presentation of the two self-report measures was counter-balanced across participants and the two sessions. During completion of the HDSS and SSQ, the research audiologist was available to answer any questions, with the exception of a short period of time in which all participants' hearing aids were run in the Fonix 70000 Hearing Aid Test System to determine the strength of the telecoils. All hearing aids were found to have adequately functioning telecoils. After completion of the HDSS and SSQ the participants who were randomized into the HA-Alone group were provided informational counseling regarding how to best use their hearing aids to meet their COSI goals. The participants in the HA-FM group were fitted with the FM systems, trained in the use and care of the devices and provided with systematic counseling, coaching and instruction with regard to the use of the devices to meet COSI goals. The approach utilized to provide instruction and training involved verbal and written instructions and role-playing, consistent with procedures previously utilized and described by Chisolm et al (2007).

Two weeks after Visit 1, all participants were contacted via telephone by the research audiologist and asked how they were doing with their devices. They were asked if they were having any difficulties. A "yes" answer resulted in scheduling of an interim visit. If the patient indicted that there were no problems, he was simply reminded of the next scheduled visit. A total of five participants were scheduled for an interim research visit, four from the HA+FM group and one from the HA-Alone group. One of those scheduled for an interim visit was in the youngest age group, with the remaining four individuals in the 70–79 year old group.

Visit 2 occurred four weeks after Visit 1 for all participants except those who were seen for an interim visit. The five participants seen for an interim visit were provided an additional four weeks of practice prior to scheduling Visit 2. In Visit 2, COSI outcomes were assessed in terms of Degree of Change and Final Ability with either HA-Alone or HA+FM. The SSQ and HDSS were readministered, again in paper-and-pencil format, with order of administration counter-balanced. Participants in the HA-Alone group were asked to complete the self-report measures with regard to hearing aid use and those in the HA+FM group were asked to complete the measures with regard to the combined use of hearing aids with the FM devices. Finally participants in the HA+FM group were asked if they wished to continue use of the FM devices and, for ethical purposes, those in the HA-

Table 2. Percentage of COSI goals in each category as a function of Age Group and Intervention Arm.

Age Group	< 70		70–79		80+	
	HA	HA+FM	HA	HA+FM	HA	HA+FM
1 or 2 Quiet		7.1	5.0		4.5	
1 or 2 Noise	12.5	14.3	15.0	16.0	18.2	18.2
Group Quiet	12.5			4.0		
Group Noise	50.0	28.6	50.0	32.0	36.4	18.2
TV/Radio	12.5	21.4	20.0	24.0	13.6	36.4
Telephone					4.5	
Meeting	12.5	28.6	10.0	4.0	4.5	9.1
Other				20.0	18.2	18.2

Alone group were asked if they wished to have a trial period with the FM systems.

Results and Preliminary Discussion

To address the two research questions, the COSI, HDSS, and SSQ data were examined as a function of intervention group (i.e., HA-Alone vs. HA+FM) and as a function of Age Group within each of the two Intervention Arms. The results for each outcome measure are discussed.

COSI

Table 2 shows the percentage of COSI goals that were assigned to each COSI category as a function of Age Group and Intervention Arm. It can be seen that for all age groups and across both intervention arms, there were goals related to: *listening to 1 or 2 in noise: listening to groups in noise; listening to the television/radio;* and, *attending church/meetings.* No systematic differences were found for the percentage of goals in the categories as a function of either Age Group or Intervention Arm.

The mean Degree of Change as a function of Age Group and Intervention Arm is shown in Table 3. It can be seen that for each COSI category for which there were goals for both HA-Alone and HA+FM participants, the mean Degree of Change was higher for the latter than the former group. The difference in Degree of Change outcomes goals in each category was further examined as a function of Intervention Arm using the Mann-Whitney U test, a non-parametric alternative to a between-groups t-test. Statistically significant differences ($p < .01$) were found for: (1) *listening to 1 or 2 in noise; (2) listening to groups in noise;* and, (3) *listening to TV/radio.* To examine the effect of Age Group on Degree of Change for the HA+FM participants, the data were subjected to the Kruskal-Wallis procedure, a non-

Table 3. Mean COSI Degree of Change as a function of Age Group and Intervention Arm.

Age Group	< 70		70–79		80+	
	HA	HA+FM	HA	HA+FM	HA	HA+FM
1 or 2 Quiet		5.00	2.00		2.00	
1 or 2 Noise	2.00	4.50	2.00	4.00	2.00	4.00
Group Quiet	2.00			5.00		5.00
Group Noise	2.00	3.50	2.30	4.88	2.38	4.88
TV/Radio	3.00	3.67	2.00	4.67	2.00	4.67
Telephone					2.00	
Church/Meeting	2.5	4.00	3.00	4.00	2.00	4.00
Other				3.20	2.00	3.20

Table 4. Mean COSI Final Ability as a function of Age Group and Intervention Arm.

Age Group	< 70		70–79		80+	
	HA	HA+FM	HA	HA+FM	HA	HA+FM
1 or 2 Quiet		4.00	1.00		3.00	
1 or 2 Noise	1.00	4.00	2.00	4.20	1.50	4.50
Group Quiet	2.00			5.00		5.00
Group Noise	2.75	3.25	1.60	4.25	2.50	2.50
TV/Radio	3.00	3.67	2.25	4.67	2.00	3.50
Telephone					1.00	
Church/Meeting	2.00	3.75	2.00	4.00	1.00	3.00
Other				3.00	1.00	4.50

parametric alternative to a 1-way between groups analysis of variance. The effect of Age Group was not significant for any category of goals ($p > .05$).

Table 4 shows the mean Final Ability data as a function of Age Group and Intervention Arm. Mean Final Ability scores are higher for the HA+FM participants for all relevant goal categories, with the exception of *listening to groups in noise* for the oldest age group, only. Mann-Whitney U analyses of the data for each COSI category, collapsed across age groups, revealed that outcomes for the HA+FM participants were significantly higher than for HA-Only participants for: (1) *listening to 1 or 2 in noise; (2) listening to groups in noise;* and, (3) *listening to TV/radio.* Perhaps not surprisingly, the results of Kruskal-Wallis ANOVAs on the data for each of the relevant COSI categories revealed that there were no statistically significant differences in Final Ability outcomes as a function of Age Group.

HDSS

Figure 3 shows the mean baseline to post-intervention change scores and standard deviations for satisfaction with device features and in various listening situations. It can be seen that across all three age groups, mean satisfaction ratings were much higher for the HA+FM participants than for the HA-Alone participants. When the HDSS change score data were subjected to a two-way ANOVA, the effect of Intervention Arm was found to be significant (F (1,30) = 7.99, p = .008) but the effect of Age Group was not (F (2,30) = .074, p = .929). Further, the interaction between Intervention Arm and Age Group was not statistically significant (F (2,30) = .106, p = .900) That is, the change in satisfaction over the study period was higher for those who were provided with FM devices than for those who simply continued to

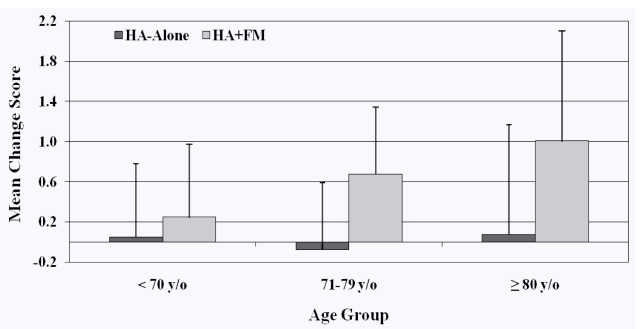

Figure 3. Mean change scores (+ 1 standard deviation) for the Hearing Device Satisfaction Survey as a function of age group and intervention arm.

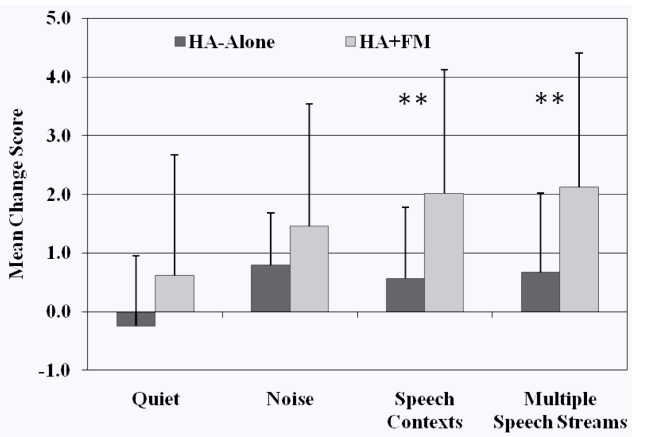

Figure 4. Mean change scores (+ 1 standard deviation) for the SSQ pragmatic Speech scale scores as a function of intervention arm.

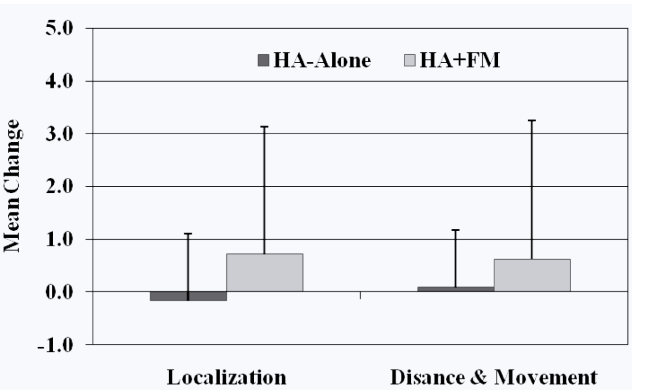

Figure 5. Mean change scores (+ 1 standard deviation) for the SSQ pragmatic Spatial scale scores as a function of intervention arm.

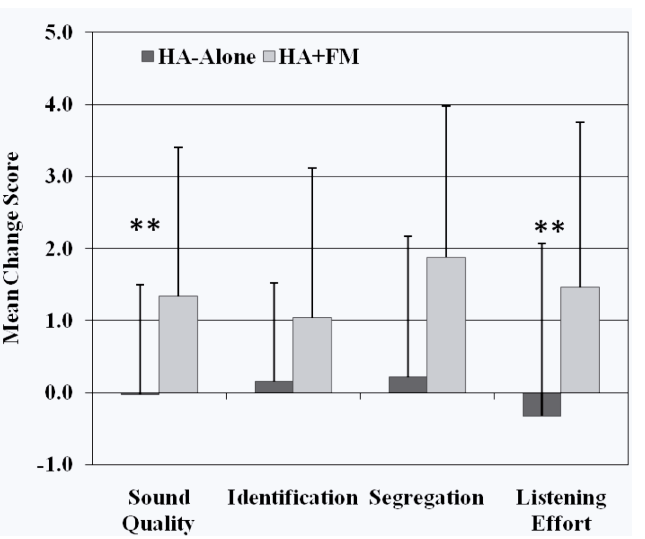

Figure 6. Mean change scores (+ 1 standard deviation) for the SSQ pragmatic other Qualities scale scores as a function of intervention arm.

utilize their custom-fit hearing aids, and although there was an observable difference as a function of Age Group, most likely due to the small *n*, the effect of Age Group was not a significant factor.

SSQ

Figures 4–6 show the mean change scores and standard deviations as a function of Intervention Arm for the Speech, Spatial and Qualities pragmatic scale scores, respectively. Although mean change scores are higher for the HA+FM participants than for the HA-Alone participants for all pragmatic scale scores, not all of the differences between the intervention arms were statistically significant. Differences that were significant ($p < .01$), as determined through between-groups t-tests, are highlighted with asterisks in the figures.

	Age Group		
	< 70	**70–79**	**80**
Pragmatic Scale			
Speech-in-Speech Contexts	3.1	1.8	1.2
Multiple-Speech Stream			
Processing & Switching	3.2	1.8	1.6
Sound Quality & Naturalness	1.0	1.4	0.9
Listening Effort	2.0	1.8	1.3

Table 5. Mean SSQ Pragmatic scale change scores for the HA+FM participants as a function of the three Age Groups.

For the pragmatic Speech scales (Figure 4), statistically significant differences as a function of Intervention Arm were found for listening to *Speech-in-Speech Contexts* and for *Multiple-Speech Stream Processing & Switching.* There were no significant differences in Spatial pragmatic scale change scores (Figure 5). For the pragmatic Qualities scales, significant differences as a function of Intervention Arm were found for *Sound Quality & Naturalness,* as well as *for Listening Effort.* Three of these findings are not particularly surprising (e.g., *Speech-in-Speech Contexts, Multiple-Speech Stream Processing & Switching, Listening Effort)* as by improving signal-to-noise ratio over that which can be obtained with directional microphone hearing aids, FM systems, could be hypothesized to make more resources available for listening when speech is the interfering signal, and thus result in reduced listening effort. Of interest was the finding for *Sound Quality & Naturalness,* as there was no a priori reason to expect outcomes to be better with FM systems than with hearing aids alone.

For each of the pragmatic scale scores which showed significant effects of Intervention Arm, the effect of Age Group was examined for the HA+FM participants, as shown in Table 5. It can be seen that for *Speech-in-Speech Contexts, Multiple-Speech Stream Processing & Switching, Listening Effort* there was a systematic decrease in change score magnitude as Age Group increased. Although this pattern was observed, between-group ANOVAs failed to find a significant effect of Age Group ($p > .05$) for any of these three pragmatic scale scores.. As with the HDSS, it is most likely that the lack of finding statistical significance for the observable systematic changes with Age Group is a result of the relatively small number of participants within each group. While the effect of Age Group was not statistically significant for the *Sound Quality & Naturalness* ($p > .05$) pragmatic scale, the observed pattern of change scores did not appear to be systematically related to age.

Decision to continue use of FM systems

In our work with FM systems in adults (Chisolm et al., 2007), we have proposed that the "gold standard" outcome is the decision to continue use of FM systems at the end of the trial period. Indeed, in early research with FM with adults (e.g., Jerger et al., 1996; Boothroyd, 2004; Lewis et al., 2005), few to none of the participants elected to utilize FM systems at the end of the study protocols. Boothroyd (2004) believed the lack of continued FM use was due to a need for the provision of more systematic counseling, coaching and instruction. Thus, in our work, we have elected to provide verbal, written, and role-playing activities to demonstrate the appropriate use of FM systems. Such an approach was also utilized in the present study and 16 of the 18 participants who had a trial period with FM systems elected to continue use. While one of the participants who elected not to continue FM use was in the oldest age group, the other was in the youngest age group. Thus "age" did not appear to influence the decision to continue FM use.

Summary and Conclusions

In the present study, the outcomes of the use of FM systems in a group of older veterans who were users of custom-fitted hearing aids were examined: (a) to determine whether older adults benefited from the use of FM

devices; and, (b) to determine if there were any observable effects of age on outcomes. Outcomes were assessed in terms of the ability to meet individualized goals as measured through the COSI procedure; satisfaction as measured with selected MarkeTrak items, averaged to provide a Hearing Device Satisfaction Score; and, in terms of perceived benefit as measured through the SSQ.

In general, outcomes were better for veterans fitted with FM devices in addition to their hearing aids than they were for a control group of veterans who utilized hearing aid alone. Thus, it is reasonable to conclude that older adults do benefit from the use of FM systems. With regard to age, the participants were divided into three groups for the purpose of analyses: < 70 years old, 71–79 years old, and ≥ 80 years old. While no statistically significant differences were found as a function of Age Group, it is important to remember that the division of participants into the age groups was completed retrospectively and the number of participants within each age group was relatively small. Thus, it is important to consider observed patterns of responses as results obtained in a prospective study with equal and larger numbers of participants with the various age groups might demonstrate statistical significance. With regard to meeting individualized goals, there were no apparent effects of Age Group. Age group effects, however, were observed for satisfaction, with older participants indicating higher overall satisfaction; and, for three of 4 SSQ pragmatic scale scores (i.e., *Speech-in-Speech Contexts, Multiple-Speech Stream Processing & Switching, Listening Effort),* with somewhat lower scores for older Age Groups. Taken as whole, these data suggest that there may be some influences of age which should be examined more thoroughly in future research.

Although there may be some influences of age on outcomes of FM use, the data reported here clearly indicate that there are many benefits of FM use in older adults. Indeed, when provided with appropriate counseling, coaching and instruction, the majority of older adults elected to continue FM use at the end of the trial period. Thus, when working with older adults whose listening needs include situations in which having a "third ear" can be beneficial, audiologists need to remember that FM systems are an important and integral component of their audiological intervention "toolboxes", regardless of a person's age.

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