The FM Benefit Counseling Tool (FM-BCT): Initial Stages of the Development of a Tool for Assessing the Benefit of FM Amplification from the Perspective of Adult Cochlear Implant Users

L'outil de consultation sur les avantages du système MF (FM-BCT) : Les étapes initiales de mise au point d'un outil pour évaluer les avantages d'un système MF selon le point de vue des adultes munis d'un implant cochléaire

KEY WORDS

COCHLEAR IMPLANT

ASSISTIVE TECHNOLOGY

SPEECH PERCEPTION

NOISE

QUESTIONNAIRE

FM SYSTEM

Philippe Fournier
Elizabeth M. Fitzpatrick
Christiane Séguin
Shelly Armstrong
Josée Chénier
David Schramm

Philippe Fournier, M.Sc.S. Audiologist, Ph.D. candidate
BRAMS
University of Montreal,
C.P. 6128 Station Centre ville,
Montreal
QC, Canada

Elizabeth M. Fitzpatrick
University of Ottawa,
Faculty of Health Sciences,
Ottawa, ON
Canada

Christiane Séguin
Ottawa Hospital,
Civic Campus,
Auditory Implant Program
Ottawa, ON
Canada

Shelly Armstrong
Ottawa Hospital,
Civic Campus,
Auditory Implant Program
Ottawa, ON
Canada

Josée Chénier
Ottawa Hospital,
Civic Campus,
Auditory Implant Program
Ottawa, ON
Canada

David Schramm
University of Ottawa,
Department of Otolaryngology
Head and Neck Surgery
Ottawa, ON
Canada

Abstract

Purpose: The purpose of this study was to undertake the first phase of the development of a clinical tool (questionnaire), the FM Benefit Counseling Tool (FM-BCT) to address both the perceived benefits associated with the use of a frequency modulated (FM) system and the factors affecting use.

Research Design: Twelve adults who used a unilateral cochlear implant participated in this phase of the study. This research involved a descriptive analysis using cross-sectional and qualitative data collected during a previous study (Fitzpatrick et al., 2010). Participants recorded their experiences using a personal FM system in a journal during a two-month trial period and responded to a questionnaire at the end of the trial.

Data Analysis: Comparisons were made between the journal entries and the questionnaire responses by examining data in all situations to assess the reliability of using a questionnaire to evaluate benefit. The questions included in the first section of the FM-BCT aim to consider clients' perception of benefit of an FM system. The content validity of this section was assessed by refining the most common situations from the journal entries and by evaluating the helpfulness rating for each of these situations. The second section addresses the factors that may influence the user's perceived benefit and is grounded in a thorough literature review.

Results: The assessment of the most common situations in the journal entries confirmed that the items presented in the questionnaire were the most relevant for cochlear implant users. Helpfulness ratings collected through the questionnaire at the end of the trial period compared favorably with the journal entries logged during the entire trial period. Analysis of the data showed no evidence of discrepancies between the journal entries and the questionnaire responses.

Conclusions: These results suggest that the new FM-BCT captures the most relevant listening situations for FM system use and can reliably assess client perception of benefit of FM system use in everyday life. The tool can also assist clinicians in identifying the factors that impact clients' willingness to use an FM system. Although a comprehensive and systematic validation needs to be carried out, this research is the first step in the validation of this new tool.

Abrégé

Objectif : Cette étude avait pour but de réaliser la première phase de la mise au point d'un outil clinique (questionnaire), l'outil de consultation sur les avantages du système MF (FM-BCT), pour résoudre à la fois les avantages perçus liés à l'utilisation d'un système de modulation de fréquence (MF) et les facteurs touchant son utilisation.

Conception de la recherche : Douze adultes porteurs d'un implant cochléaire unilatéral ont participé à cette phase de l'étude. La recherche consistait en une analyse descriptive à partir de données transversales et qualitatives recueillies au cours d'une étude antérieure (Fitzpatrick et coll., 2010). Les participants ont consigné leurs impressions sur l'utilisation d'un système MF personnel dans un carnet durant une période d'essai de deux mois et ils ont répondu à un questionnaire à la fin de l'essai.

Analyse des données : Nous avons effectué des comparaisons entre les entrées du carnet et les réponses au questionnaire, en examinant les données issues de toutes les situations afin de déterminer la fiabilité d'utiliser un questionnaire pour évaluer les avantages. Les questions comprises dans la première section du FM-BCT visaient à étudier les perceptions des clients face aux avantages de l'utilisation d'un système MF. Nous avons évalué la validité du contenu de cette section en raffinant les situations les plus courantes extraites des entrées du carnet et en établissant la cote d'utilité de chacune de ces situations. La deuxième section traitait des facteurs pouvant influer sur les avantages perçus des utilisateurs et elle repose sur un examen approfondi de la littérature.

Résultats : L'évaluation des situations les plus courantes se trouvant dans les entrées du carnet a confirmé que les aspects présentés dans le questionnaire étaient les plus pertinents pour les utilisateurs de l'implant cochléaire. Les cotes d'utilité recueillies grâce au questionnaire à la fin de la période d'essai se comparaient favorablement aux entrées consignées dans le carnet durant toute la période d'essai. Une analyse des données n'a montré aucune différence entre les entrées du carnet et les réponses au questionnaire.

Conclusions : Ces résultats laissent entendre que le nouveau FM-BCT saisit les situations d'écoute les plus pertinentes pour l'utilisation d'un système MF et peut évaluer en toute fiabilité la perception des clients face aux avantages d'utiliser un système MF au quotidien. L'outil peut également aider les cliniciens à déterminer les facteurs influant sur la disposition des clients à utiliser un système MF. Bien qu'on doive mener un exercice de validation vaste et systématique, cette recherche constitue la première étape d'un processus de validation de ce nouvel outil.

Individuals with hearing loss experience considerable difficulty with speech understanding in suboptimal listening environments such as background noise and group interactions (Bronkhorst, 2000). A remote microphone system such as a frequency modulated (FM) system is one of the many assistive listening technologies that can be offered to individuals with hearing loss. These devices, which include both sound field and personal FM systems, have been recommended for children with hearing loss in educational settings for many years (Anderson, Goldstein, Colodzin, & Inglehart, 2005; Flexer, 2004). A personal FM system (individually worn FM device) consists of a wireless microphone worn by the speaker and a receiver worn by the listener. The microphone captures the speaker's voice and the signal is transmitted directly to the listener via the FM system. The speaker's voice is the predominant signal captured by the microphone, thereby reducing the effect of distance between the speaker and the listener and decreasing the negative effects of background noise. These systems increase the signal-to-noise ratio and the signal-to-reverberation ratio to enhance the overall listening conditions for the user.

The benefits of these remote microphone systems have been documented for adults with hearing aids (Boothroyd, 2004; Chisolm, Noe, McArdle, & Abrams, 2007; Jerger, Chmiel, Florin, Pirozzolo, & Wilson, 1996). Even though these studies reported significant benefits related to the use of FM systems, investigators also highlighted that several non-audiologic factors contributed to the decision to use an FM system in everyday life situations. Jerger et al. (1996) reported that even though many individuals preferred the sound quality of the FM system, 175 of 180 participants indicated that they preferred to use hearing aids alone in their daily life. The study concluded that factors particularly associated with individuals' perceptions of the inconveniences of using an FM system with relatively large transmitting/receiver components and wired connections might have accounted for the lack of adoption of FM systems. Similarly, Boothroyd (2004), found that despite measurable improvements on phoneme recognition in noise using an FM system in a laboratory setting, adult hearing aid users did not indicate an intention to acquire the device at the end of a two-week trial period. The author suggested that factors such as cost, esthetics and the lack of counseling might have interfered with the final decision to acquire the device.

A recent study conducted by Chisolm et al. (2007) attempted to control some of the factors such as costs and counseling, that potentially interfere with FM system use in everyday life. Thirty-five adult hearing aid users recruited through the National Veteran's program were provided with considerable counseling, instruction and coaching throughout an extended six-week trial period. All participants continued using the FM system after the trial period. Communication using the FM system coupled to hearing aids was reported to be superior to hearing aids alone. However, the study was unable to identify differences in users' self-perception of quality of life when using a hearing aid alone versus with an FM system. The authors concluded that despite the benefits of the FM system, equipment-related aspects including battery charging and connecting units to hearing aids might have partially offset the perceived benefits.

Benefits related to FM system use have also been reported for cochlear implant users both in children (Davies, Yellon, & Purdy, 2001; Schafer & Thibodeau, 2006) and in adults (Fitzpatrick, Seguin, Schramm, Armstrong, & Chenier, 2009; Schafer & Thibodeau, 2004; Schafer, Wolfe, Lawless, & Stout, 2009; Wolfe & Schafer, 2008). In a laboratory setting, Shafer and Thibodeau (2004) documented improvements in speech recognition in quiet for eight adults in the FM versus no-FM condition. Fitzpatrick et al. (2009) recently reported significant improvements for adults who used an FM system coupled to their implant both for open-set sentence recognition in noise and for television listening. Two studies that investigated the benefits of FM systems for adult clients in order to make recommendations for optimization with a cochlear implant (Schafer et al. 2009; Wolfe & Schafer, 2008), concluded that FM technology offers significant advantages over the cochlear implant alone in noisy listening environments. In addition to improvements in speech understanding, positive attitudes toward the everyday benefits of FM systems for adults were also documented through questionnaires (Wolfe & Schafer, 2008) and via both questionnaire and journal entries during a trial period (Fitzpatrick et al., 2010). Although these questionnaires were not validated or standardized, the information collected complemented other measures in documenting the subjective benefits of FM systems. While the results obtained from these questionnaires seemed to corroborate other measure of improvements documented in the studies, the lack of standardization and validation limit their clinical application. It is also important to note that the principal focus for hearing aid benefit questionnaires has been the assessment of benefits with little attention accorded to the influencing factors. Fitzpatrick et al. (2010) documented a spectrum of perceived advantages such as ease of listening and reduction of background noise related to use of the FM systems in everyday life situations in an adult

cochlear implanted population. However, this study also found that several factors identified as environmental, technical, social and individual characteristics may interfere with the implant user's decision to wear an FM system in everyday life. These findings highlight the importance of assessing not only the benefits of FM system use but also the factors which may influence the individual user's experience.

Taken together, these studies provide evidence from laboratory and real-world settings that coupling an FM system provide advantages over the use of hearing aids or cochlear implants alone for adult users. Despite the documented benefits, there appears to be low penetration of FM systems among the adult population of cochlear implant users. Fitzpatrick et al. (2009) reported that less than 10% of implant recipients from a clinical population of 300 adults used FM systems. It is unclear to what extent these results are due to users' reluctance to use additional devices with their cochlear implants or from lack of recommendations from audiologists. Schafer and Thibodeau (2004) have suggested that this situation may be due to the lack of information available for audiologists regarding the use and benefits of FM systems or other remote microphone technologies. Another possible explanation may be the limited availability of outcome measures that are specific to the assessment of FM systems. Audiologists may be reluctant to recommend a system in the absence of suitable tools to assess client benefits. To our knowledge there are no available validated and standardized questionnaires to assess the benefit of FM systems. In contrast, several self-report outcome questionnaires addressing benefit, satisfaction and quality of life, are widely available for the assessment of hearing aid fitting outcomes in real-world situations. Examples of such questionnaires for hearing aid users include the Client Oriented Scale of Improvement (COSI) (Dillon, James, & Ginis, 1997), the Abbreviated Profile of Hearing Aid Benefit (APHAB) (Cox & Alexander, 1995), the Hearing Handicap Inventory for the Elderly (HHIE) (Ventry & Weinstein, 1982), and the Glasgow Hearing Aid Benefit Profile (GHABP) (Gatehouse, 2000). Although some of these instruments may be useful for the assessment of a personal FM system fitting, they were not specifically designed for that purpose and therefore the situations presented are not sufficiently sensitive to capture the benefits of an FM system. Moreover, these questionnaires provide a measure of outcome on topics such as benefits and satisfaction from hearing aids without probing the factors influencing the users' perceptions. Consequently, a positive outcome on a questionnaire may provide insight on the success of the fitting while a more negative result does not provide the practitioner with any information that might enhance the fitting process for the specific individual.

The use of self-report measures of real-world outcome has gained importance in the audiology field for at least three main reasons (Cox, 2003). First, health care services have evolved to become more consumer-driven, that is, the client's point of view has become recognized as an important indicator of the outcome of intervention. Second, there is an understanding that many real-world experiences cannot be translated or simulated efficiently in a laboratory setting. The use of any amplification system/auditory implant in everyday life is a complex and dynamic process involving more factors than those that can be measured in the laboratory. Finally, the client's own impressions of actual real-life experiences cannot be documented in a laboratory setting even if acoustic conditions are close to the real-life listening situation.

There is a need for an outcome measure specific to the FM system, one that includes the assessment of the different factors influencing use. Such an instrument can help provide an evidence base for FM system recommendations and practices. Self-reported measures are becoming a gold standard measure as it is well recognized that client perception of benefit determines the success or failure of treatment (Taylor, 2007). The overall purpose of this research was to create a clinical evaluation tool specific to the FM system for the adult cochlear implant population. The intent was to develop a client-directed tool to address both the perceived benefits associated with the use of an FM system and the factors affecting those benefits. A model of FM system use (see figure 1.) generated from a previous study (Fitzpatrick et al., 2010) provided the starting point for the new questionnaire (FM-BCT). Based on further review of the literature, we refined the model initially proposed to include two additional components; outcome measures and counselling (Cox, 2003; Taylor, 2007). In this phase, we assessed the reliability and the content validity of a research questionnaire (adapted from Boothroyd, 2004) in order to design the new clinical questionnaire (FM-BCT).

Methods

Settings and Participants

Details of the settings and participants are reported in a previous paper (Fitzpatrick et al., 2010) and are summarized briefly here. As part of a study investigating several aspects of FM and cochlear implant use, 14 adults with postlinguistic deafness were recruited through the University of Ottawa Auditory Implant Program. The 10 women and four men were between the ages of 48 and

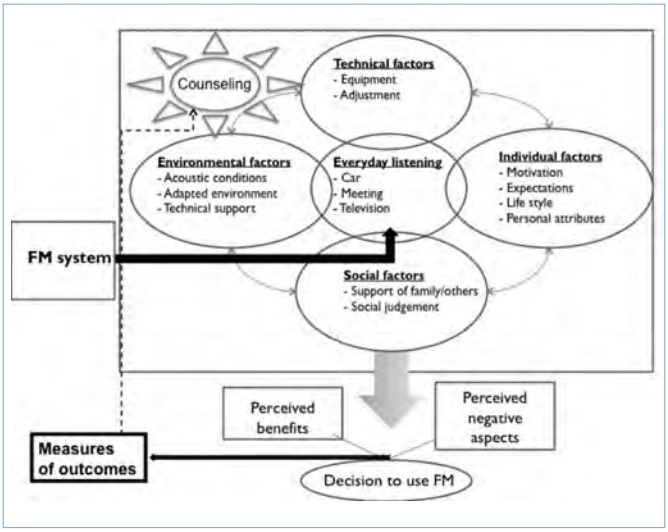

Figure 1. Revised Model of FM use. (From Fitzpatrick, E. M. et al. (2010). Users' perspectives on the benefits of FM systems with cochlear implants. *International Journal of Audiology, 49*(1), 44-53. Reprinted with permission).

71 years and duration of cochlear implant use ranged between 1.0 and 6.4 years. All participants used an Advanced Bionics speech processor (Auria or Harmony) with the exception of one participant who used a Nucleus Freedom speech processor. Only 12 participants were retained for the analysis of the current study as two of them did not submit a completed journal at the end of the two-month field trial (Table 1).

Procedures and equipment

As described in detail in our previous work (Fitzpatrick et al., 2010), all participants were seen individually for fitting and counseling during a one-hour session, in which they were provided with a Sennheiser Mikroport FM system 2015 for a period of two months. The Sennheiser system consists of a transmitter (SK 2015) and body-worn receiver unit (EK 2015). Participants were encouraged to explore all possible opportunities to use their FM system. They were asked to complete a journal entry each time the FM system was worn and to record the following information: (1) listening environment and activity; (2) amount of time worn during each activity; (3) a rating of the utility of the system ranging from not helpful at all to very helpful; and (4) their qualitative comments on speech understanding, benefits and limitations of the system and other related observations. At the end of the trial period, the participants also completed a brief questionnaire from a published study that examined the benefits of FM systems for adult hearing aid users (Boothroyd, 2004). The first section of the questionnaire consisted of 15 items designed to probe users' perceptions of FM system benefit in common listening situations: quiet, noise, church, television viewing, and restaurant (adaptation from Boothroyd, see Fitzpatrick et al., 2010). The second section included three open-ended questions: (1) What did you like about this equipment? (2) What problems did you encounter? and (3) Is this something you might wish to acquire? A fourth question was added to document previous experience with FM systems (with hearing aids or cochlear implants).

Current Study

The principal purpose of this study was to validate the first section (assessment of perceived benefits) of the research questionnaire (Boothroyd, 2004) in order to create the new questionnaire (FM-BCT). One focus of this phase was the analysis of the data from the journal entries. A total of 169 journal entries were collected from 12 participants who used an FM system coupled to a unilateral cochlear implant during an approximate two-month period resulting in an accumulated total of at least 230 hours. This first step aimed to assess the content validity of the first section. The content validity refers to the degree to which a measure covers the full range of behaviours of the ability being measured (Clark-Carter, 1997). In this study, the content validity involves the most common situations in which individuals experienced benefit from the FM system. We first assessed the most common everyday situations in which the FM system was reported to be beneficial, based on the 169 journal entries to ensure that the new questionnaire (FM-BCT) included these situations. We also assessed the situations where the FM system was reported to be the most helpful in the journal to again ensure that these were included in the questionnaire. In addition, we conducted a careful analysis of participants' comments to detail the various situations in which the FM system was used.

The second step of the analysis involved an assessment of the reliability of section one of the research questionnaire (Boothroyd, 2004) in order to create the new questionnaire (FM-BCT). Specifically, we wanted to examine whether a questionnaire such as the one developed by Boothroyd (2004) and used in our past study (Fitzpatrick et al., 2010) could adequately capture the overall experience of adult cochlear implant users during an FM trial period. Comparisons were made between the most common situations extracted from the journal entries and the situations that were included in the completed Boothroyd (2004) questionnaires following the FM trial period. Two participants were excluded from the comparison analysis because they did not complete the entire Boothroyd questionnaire, leaving information from 10 participants available for

Table 1. Description of 12 participants

Participant Number #	Sex	Age at CI (yr)	Duration of severe loss (yr)	Duration CI use (yr)	PTA Implant ear (dB HL)	PTA Contralateral ear (dB HL)	Pre-study HINT-Q (%correct)[1]	Pre-study HINT+10 (% correct)[1]
1	M	48	28.4	4.7	115	113	97	69
2	F	59	1.1	3.2	87	75	97	45
3	M	55	6	2.4	100	112	100	99
4	F	71	20.8	4.7	100	88	77.5	34.5
5	F	51	15.7	3.4	98	103	100	97
6	F	51	11	6.4	97	97	100	90
7	F	47	6	3.7	90	132	99.1	87.6
8	M	51	1.4	1	98	103	94	82
9	F	65	0.5	4.2	83	102	98.2	79
10	F	40	1.8	4.5	100	103	95	67.5
11	F	60	4.3	4.1	115	125	76.5	56
12	F	52	3.5	5.5	102	98	79	28

CI: cochlear implant; PTA: pure-tone average (500, 1000, 2000 Hz); HINT-Q: Hearing in Noise Test administered in quiet; HINT+10: HINT administered at signal-noise ratio of +10 dB. 1Tests administered at 60 dB SPL except for Participants 1 and 15 (70 dB SPL).

this analysis. The comparison of the journal entries and the questionnaire responses involved an examination of both individual and group data in all listening situations. All analysis involved descriptive statistics of proportion and frequency and were carried out using SPSS 16.

The second purpose of this study was to generate questions for the FM-BCT to assess the factors influencing clients' perceptions of benefit. The content of the questions were anchored within the model (Figure 1) from our previous study (Fitzpatrick et al., 2010) and from a thorough literature review (Table 2).

Results

Journal Results

Figure 2 presents, in order of frequency of use, a summary of the situations in which the FM system was worn with the implant throughout the two-month trial period. The pattern of utilization is shown as the total number of times the FM system was used in a particular situation, the total number of hours of FM use and the number of different participants reporting use for the listening situation. As shown, the most frequently occurring single activity was television

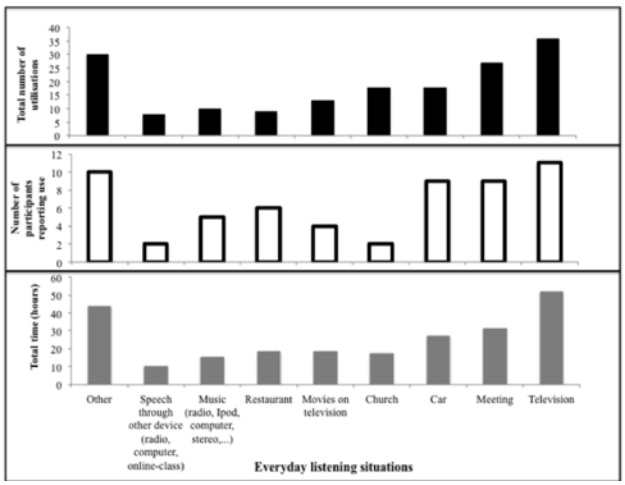

Figure 2. Frequency, hours and number of different participants reporting use of the FM system in everyday listening situations (12 adults, 169 journal entries) over a two month trial period.

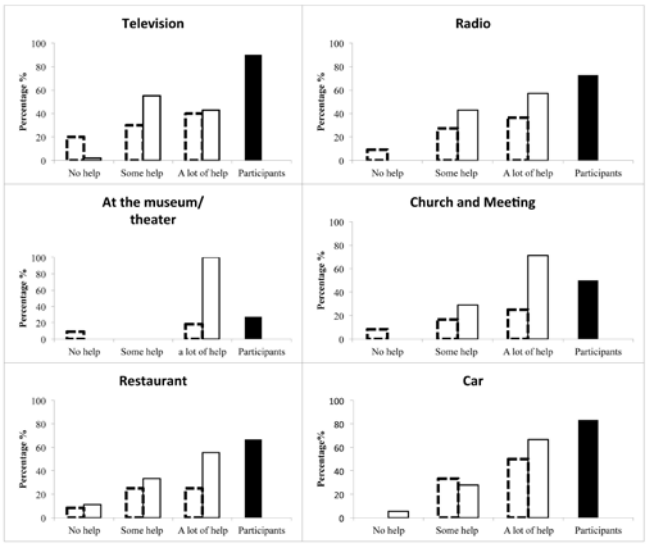

Figure 3. Overall percentage for each helpfulness rating for the Boothroyd questionnaire (dashed line) and for journal entries (continuous line) in each listening situation. The black column represents the percentage of participants who reported the particular situation.

watching where the FM device was used 36 times for a total of 51.7 hours. Other common listening situations with high FM use included meetings, car travel, and church. During the trial period, 11 of 12 participants tested the FM system with the television, making it the most common situation for FM use. Nine participants reported use during car travel and during meetings. As shown in Figure 2, the device was used less frequently for movies and restaurants with a total of 13 (18.5 hours) and 9 (18.5 hours) events respectively. The section entitled "other" in Figure 2 groups all of the less common situations of use and included several diverse activities such as shopping and horseback riding. Figure 3 presents the helpfulness rating of the journal entries and the Boothroyd questionnaire for the most common situations. The number of participants reporting use was also added to the graph. As shown in Figure 3, the helpfulness rating in all situations except "museum/ theatre" was similar between the journal entries and the Boothroyd questionnaire. For the "museum/theatre" situation, all participants reported the FM to be very helpful in the journal entries but one participant reported this situation as not helpful in the Boothroyd questionnaire.

Comparison of Overall Journal and Questionnaire Responses

Figure 4 presents the comparison in percentage of responses between the 169 journal entries and the overall helpfulness item of the Boothroyd questionnaire. For each journal entry describing a listening situation during the FM trial period such as watching television, the participants provided a rating of helpfulness (not helpful at all, a little helpful, somewhat helpful, very helpful). The ratings for all listening situations reported in the journals were combined across all participants to yield a percentage of responses for each of the four rating categories. Figure 4 shows a comparison between these journal results and participants' rating of overall helpfulness (worse, a little help, some help, a lot of help) on the Boothroyd (2004) questionnaire. To facilitate comparison, the questionnaire categories labelled as "some help" and "a lot of help" were reclassified as somewhat helpful and very helpful. A comparison was then made between the percentage of responses of overall helpfulness on the questionnaire and the percentage of helpfulness for all situations in which the FM system was used during the trial period for all participants. As shown in Figure 4, 8 of 10 (80%) participants rated the FM system as very helpful when rating overall helpfulness on the Boothroyd (2004) questionnaire, and 2 of 10 (20%) found it somewhat helpful. No participants at the end of the trial period reported that the system was of little help or interfered with understanding. Results of the journal entries showed that participants rated the FM system to be very helpful 58% of the time used, somewhat helpful 30% of the time, a little helpful 8% of the time, and not helpful at all 4% of the time. Overall, based on their experiences during a two-month trial

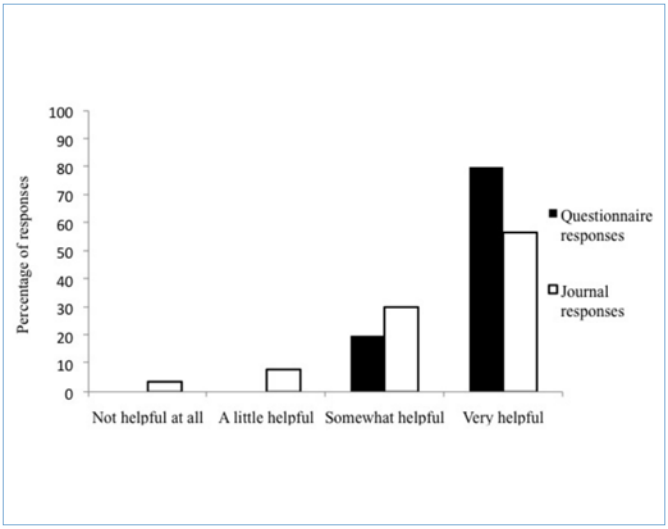

Figure 4. Comparison between the overall helpfulness rating from the entire journal entries for all participants and the rating of overall helpfulness of the FM system on the Boothroyd (2004) questionnaire (10 participants).

period, participants rated the FM system to be very or somewhat helpful 88% of the time.

Comparison of Individual Journal and Questionnaire Responses

Figure 5 displays a comparison of individual participants rating of overall helpfulness on the Boothroyd (2004) questionnaire and their ratings of helpfulness in the journal entries. This individual comparison permitted an examination of whether the global helpfulness rating of all the journal entries collected over a two-month period for a specific individual was consistent with the overall helpfulness rating from the participant's questionnaire at the end of the trial period. As shown in Figure 5, 8 of 10 participants provided a helpfulness rating for the questionnaire that corresponded to the most frequently occurring rating of their experience in various listening situations during the trial period (sum of the helpfulness of all journal entries for a given individual). For example, participant #1 rated the FM system as very helpful on the questionnaire and also rated their journal-documented experiences as very helpful 21 out of 28 times used. Participant #7 provided a "somewhat helpful" rating on the questionnaire and also rated the FM as somewhat helpful for 9 of a total of 11 listening experiences logged in the journal. Two of 10 participants (#2, #10) rated the FM system as more helpful in the questionnaire than in their overall rating of situations in the journal. Participant #2 judged the FM device to be very helpful when completing the questionnaire but rated the FM as very helpful only 1 of 11 times in the journal.

The FM Benefit Counseling Tool (FM-BCT):

The new questionnaire, the FM Benefit Counseling Tool (FM-BCT) (Appendix 1) resulting from our research is comprised of two sections. The aim of section one of the FM-BCT is to evaluate cochlear implant users' perceived benefit of the use of an FM system in real-world difficult listening situations. The items of this section are primarily based on the Boothroyd (2004) questionnaire that was administered during the previous study. However, the 10 common listening situations in the original Boothroyd questionnaire were expanded to include 12 situations based on our analysis. In the FM-BCT, the meeting and church situations were divided into two distinct items as all participants who reported FM use during these two situations described them as very different listening activities. As illustrated by the following participant comments, a meeting was described as a discussion with a large number of speakers while church was described as a single speaker at a distance, a listening experience that is very similar to a lecture.

Meeting

Meeting 10 people: « Very good, simply put the transmitter on the table – All went well except for one person who was very soft spoken. » (Participant #7)

Church

Church: « I had our priest Father X wear the transmitter during Sunday a.m. mass. It's a Catholic mass with a small chair and a half-full church. The entire mass was wonderful. I don't think it could have been any better. Father is from Nigeria and has an accent but I've known him for several years. I've never fully understood him doing the mass. Today, he was crystal clear and his voice was very distinct. …» (Participant #5)

Lecture

Did a presentation for a group of 15 people: « Small room [with] conference table for my microphone. Worked well enough, used as a tracking tool to group I was presenting to. Most of them were hard of hearing. Wires seem to intimidate them a bit (me too!) but [they] were impressed with my ability to hear so well. Quality of sound - excellent. » (Participant #7)

Listening to music and listening to speech were also described as very different from listening to the radio. This may be because, as technology evolves, music and speech are not only radio-based activities but are also provided by devices such as computers, MP3 players and other electronic devices. As indicated in the examples below, individuals with cochlear implants may also

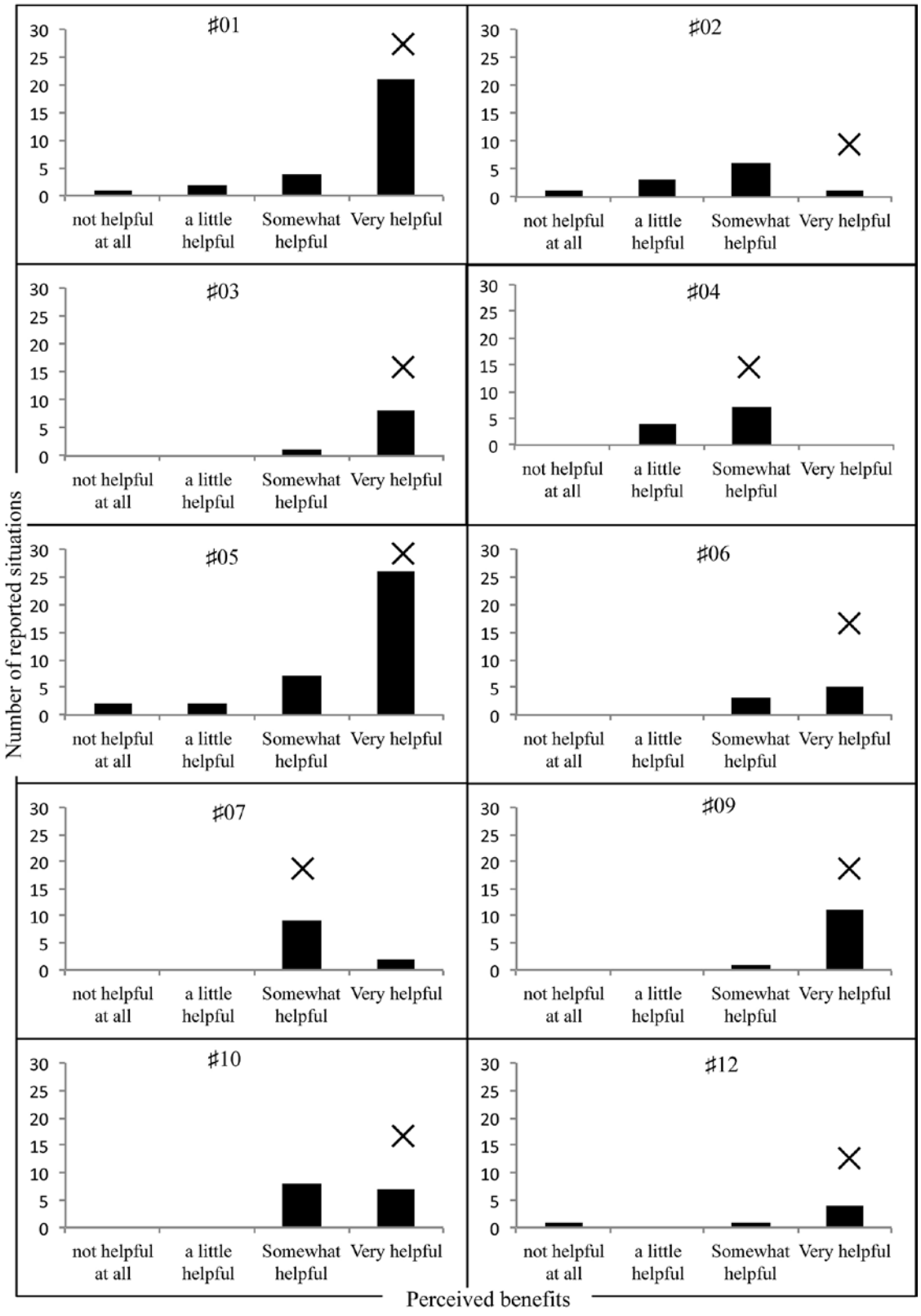

Figure 5. Comparison between overall helpfulness rating from the entire journal entries and overall helpfulness rating on the Boothroyd (2004) perceived benefit questionnaire for 10 participants. The X refers to the questionnaire rating of "Overall" helpfulness.

differentiate these two listening situations based on the need to directly couple their speech processor to electronic devices whereas this does not typically apply to listening to speech, for example on the radio.

Music

Listening to music on computer: « This is great! Allows a wireless direct hook up to music + video stored on my computer. CI direct input (I was told) should never be used with non-battery, AC powered devices. But, with the FM system I can plug FM transmitter into headphone output on computer and listen to music anywhere in my apartment and still talk to my wife… » (Participant #3)

Speech

Listening to an on-line class: « I attached the speaker on the FM system close to the computer. I listened to an on-line course that we had at work. The quality of speech was very good and I was able to understand all but one of the speakers who talked very quickly. » (Participant #10)

All other situations from the Boothroyd (2004) were retained as they were consistent with the most common situations reported in the journal entries and with those reported as most helpful in both the journal entries and the Boothroyd questionnaire.

In the new questionnaire, using Likert-scaled items, participants will rate their perception of the benefit of the FM system in each of the 12 listening environments. In the original Boothroyd questionnaire, a choice of five ratings is available for each situation: Not used, Made things worse, No help, Some help, and A lot of help. These were retained for the FM-BCT and one additional label was added: Not required in that situation. This new response option was added based on our analysis of all participants' journal entries. Most participants made a clear distinction between a situation where they perceived that the FM system was not required and a situation where they judged the FM system might have been helpful but they opted to not use it for various reasons that fell into the categories of environmental, technical, social or individual factors. This is potentially an important distinction and counseling may differ depending on which of these factors apply to the listening situation.

The purpose of section two of the FM-BCT is to assess the factors that may influence the implant user's perceived benefit of the FM system and consequently the final decision to use an FM system in everyday life situations. The questions are based on a literature review of studies that have addressed factors affecting FM use (Table 2). The most recurrent factors identified were technical factors, individual factors, environmental factors and social factors which are probed in the questionnaire. As shown in the questionnaire (Appendix 1), this section consists of a total of 13 questions, 11 that are related to the four categories of factors that potentially affect FM use. The impact of the factor is rated on a five-point scale ranging from 1 (never) to 5 (always). In addition, users are given the opportunity of providing descriptive comments related to their experience. Two additional questions that were included from Boothroyd (2004) questionnaire probe previous FM system experience and users' intention to acquire an FM system following the initial trial period.

Discussion

Investigation of the benefits and difficulties associated with FM systems for cochlear implant users' has received little attention in the literature. While a few published studies suggest that FM systems can enhance listening opportunities for individuals with cochlear implants (Fitzpatrick et al., 2009, 2010; Schafer et al., 2009; Wolfe & Schafer, 2008), little guidance has been available for clinicians to evaluate their FM system fittings with these clients and to assist in counseling them as they adapt to the additional technology. The findings from a previous study (Fitzpatrick et al., 2010) pointed to the influence of multiple factors that impact FM system use for adults with a cochlear implant. It was therefore considered important that a clinical tool be developed to not only assess functioning but also factors that facilitate or hinder positive outcomes in everyday life with an FM system.

The present study was designed to create a clinical tool to assess the adult cochlear implant users' perceived benefit from an FM system as well as the factors influencing the users' experience with an FM system. A review of the literature and further analysis of findings from our previous research (Fitzpatrick et al., 2010) provided the foundation for a new questionnaire. The first section of the FM-BCT was based on a modified version of the Boothroyd Perceived Benefit questionnaire (2004). The new questionnaire includes the more relevant difficult listening situations identified in the literature (Boothroyd, 2004; Fitzpatrick et al., 2010; Wolfe & Schafer, 2008). These situations were also consistent with those reported in the journal entries in our previous research. In this subsequent research, we conducted further analysis of 169 detailed journal entries and responses to the Boothroyd questionnaire. Using group analysis, the results showed that generally adult cochlear implant users' ratings of overall FM system helpfulness in the Boothroyd questionnaire were comparable to their ratings of individual listening

Table 2. Published papers on FM system utility and factors influencing FM use

Authors, year	Boothroyd, 2004	Wolfe and Schafer, 2008	Fitzpatrick et al., 2010
Device	Hearing aids	Cochlear implants	Cochlear implants
Most beneficial situations	One person at distance, in noise or in quiet One person close by, in noise Watching TV Meetings	Listening in the car Listening to the television Listening in a large group Listening in a small group	One person at a distance, in noise or in quiet One person close by, in noise or in quiet Watching TV In car Listening to radio
	All participants perceived some or considerable overall benefit	All but one participant perceived some or considerable overall benefit	All but one participant perceived some or considerable overall benefit
Least beneficial situations	Restaurant One person close by in quiet	Not reported	Restaurant Meetings
Method of data collection	Qualitative data-quotes from participants	Participant comments and a questionnaire	Qualitative analysis of participant journal entries
Factors affecting perceived benefit	Several participants experienced occasional, but annoying, interrupted FM reception.	Not comfortable to wear with certain items (e.g. hats, eyewear)	Technical factors (equipment, adjustment)
	Participants reported the least amount of benefit during group interaction (problem of passing the microphone when eating with many friends)	Several users commented on the complexity of the FM transmitter	Individual factors (lifestyle, expectations)
	Other examples of difficulties: intrusiveness of technology: participant was uncomfortable asking a friend to wear the microphone	Several users reported interference with the FM system on some channels	Social factors (social judgments)
	Lack of improvement in noise (it is still a problem in a noisy room)	Most of the participants continued to experience difficulty in high levels of noise.	Environmental factors (acoustic conditions)
	Difficulty with localization (One participant liked to be able to hear when his wife called but didn't know where she was.)	One participant reported static on several FM system channels, had difficulty learning to use the Smartlink transmitter and was hesitant to use the FM system.	

situations as documented in their journals during a two-month trial period. Since group analysis tends to emphasize the results of the individuals who use the device more often and who therefore may have experienced more benefit, an individual analysis was performed which yielded similar results. The results support the notion that a questionnaire administered at the end of a brief two-month trial period reflects users' judgment of FM system benefit in a variety of useful listening situations even if the information is collected at a single point in time rather than in an ongoing manner during the trial period. These findings provide preliminary support for a clinical tool such as the FM-BCT proposed in this paper, suggesting that it can be a reliable method of collecting client information in an efficient manner. This constitutes the preliminary step in the validation of this questionnaire but further testing is required with a larger population.

The second part of the FM-BCT was grounded within the literature review and the conceptual framework from Fitzpatrick et al. (2010). The findings from this previous study enabled us to develop questions to assess the factors that may influence the users' perceived benefit. The four factors of the conceptual framework assessed in this part of the questionnaire include: technical factors, individual factors, social factors and environmental factors. These aspects are essential components of the clinical tool as they have been documented in the literature and emerged in the previous research as having a major impact on the perceived benefit of FM system use. Consequently, these factors can be expected to have a significant effect on the decision to use an FM system in various listening environments. By gleaning an understanding of how these factors can influence clients' experiences and decisions, clinicians can become better aware of their clients needs when fitting FM systems to cochlear implant recipients.

Although the data underlying the development of the FM-BCT were based on a relatively small number of participants, a rich dataset of 169 journal entries collected over a two-month period provided ratings of helpfulness during a large number of diverse situations for this analysis. Furthermore, the analysis revealed that situations in which the FM system was documented as helpful were consistent with those reported in the literature on FM systems and hearing aids (Boothroyd, 2004; Chisolm et al. 2007; Jerger et al. 1996). These findings suggest considerable similarity between the difficult listening situations reported by adult cochlear implants and adult hearing aid users'. Comparisons of questionnaire and journal data were based on a two-month trial period; it is important to evaluate the utility of this type of questionnaire after longer-term FM system use. The development of the tool was undertaken with a specific subset of adults with hearing loss, primarily because no similar tools exist for cochlear implant users and to keep the sample as homogeneous as possible. However, there is no evidence in the literature that hearing aids users are not affected by the same factors. Additional research should be conducted with a larger and more diverse population of adult cochlear implant users as well as hearing aids users in different clinical programs in order to further refine the questionnaire. The next step in the validation of the questionnaire will need to assess the convergent validity of the questionnaire by comparing the score obtained from this new questionnaire (FM-BCT) to existing benefit questionnaires. As there are no existing validated questionnaires on FM system benefit, we will need to rely on hearing aid benefit questionnaires (e.g. HHIE, APHAB). Furthermore, in Fitzpatrick et al. (2010) study, the interest was focused on identifying the factors that affect users' perceptions of benefit and not on quantifying the impact of these factors. Further research is required to evaluate the potential predictors of self-perceived benefits of FM system use; the predictive value of each question should be assessed to determine which factors have the largest impact on the perception of benefit score and to eliminate the questions that have no impact on the score.

Although the FM-BCT has not yet been validated with a large clinical population and rigorous psychometric analyses are required, it represents a useful contribution as, to our knowledge, no other FM-cochlear implant specific questionnaires have been published. Using this tool to help evaluate the impact of the four factors on users' perceived benefits can help the clinician discern which issues negatively and positively impact the users' FM system experience. This information may enable clinicians to better tailor FM system selection and adjustment, and target counseling to the individual client. This will in turn provide clients with a better opportunity to derive maximum benefit from the FM system.

Acknowledgements

The participation of the adults from the University of Ottawa Auditory Implant Program (Ottawa Hospital) is gratefully acknowledged. The research was supported through the Faculty of Health Sciences, University of Ottawa. Sennheiser (Canada) Inc. provided the FM technology as well as partial funding for the study. The comments from two anonymous reviewers which helped to improve the manuscript are greatly appreciated.

References

Anderson, K. L., Goldstein, H., Colodzin, L., & Inglehart, F. (2005). Benefit of S/N enhancing devices to speech perception of children listening in a typical classroom with hearing aids or a cochlear implant. *Journal of Educational Audiology, 12,* 14-28.

Boothroyd, A. (2004). Hearing aid accessories for adults: The remote FM microphone. *Ear and Hearing, 25,* 22-33.

Bronkhorst, A. W. (2000). Cocktail party phenomenon: A review on speech intelligibility in multiple-talker conditions. *Acta Acustica, 86,* 117-128.

Chisolm, T. H., Noe, C. M., McArdle, R., & Abrams, H. (2007). Evidence for the use of hearing assistive technology by adults: The role of the FM system. *Trends in Amplification, 11*(2), 73-89.

Clark-Carter, D. (1997). Doing quantitative psychological research: From design to report. Hove, U.K.: Psychology Press Ltd.

Cox, R. M., & Alexander, G. C. (1995). The abbreviated profile of hearing aid benefit. *Ear and Hearing, 16,* 176-183.

Cox, R. M. (2003). Assessment of subjective outcome of hearing aid fitting: Getting the client's point of view. *International Journal of Audiology, 42 Suppl 1,* S90-96.

Davies, M. G., Yellon, L., & Purdy, S. C. (2001). Speech-in-noise perception of children using cochlear implants and FM systems. *Australian and New-Zealand Journal of Audiology, 23,* 52-62.

Dillon, H., James, A., & Ginis, J. (1997). Client Oriented Scale of Improvement (COSI) and its relationship to several other measures of benefit and satisfaction provided by hearing aids. *Journal of the American Academy of Audiology, 8*(1), 27-43.

Fitzpatrick, E. M., Fournier, P., Seguin, C., Armstrong, S., Chenier, J., & Schramm, D. (2010). Users' perspectives on the benefits of FM systems with cochlear implants. *International Journal of Audiology, 49*(1), 44-53.

Fitzpatrick, E. M., Seguin, C., Schramm, D. R., Armstrong, S., & Chenier, J. (2009). The benefits of remote microphone technology for adults with cochlear implants. Ear and Hearing, 30(5), 590-599.

Flexer, C. (2004). Classroom amplification systems. In R. J. Roeser & M. P. Downs (Eds.), *Auditory Disorders in School Children* (pp. 284-305). New York: Thieme.

Gatehouse, S. (2000). The impact of measurement goals on the design specification for outcome measures. *Ear and Hearing, 21*(4 Suppl), 100S-105S.

Jerger, J., Chmiel, R., Florin, E., Pirozzolo, F., & Wilson, N. (1996). Comparison of conventional amplification and an assistive listening device in elderly persons. *Ear and Hearing, 17*(6), 490-504.

Schafer, E. C., & Thibodeau, L. M. (2004). Speech recognition abilities of adults using cochlear implants with FM systems. *Journal of the American Academy of Audiology, 15,* 678-691.

Schafer, E. C., & Thibodeau, L. M. (2006). Speech recognition in noise in children with cochlear implants while listening in bilateral, bimodal, and FM-system arrangements. *American Journal of Audiology, 15,* 114-126.

Schafer, E. C., Wolfe, J., Lawless, T., & Stout, B. (2009). Effects of FM-receiver gain on speech-recognition performance of adults with cochlear implants. I*nternational Journal of Audiology, 48*(4), 196-203.

Taylor, B. (2007). Self-report assessment of hearing aid outcome-An overview, *Audiology Online,* Retrieved from: http://www.audiologyonline.com/articles/article_detail.asp?article_id=1888

Ventry, I. M., & Weinstein, B. E. (1982). The hearing handicap inventory for the elderly: a new tool. *Ear and Hearing, 3*(3), 128-134.

Wolfe, J., & Schafer, E. C. (2008). Optimizing the benefit of sound processors coupled to personal FM systems. *Journal of the American Academy of Audiology, 19*(8), 585-594.

Authors' Note

Correspondence concerning this article should be addressed to Philippe Fournier, M.Sc.S. Audiologist, Ph.D. candidate, BRAMS 'International Laboratory for Brain, Music and Sound Research' – Suite 0-120, Pavillon 1420 boul. Mont Royal, University of Montreal, C.P. 6128 Station Centre ville, Montreal (QC) H3C 3J7. Canada. Email: philippe.fournier.1@umontreal.ca.

Received date: September 15, 2010

Accepted date: June 27, 2011

APPENDIX A

FM Benefit Counseling Tool (FM-BCT) questionnaire

Name: _____ Date: _____

Duration of the trial period: _____

(Section one from Boothroyd, A. (2004). Hearing aid accessories for adults: The remote FM microphone. Ear and Hearing, 25, 22-23. (Adapted and reprinted with permission.)

How helpful was the FM microphone:	Not applicable/ necessary	Not used	Made things worse	No help	Some help	A lot of help
Overall?						
Listening to one person in quiet at a few feet?						
Listening to one person in quiet at several yards?						
Listening to one person in noise at a few feet?						
Listening to one person in noise at several yards?						
Watching TV?						
Listening to speech through a device						
(Radio, Computer, Online class, etc.)?						
At the museum/theater?						
In a meeting?						
A lecture, a presentation?						
(e.g., a place of worship)						
In a restaurant?						
In a car?						
Listening to music						
(Radio, Music player, Computer, Stereo, etc.)?						
Other?						

1. Did you encounter problems with the equipment itself? (e.g., set-up, cables, battery, size, etc.)
   - ☐ 0% of the time (never)
   - ☐ < 25% of the time (rarely)
   - ☐ 25-50% of the time (sometimes)
   - ☐ 50-75% of the time (often)
   - ☐ 75-100% of the time (almost always)

Please describe the problem(s): _____

_____

_____

_____

2. Was the « esthetic » aspect of the equipment (e.g., visibility of cables) a concern?
   - ☐ 0% of the time (never)
   - ☐ < 25% of the time (rarely)
   - ☐ 25-50% of the time (sometimes)
   - ☐ 50-75% of the time (often)
   - ☐ 75-100% of the time (almost always)

3. Did you encounter problems with the adjustment of the equipment (volume control, programs, sensitivity, etc.)?

a. FM system?
   - ☐ 0% of the time (never)
   - ☐ < 25% of the time (rarely)
   - ☐ 25-50% of the time (sometimes)
   - ☐ 50-75% of the time (often)
   - ☐ 75-100% of the time (almost always)

b. Cochlear implant speech processor?
   - ☐ 0% of the time (never)
   - ☐ < 25% of the time (rarely)
   - ☐ 25-50% of the time (sometimes)
   - ☐ 50-75% of the time (often)
   - ☐ 75-100% of the time (almost always)

Please describe the problem(s): _____

_____

_____

_____

4. Did you receive support from others? (family, friends, coworkers, etc.)

- ☐ 0% of the time (never)
- ☐ < 25% of the time (rarely)
- ☐ 25-50% of the time (sometimes)
- ☐ 50-75% of the time (often)
- ☐ 75-100% of the time (almost always)

Please describe situations where you were not supported in using the FM, (e.g., refusal to use the microphone, improper use of microphone by the speaker; microphone not passed around in group situation).

_____

_____

_____

_____

5. Overall, what percentage of the time did you try the equipment in difficult listening situations (e.g., restaurant, car,etc.)?

- ☐ 0% of the time (never)
- ☐ < 25% of the time (rarely)
- ☐ 25-50% of the time (sometimes)
- ☐ 50-75% of the time (often)
- ☐ 75-100% of the time (almost always)

Please indicate reasons for not using the equipment? _____

_____

_____

6. How effective was the FM system in difficult listening situations (e.g., restaurant, car, television)?

- ☐ 0% of the time (never)
- ☐ < 25% of the time (rarely)
- ☐ 25-50% of the time (sometimes)
- ☐ 50-75% of the time (often)
- ☐ 75-100% of the time (almost always)

If yes, please describe the environments and the difficulties encountered: _____

_____

_____

_____

7. Did the FM system meet your expectations in difficult listening situations?
   - ☐ 0% of the time (never)
   - ☐ < 25% of the time (rarely)
   - ☐ 25-50% of the time (sometimes)
   - ☐ 50-75% of the time (often)
   - ☐ 75-100% of the time (almost always)

Describe situations that remained difficult despite using an FM system: _____

_____

_____

_____

_____

8. What improvements or supports would make the FM system easier to use? (check all that apply)
   - ☐ Wireless device
   - ☐ Simpler device (easier adjustment, etc.)
   - ☐ Multiple FM transmitters (remote microphones) for multi-listener talker situations
   - ☐ More counseling on how to use the FM
   - ☐ Other: _____

     _____

     _____

     _____

9. Which of these elements would lead to more FM use? (check all that apply)
   - ☐ More practice
   - ☐ More counseling
   - ☐ More activities requiring FM use
   - ☐ More cooperation from family and friends
   - ☐ Help from technician (during talks, meetings, …)
   - ☐ Lip reading
   - ☐ Other: _____

     _____

     _____

     _____

10. What others factors may have influenced your experience during the trial period?

- ☐ Equipment was difficult to use
- ☐ Size of equipment
- ☐ Personal problems
- ☐ Lifestyle limited opportunities to use FM
- ☐ Travel limited opportunities to use FM
- ☐ No motivation to use FM
- ☐ Other: _____

_____

_____

_____

11. How was the length of the trial period?

- ☐ Too short
- ☐ A little short
- ☐ Just right
- ☐ A little long
- ☐ Too long

12. Did you have any previous experience using FM systems with hearing aid(s) or cochlear implant(s)?

- ☐ None
- ☐ A little (< than 6 months)
- ☐ Some (6 months to 2 yrs)
- ☐ Quite a bit (2 yrs to 5 yrs)
- ☐ A lot (more than 5 years)

13. Would you be interested in using an FM system device long-term?

- ☐ Definitely not
- ☐ Not likely
- ☐ Maybe
- ☐ Very likely
- ☐ Definitely yes

CLINICIAN NOTES

_____

_____

_____