PILOT TESTING A MUSIC APPRECIATION TRAINING PROGRAM FOR COCHLEAR IMPLANT RECIPIENTS AND USERS OF HEARING AIDS

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Abstract

A clinically-focused music appreciation training program (MATP) was developed for use by recipients of cochlear implants (CI) and wearers of hearing aids (HA). It aimed to enhance listeners' music appreciation abilities, with a specific focus on timbre and musical style. The MATP was pilot-tested on 17 adult postlingually deafened CI recipients (8 female, 9 male, mean age = 60.2 years) and 13 adult HA users (7 female, 4 male, mean age = 63.9 years), with each device group divided into a control and a training group. The training groups were asked to use the MATP for 30 minutes per day four times a week for 10 weeks. The control groups were asked to continue with their normal listening habits for the same time period. Both the training and control groups were assessed on tests of instrument, ensemble and style identification as well as pleasantness ratings of musical excerpts, before and after the 10-week period. Participants in the training groups also completed a program evaluation questionnaire at the end of the training period.

The results showed that the training program significantly improved the quality ratings of CI recipients for ensemble stimuli (p = .034). There were, however, no significant improvements for CI users on the timbre discrimination tasks or quality ratings for single instruments, nor were there any significant improvements for the HA users on any of the discrimination tasks or in their quality ratings. The findings suggest that CI recipients' quality appraisal can be improved through training, independent of perceptual accuracy. On evaluating the program, the majority of CI and HA trainees reported that the MATP was enjoyable and beneficial in terms of music appreciation. Future directions for continued development of the MATP and testing of its efficacy are discussed.

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Abbreviations

A/D	Analogue to digital
BTE	Behind the ear
CI	Cochlear implant
DSP	Digital signal processing
dB A	Decibel A-weighted
dB HL	Decibel hearing level
dB SPL	Decibel sound pressure level
GBI	Glasgow Benefit Index
HA	Hearing aid
ID	Identification
I/E/S	Instrument/ensemble/style
MAP	Parameters for electrical stimulation via cochlear implant electrodes
MATP	Music Appreciation Training Program
MTB	Music test battery
NH	Normal hearing
QOL	Quality of life
QR	Quality rating
WHOQOL	World Health Organization Quality of Life

1 Introduction

1.1 Enjoyment of music

For both young and old, music, be it passive listening or active participation in its creation, plays an important part in one's life. In a questionnaire-based study of the importance of music to adults, the majority of 393 responders reported that music was very important to them, with 96% of young adult responders (mean age = 18.8 years) and 70% of senior responders (mean age = 78.3 years) considering themselves to be daily music listeners (Cohen, Bailey, & Nilsson, 2002). The authors posited that this pleasurable activity may contribute to wellbeing throughout an individual's life. The findings of a series of 166 interviews with older people suggest that this benefit to wellbeing comes from the meaning to one's life that the aesthetic experience of music listening can offer (Wikström, 2004). Some felt that listening to music represented a cornerstone of their life or made them feel *"whole as a person"* (Wikström, 2004, p. 33). Focus group discussions (N = 38) conducted by Hays & Minichiello (2005) revealed similar themes of music enjoyment promoting the quality of life (QOL), through the contribution to a sense of well-being and health, maintaining connections with one's past, facilitating spirituality, and reducing isolation and loneliness. This last theme of music as a catalyst for social interaction and comradeship through activity participation was noted by Solé, Mercadal-Brotons, Gallego, & Riera (2010) as one of the main motivators to join in musical activities such as choirs, music appreciation classes or music therapy.

Given the important roles that music plays in many people's lives, the diminution of musical enjoyment experienced by many hearing device users is of significant concern. This issue will be discussed further in Sections 1.2.2 and 1.3.2

1.2 Hearing aids and music

1.2.1 Hearing aid technology

Hearing aids are externally worn electronic devices designed to amplify sounds that are beneath a person's hearing threshold to an audible level, with the goal of achieving intelligibility for speech. The extent of amplification of any one sound is frequency-dependent as the hearing loss of an individual varies across the audible spectrum. The main components of a hearing aid are the microphone, amplifier and loudspeaker, the latter being traditionally referred to as the receiver. A cross sectional illustration of a typical hearing aid and its components is shown in Figure 1.

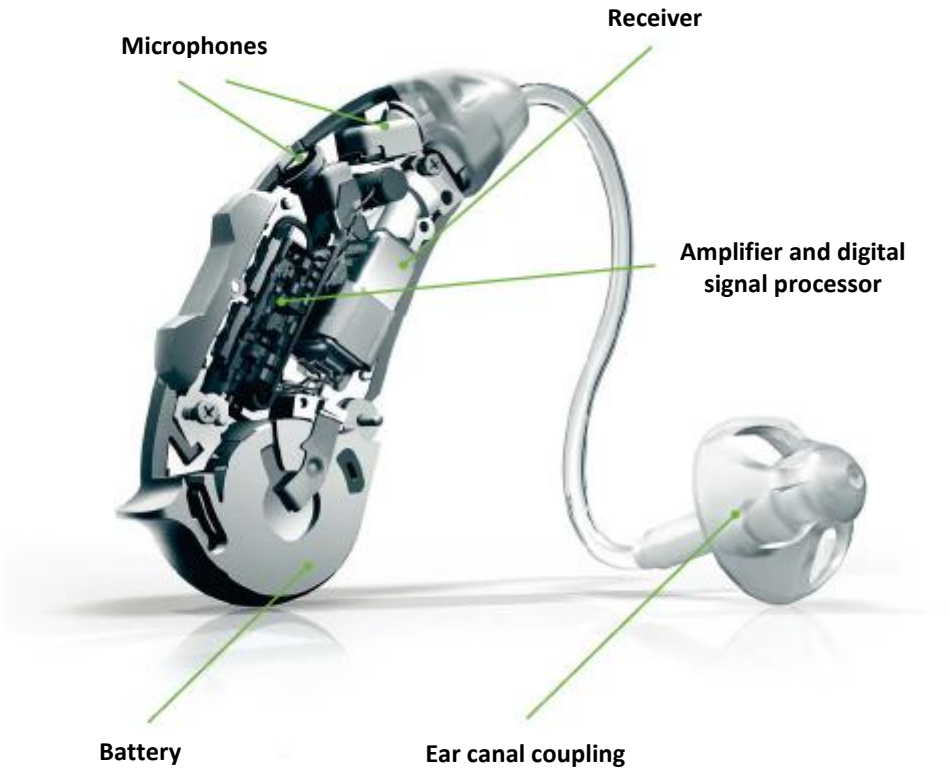

Figure 1. Cross sectional illustration of a behind-the-ear (BTE) style HA showing its basic components. The electronic components of a BTE HA are housed in a casing and worn behind the pinna of the ear. Amplified sound produced by the receiver enters a tube and is delivered to the ear canal via a coupling piece which may take the form of a custom-made ear mould, or a non-custom rubber dome as shown above. Other common styles of HA include: 1) receiver-in-the-ear canal (RITE) where the receiver sits in a coupling piece in the ear canal and is connected by a wire to the other components sitting behind the pinna; 2) in-the-ear (ITE) and in-the-canal (ITC) where all components are housed in a custom made shell that sits inside the concha portion of the pinna, and 3) completely in-the-canal (CIC) where the custom made shell is small enough to fit entirely in the ear canal, without having to occupy the concha. Press image adapted and used with permisison from Siemens Hearing Instruments Ltd (2013).

The microphone transduces sound waves into an electrical signal, which is then converted to digital information and processed by a digital circuit. The information is then converted back to an analog electrical signal and sent to the receiver, which generates the differentially amplified sound waves that are presented to the wearer's ear canal. In older styles of hearing aids, the electrical signal passes through filter banks before and/or after it is amplified by an analog amplifier, and is then sent to the receiver. The amount of amplification, or gain, at each frequency and for different intensities of input is programmed or set by a hearing specialist according to prescribed amplification targets derived from a plot, or audiogram, of the individual's hearing thresholds. The targets are formulated to compress the dynamic intensity range of the output into the dynamic range of the wearer's residual hearing, so that it is both comfortable and optimal for audibility of speech, that is, weak sounds are amplified more than very intense sounds. Some older hearing aids provide equivalent gain for all inputs and 'clip' the

most intense peaks of the signal to avoid discomfort. Most hearing aids have the options of multiple programs for users to select from for different listening situations.

1.2.2 Enjoyment of music by hearing aid users

As one might expect, hearing loss can diminish enjoyment of music listening. In an early questionnaire-based study of 206 experienced hearing aid (HA) users, 79% of respondents reported that their hearing loss impacted negatively on the pleasure they derived from listening to music (Feldmann & Kumpf, 1988). Ninety five percent of the 206 respondents had enjoyed music prior to their hearing loss. With regards to hearing aids, 74% of respondents wore their devices when listening to music. Sixty seven percent of all respondents reported that hearing aids made music more enjoyable, 4% felt there was no difference, while 25% felt music was less enjoyable while wearing hearing aids. More recently, Leek, Molis, Kubli, & Tufts (2008) conducted a similar study involving telephone interviews with 68 individuals with hearing loss. Seventy eight percent of participants wore their hearing aids when listening to music, a similar figure to that observed in the Feldmann & Kumpf (1988) study. However, for the same response categories ‘more enjoyable’, ‘no difference’ and ‘less enjoyable’ the response percentages were 41%, 37% and 6% respectively. In considering the changes to response patterns over the two decades that separated the two studies, Leek et al. (2008) suggested that the advances in digital signal processing (DSP) technology had been enough to mitigate the negative effects of amplification that lessened the enjoyment of music, but had not moved far enough toward improving noticeable benefit above not wearing the hearing aids at all.

1.3 Cochlear implants and music

1.3.1 Cochlear implant technology

A cochlear implant (CI) is a surgically implanted electronic device used to provide stimulation to the auditory nerves of wearers whose sensory hair cells are damaged or missing to an extent that sound is no longer adequately coded by those cells, resulting in a profound hearing loss. An illustration of a CI positioned in the ear of a user is shown in Figure 2.

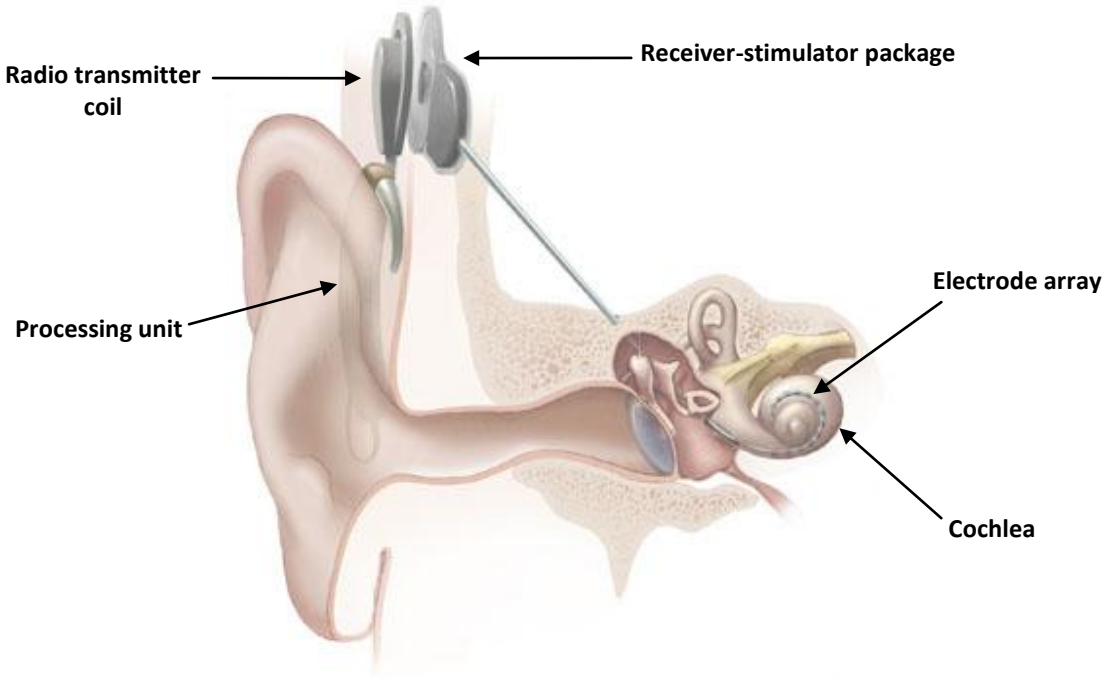

Figure 2. Illustration of major CI components. Adapted from public domain image, National Institutes of health, United States Department of Health and Human Services (2005).

A receiver-stimulator sits under the skin and in the mastoid bone of the recipient, with an array of electrodes extending into the cochlea near the auditory nerve. The recipient also wears processing unit behind the ear, containing a microphone, digital speech processor and radio processor. This is connected by a wire to an external magnetic radio transmitter coil that sits on the scalp. Sound is captured by the microphone and processed digitally into a temporal and spatial mapping of stimulation patterns. This information is then transmitted via electromagnetic radio waves through the skin to the implanted receiver-stimulator package and, after conversion to an electrical current, is presented at different locations along the auditory nerve according to the pattern of electrode stimulation encoded. The increasing number of electrodes and sophistication of processing strategies used in implants has dramatically improved the perception of spoken sounds but the perception of musical sounds remains problematic.

1.3.2 Enjoyment of music by cochlear implant users

CI users are a second population of hearing impaired individuals for whom the use of a hearing-related device can negatively affect the enjoyment of music. The consensus from questionnaire-based studies of postlingually deafened adult CI users shows that for this population the enjoyment of music and time spent listening to music diminishes post-implantation. Gfeller et al. (2000) found that 23% of 65 respondents reported little satisfaction in listening to music following implantation, while 43% reported that music sounded less pleasant than before implantation, but that this was better than no music at all. Mirza, Douglas, Lindsey, Hildreth, &

Hawthorne (2003) asked 35 respondents to rate their enjoyment of music before hearing loss and after implantation using a self-assessment scale (where 0 = not at all, 10 = very much). The mean score for pre-deafness enjoyment was 8.7 compared with 2.6 for post-implantation enjoyment. Only 16 of the 35 respondents still listened to music following implantation. The mean enjoyment score for the 16 who had continued to listen to music was 5.6, significantly less than their pre-deafness mean score.

In a larger study involving 100 postlingually deafened CI recipients, Looi & She (2010) found the mean self-assessed rating scores for the amounts of time (0 = never, 10 = very often) spent listening to music pre-hearing loss and post-implantation were 7.20 and 4.58 respectively, while the mean ratings for enjoyment of music (0 = did not enjoy at all, 10 = greatly enjoyed) pre-hearing loss and post-implantation were 8.37 and 5.15 respectively.

Most recently Philips et al. (2012) investigated the effects of cochlear implantation on changes to music listening habits, enjoyment of music and music appreciation. Of the 43% of participants who regularly listened to music prior to implantation, only 13% of them continued their regular listening post-implantation, with the number of those participants reporting enjoyment of music declining from 50% to 13% pre- and post-implantation. The researchers noted that while 52% of their participants valued the ability to enjoy music and 35% felt that music was an important part of their social life, only 28% of all participants reported that they could currently appreciate music, with 82% stating that music no longer sounded natural.

Previous research has shown that music appreciation is associated with perceptions of QOL. Lassaletta et al. (2007) asked 65 postlingually deafened adult CI users to rate the overall quality of music heard through their device on 100-point visual analogue scales anchored by bipolar adjectives such as ‘doesn’t sound like music–sounds like music’, ‘mechanical–natural’, and ‘difficult to follow–easy to follow’. Compared to the negative responders (00 – 50), participants who gave positive responses (50 – 100) on each of these scales were found to have significantly higher QOL scores, as measured by the (GBI), a generic QOL outcomes measure for otolaryngological interventions (Robinson, Gatehouse & Browning, 1996). GBI scores were found to be unrelated to participant factors such as demographic variables, musical background, listening habits, duration of deafness, length of implant use or CI model. Both the Philips et al. (2012) and Lassaletta et al. (2007) studies point to the need for music to sound more natural through cochlear implants as one way to improve individuals’ ability to appreciate music and their QOL.

In a study by Looi, McDermott, McKay, & Hickson (2007), involving both HA and CI users, participants also provided appraisement ratings of the overall pleasantness of sounds produced by a variety of musical instruments. CI users provided lower appraisal scores than NH

participants, with CI users showing a significant preference for lower frequency instruments and rating higher pitched instruments as sounding less brilliant, and more scattered or undesirable.

An analysis of sound quality ratings given for excerpts of eight common musical instruments by Looi & She (2010) showed that respondents generally found music to sound significantly different to how they would expect those instruments to sound to a person with normal hearing.

1.4 Timbre

The issue of whether a piece of music sounds 'like music', in terms of sounding natural as opposed to mechanical, is largely one of the tone colour of the instrument or voice, otherwise known as 'timbre'. In music, timbre is a multidimensional quality that allows one to distinguish the sound of one musical instrument or singing voice from another, independent of the intensity, pitch or duration of the sound being played or sung. Timbre recognition is highly dependent on frequency spectra information contained within the sound, namely the temporal envelope (changes in intensity over time) and the distribution of transient overtones generated above the fundamental frequency. One difficulty facing CI and HA users when they listen to music through their device is that the faithful reproduction of these timbre cues is compromised by the hardware and digital processing strategies of the implants and hearing aids, which are chiefly designed for enhancing the sound quality of speech, rather than music, as discussed below.

1.5 Comparing music and speech as hearing device inputs

While music and speech share roughly the same upper and lower frequency limits in terms of useful audible cues, the spectral intensities and crest factors of the two sound types are remarkably different (Chasin, 2012; Chasin & Russo, 2004). Whereas the most intense components of everyday speech are approximately 85 dB SPL (decibels Sound Pressure Level), sustained levels within musical passages can easily exceed 100 dB SPL, with elements of even quiet music still reaching 80 dB SPL. This difference is largely due to the damping effect that the softness of the oral and nasal cavity walls, cheeks, tongue, lips and saliva have on sound as it exits the vocal tract. Compared to the large array of shapes and sizes of musical instruments, the range of human vocal tract lengths is limited, and hence does not allow for huge variations in spectral intensities. The term 'crest factor' refers to the dynamic range of a sound over a short time scale and is a measure of the difference between the instantaneous peak intensity and average (or root mean square [RMS]) intensity values. The limited length and damping effects of the human vocal tract result in a typical crest factor of 12 dB for speech, whereas the crest factor of different musical instruments can range from 18 to 20 dB, resulting in the sounds having a much more 'peaky' quality.

1.6 Consequences of hearing device design priorities

With the amplification and/or processing of speech signals being the first priority in the design of hearing devices, this creates significant limitations on the ability of the devices to faithfully reproduce the spectral characteristics that convey the timbre cues of musical sounds, thereby degrading the quality of the sounds into a 'less than natural' and potentially unpleasant state.

1.6.1 Technological limitations of hearing aids for music appreciation

The two main limitations of modern digital HAs for reproducing high quality musical sounds relate to input limiting and multichannel processing. The threshold for compression of input intensity at the 'front end' of the HA (i.e. before sound input is converted to digital information by the analog to digital [A/D] convertor) is typically 96 dB SPL at best, but possibly as low as 85 dB SPL (Hockley, Bahlmann, & Fulton, 2012; Schmidt, 2012). While such a limit is suitable for almost all speech signals (which as noted above are mostly less than 85 dB SPL), it is not suitable for maintaining spectral peaks within music. Because the compression takes place prior to A/D conversion and digital signal processing (DSP), the lost higher intensity spectral information cannot be retrieved or compensated by the DSP chip, regardless of the sophistication of the processing employed. Industry-standard DSP has the potential to further degrade the already compromised digital signal as it passes through the multi-channel processor because the processing disrupts the relationships between high frequency harmonic intensities.

Technical solutions to the above problems are only beginning to be embraced by HA manufacturers (e.g. Hockley et al., 2012) and do not feature in the older devices that many individuals are currently wearing. A few limited but practical solutions can be put in place by the HA user. For listening to recorded or monitored music, turning down the volume of the sound system and increasing the volume of the hearing aid can help toward increasing perceived loudness and detail with less risk of input compression. For live or very loud music, Chasin (2010) recommends that hearing aid users affix one or two layers of cellotape over the hearing aid's microphone ports to create a near-uniform attenuation of the input spectrum by 5–10 dB, thereby reducing the need for input compression before the signal is processed.

In an earlier review, Chasin & Russo (2004) also suggests that a hearing specialist can improve the quality of musical sounds to some extent by fitting a device with only one compression channel (i.e. the same level of gain across all frequencies), or programming a multichannel device to emulate one with only one channel, in order to preserve the relationships between lower-frequency fundamental energy and the higher-frequency harmonics.

1.6.2 Technological limitations of cochlear implants for music appreciation

Even though some features of music, such as rhythm, can be transmitted relatively accurately through a CI, the speech processing strategies of CIs discard much of the fine-spectral and temporal details of the musical signal that are usually decoded by a healthy auditory system with thousands of sensory hair cells. Looi (2008) describes the limited coding of spectral shape and the reduction of temporal fine structure cues down to temporal envelope cues as being due to such factors as insufficient number of stimulation channels and subsequent mapping of frequency bands to electrodes, phase misalignments, and constraints due to individual physiological characteristics of the implanted ear. Further audible cues relating to timbre may be lost due to smearing of the frequency spectra perceived by the CI user resulting from the spread of current around the electrode to nerve fibres not usually associated with the frequency band intended for stimulation. Unintended interactions between stimulation channels and the pattern of nerve cell survival specific to the individual may also contribute to this spectral smearing. While the spectral and temporal information conveyed by a CI may be adequate for speech perception, it is not sufficient for effective music perception for most users.

1.7 Accurate identification of timbre by HA and CI users

Studies that have compared the abilities of HA and CI users indicate that difficulties in accurately recognising musical stimuli are shared by both groups. Looi, McDermott, McKay, & Hickson (2008a) assessed the abilities of 15 postlingually deafened adult CI users with 15 adult HA users (with similar levels of hearing loss to the CI users) to recognise individual instruments and ensembles across three levels of difficulty. The mean percent correct scores of the CI group for identifying single instruments (subtest 1), solo instruments with background accompaniment (subtest 2), and cohesive ensembles (subtest 3) were 61%, 45%, and 43% respectively, while for the HA group, the respective scores were 69%, 52% and 47%. The between-group differences were not statistically significant, indicating that the two groups had similar levels of ability. The difference in scores between subtests 1 and 2 and subtests 1 and 3 were statistically significant for both the CI and HA groups, reflecting the increased difficulty that individuals in both groups experienced when presented with stimuli of greater spectral complexity. NH participants had previously scored greater than 95% correct on each sub test.

CI users do not perform as well as NH individuals on instrument identification tasks. Gfeller et al. (2002) tested the timbre recognition abilities of NH adults and postlingually deafened CI users across eight different instruments, representing three frequency ranges of low, middle and high. Each instrumental recording consisted of the same seven-note sequence of equal duration. The mean percent correct score of 47% for the CI group was significantly lower than that of the

NH group's 91%. The researchers suggested that the high frequency emphasis of some CI speech processing maps creates disproportionately higher overtone amplitudes than would be heard in a normal ear, leading to a shrill or distorted musical sound. Unfortunately, current musical perceptual accuracy scores for HA and CI users are not dissimilar to those from such older studies, indicating that advances in technology have yet to restore normal, or even near-normal, music perception for either of the device groups (Looi, King, & Kelly-Campbell, 2012).

1.8 Rationale for the study

1.8.1 Need for a music-focused auditory training program

While attempts have been made by device manufacturers over the past two decades to develop technologies that enhance the audibility of spectral cues needed for musical enjoyment, many CI and HA users are still left with diminished musical experience. An alternative approach to enhancing the perception of spectral cues is to utilize the plasticity of the brain through perceptual training, thereby rewiring neuroplastic changes that have taken place as the result of hearing loss (Woods & Yund, 2007). The beneficial effects of a training-based approach to increasing musical appreciation through instrument identification and sound quality appraisal have been examined by Gfeller et al. (2002). Eleven postlingually deafened adult CI users underwent a 12-week computer based training program in which they were introduced to excerpts of musical passages played by various instruments within four instrument families. For each instrument, detailed images and information were provided on its characteristics, the materials of which it was made, and so on. As the program progressed, multiple instruments were contrasted, and interactive activities required participants to name instruments and provide quality appraisals. Pre- and post-training tests involved a set of timbre recognition and appraisal tasks. For each timbre recognition task, participants were presented with an excerpt of a single instrument and asked to select the instrument that they had heard from a visual grid of 16 instruments. The timbre appraisal grid involved rating how much they liked a single instrument excerpt on a scale of 0 = "dislike very much" to 100 = "like very much". The training program group showed significant improvement in the recognition tasks and significantly increased their quality appraisal ratings as compared to a control group who had not participated in training and instead were exposed only to incidental listening in their daily routines.

Despite the success of the program develop by Gfeller, Witt, Adamek, et al. (2002), currently there are no commercially available music training programs for the hearing impaired that target music appreciation and none that focus on timbre recognition. Other training programs have been shown to improve music perception (Gfeller, Witt, Stordahl, Mehr, & Woodworth, 2000), but these focus on pitch rather than timbre perception, and are also not available commercially.

Fifty four percent of the 84 CI respondents to the questionnaire study of Looi & She (2010) indicated that they would be interested in using a music training program if one become available, and expressed a desire to improve instrument and genre recognition skills. Rutledge (2009) found that close to 30% of the 89 HA users in her study would be interested in participating in a music training program to improve the same skill set. Substantial demand therefore exists for such programs.

1.8.2 Research task and hypotheses

As a response to the need identified above, a computer based Music Appreciation Training Program (MATP) was developed for use by adult HA users and postlingually deafened CI recipients. The goal for the program was to improve users' appreciation of the subtle differences between the timbres of musical instruments and ensembles, as well as the differences between musical styles. The program was designed to be used at home over the long term for self-guided training, and to contain a sufficiently wide range of instruments, ensembles and styles to be of interest to users with different musical backgrounds.

The purpose of this study, in addition to developing the MATP, was to pilot test and then evaluate the efficacy of the program. Efficacy was measured by comparing pre- and post-training performances on timbre perception orientated tasks, namely the identification of solo instruments, ensembles and musical genre/style when excerpts are heard, and also by comparing mean quality appraisal or 'pleasantness' ratings for the same musical stimuli pre- and post-training.

For both HA and CI users, the primary hypothesis was that for the identification tasks and the quality rating measures, the difference between pre- and post-training session scores for the training group would be significantly greater than for the control group. As it was anticipated that HA users recruited for this study would have better residual hearing ability than participants with CIs, that is the HA users would not meet CI candidacy criteria, and given the primary purpose of the study was to assess efficacy of the MATP, comparisons of outcomes for the two groups was not conducted.

Also of interest in this study was whether participants in the training groups reported perceived benefits of the training and, if so, what form these took. Finally, the associations between participants' musical backgrounds (formal music training, participation in musical activities, and music listening habits) that have been observed in other studies (Gfeller et al., 2008; Looi, 2008; Looi et al., 2008a) will be examined.

2 Method

2.1 Ethical approval

Ethical approval for this research was obtained from the New Zealand Health and Disability Ethics Committee, as well as the University of Canterbury Human Research Ethics Committee, and all research was undertaken in accordance with the requirements of those bodies. Participation in the present study was voluntary and participants were free to withdraw from the study at any time.

2.2 Participants

Participants were recruited from audiology clinics and hearing service providers in Australia and New Zealand. Australian participants were recruited by way of mail-out invitations sent to clients of several audiology clinics. New Zealand participants were recruited by way of poster advertisements placed in audiology and hearing service clinics and community spaces, advertisements in hearing service newsletters, and targeted telephone invitations drawn from the University of Canterbury Speech and Hearing Clinic client database.

The inclusion criteria required that each participant:

(i) had at least six months experience with their primary device;
(ii) spoke English as their first language or had been speaking English for more than 10 years;
(iii) was above 18 years of age;
(iv) had no major cognitive, neurological, visual or significant physical impairment that would impede their ability to use the training program; and
(v) had access to a computer for a period of 10 weeks to undertake the training program.

In addition, HA users were expected to have bilateral, postlingually acquired, sensorineural hearing loss requiring hearing aids, and CI users, a stable MAP over the training period for this study. The training program did not require participants to have any knowledge of musical notation or technical musical terminology.

Within both device groups, those participants who enrolled early were free to join either a training or control group, depending on their availability over the 10-week training period. If participants wished to join a training group but were unable to complete 10 weeks of training within the prescribed time frame or if the respective training group was oversubscribed, then they were assigned to the control group, with the knowledge that they could begin training after the conclusion of the study. All participants received a copy of the MATP program in appreciation of their participation. Those in the training groups were also permitted to keep the

computer desktop speakers provided as part of the study in recognition of their contribution to the research through the time they devoted to training.

At the pre-training stage of the study, the CI training group consisted of 11 participants (6 female, 5 male; aged 34 – 76y, *M* = 57.6y) and the CI control group of 8 participants (3 female, 5 male; aged 35 – 83y, *M* = 61.5y).The HA training group consisted of 6 participants (3 female, 4 male; aged 43 – 84y, *M* = 63.6y) and the HA control group of 7 participants (5 female, 1 male; aged 48 – 73y, *M* = 61.3y).

Participant attrition and exclusion of some participants' data led to a change in group numbers by the data analysis stage. The flow of participants and contributing factors to these changes are reported in section 3.1. At the data analysis stage there were 8 participants in the CI training group (aged 38 – 76y; *M* = 60.0y), 9 in the CI control group (aged 35 – 83; *M* = 60.3y), 5 in the HA training group (aged 51 – 84y; *M* = 67.0), and 6 in the HA control group (aged 48 – 70, *M* = 61.3y). Relevant details drawn from participants' clinical files and most recent audiological assessment results from their respective clinics are included in Table 1 (CI participants) and Table 2 (HA participants). The purpose of the control group was to control for learning effects resulting from administration of the pre-training tests and any potential improvement in music appraisal as a function of incidental listening over the same time period.

Table 1

Cochlear implant participant details

Group	Participant (sex)	Age (years)	Age diagnosed with HL (years)	Aetiology	Age implanted (years)	Device experience (months)	Speech perception score (%)*	Type of CI	CI sound processor	CI sound processing strategy	Ear implanted	Bimodal	Formal music training‡	Self-rated overall music ability§	Pre-HL music listening‖	Post-device music listening‖
Training	1 (M)	65	20	C/P	64	7	99	CI512	CP810	ACE 1200 Hz	R	N	2	1	4	3
	2 (F)	64	11	C/P	63	14	100	CI512	CP810	ACE 900 Hz	L	Y	2	2	2	2
	3 (F)	67	20	Otosclerosis	67	6	99	CI512	CP810	ACE 1200 Hz	L	Y	0	0	3	1
	4 (M)	38	28	Ménière's disease	37	12	100	CI512	CP810	ACE 900 Hz	R	Y	3	2	3	2
	6 (F)	66	47	C/P	62	42	100	CI24RE	Freedom	ACE 1200 Hz	L	N	2	1	4	0
	7 (F)	51	0	C/P	44	68	94	CI24RE	Freedom	ACE 1200 Hz	R	N	3	1	4	4
	8 (F)	53	3	C/P	43	116	97	CI24M	Freedom	ACE 900 Hz	R	N	1	1	1	1
	9 (M)	76	40	C/P	69	74	98	CI24RE	Freedom	ACE 1200 Hz	R	N	1	0	3	3
	M/Mdn	60.00	21.13		56.13	42.38	98.38						2	1	3	2
	SD	11.93	16.70		12.61	40.32	2.07									
Control	1 (M)	35	5	Rubella	32	28	99	CI512	CP810	ACE 900 Hz	R	Y	1	1	2	2
	2 (F)	63	43	SSNHL	60	25	98	CI24RE	Freedom	ACE 900 Hz	R	Y	0	2	4	0
	3 (M)	54	11	C/P	51	33	100	CI512	CP810	ACE 1200 Hz	L	Y	0	3	4	4
	4 (F)	56	28	C/P	54	18	97	CI24 CA	CP810	ACE 720 Hz	R	Y	1	2	3	3
	5 (M)	76	49	Unknown	73	37	97	CI24RE CA	Freedom	ACE 500 Hz	L	N	3	2	3	3
	6 (M)	83	48	Unknown	82	17	96.5	CI512	CP810	ACE 720 Hz	L	Y	3	3	4	0
	7 (F)	45	20	C/P	36	105	58.9†	CI512 / SONATIti100	CP 810 / Opus	ACE 1200Hz / FSP	R + L	N	3	3	4	2
	8 (M)	80	25	Otosclerosis	78	23	100†	CI24RE CA	Freedom	ACE 900 Hz	R	N	3	3	0	4
	9 (M)	51	0	C/P	45	78	100	CI24CA / CI24RE	Freedom	ACE 500Hz	R + L	N	3	2	1	3
	M/Mdn	60.33	25.44		56.78	40.44	98.21						3	2	3	3
	SD	16.49	18.31		17.98	30.41	1.47									
Training and control combined	*M/Mdn*	60.18	23.41		56.47	41.35	98.30						2	2	3	2
	SD	14.08	17.16		15.21	34.27	1.75									

Note. C/P = congenital/progressive; CI = Cochlear implant; HL = hearing loss; *M* = mean; *Mdn* = median (last four columns); SD = standard deviation; SSNHL = sudden sensorineural hearing loss

*Word score (%) on CUNY sentence test, implanted ear, tested auditory alone in quiet at 65 dB SPL.

†Word score (%) on HINT sentence test; tested binaurally, auditory alone in quiet at 65 dB SPL.

‡Score assigned to participants based on the longest reported duration of training (pre-hearing loss or post-device fitting) that involved learning a musical instrument, singing lessons, music theory or general music classes. 0 = No formal training; 1 = less than three years; 2 = 3 – 5 years ; 3 = more than 5 years.

§0 = none or not able; 1 = limited; 2 = average; 3 = above average; 4 = extensive or very able.

‖As rated by participant, where: 0 = never; 1 = occasionally; 2 = sometimes; 3 = often; 4 = very often.

Table 2

Hearing aid participant details

Group	Participant (sex)	Age (years)	Aetiology	Age first fitted with HA (years)	Device experience (months)	Type of HA*	PTA of better hearing ear (dB HL)†	Speech Perception Score (%)‡	Formal music training‖	Self-rated overall music ability¶	Pre-HL music listening#	Post-device music listening#
Training	1 (M)	81	Presbycusis	75	72	Phonak Versata	41.25	91	2	3	3	2
	2 (F)	57	Unknown	46	132	Phonak Audeo S Smart 1X	46.25	82	1	0	3	1
	3 (F)	62	Unknown	60	24	Versata Art P	60.00	36	4	3	3	2
	4 (M)	84	NIHL/Surgery	84	10	Unitron Latitude 8	45.00	40	2	2	2	2
	7 (M)	51	NIHL	49	24	Phonak Exelia Art M	43.75	0	1	0	4	0
	M/Mdn	67.00			52.40		47.25	49.80	2	2	3	2
	SD	14.71			50.33		6.59	37.08				
Control	1 (F)	65	Ménière's disease	45	180	Phonak Naida V	55.00	§	2	3	2	1
	2 (F)	47	Unknown	46	10	Oticon Vigo Connect	37.50	100	0	1	2	2
	3 (F)	48	Otosclerosis	38	120	Oticon Epoch XW	43.75	§	4	3	4	4
	4 (F)	65	Otosclerosis	55	120	Oticon Vigo Connect	45.00	65	1	1	3	1
	5 (M)	73	Presbycusis	72	7	Siemens Motion 701	31.25	100	2	0	3	3
	6 (F)	70	Presbycusis/NIHL	60	120	Oticon Safran	46.25	95	2	3	4	4
	M/Mdn	61.33		52.67	92.83		43.13	90.00	2	2	3	3
	SD	11.15		12.26	69.34		5.71	16.83				
Training and control combined	*M/Mdn*	63.91		57.27	74.45		45.00	67.67	2	2	2	2
	SD	11.27		14.53	62.15		7.69	35.25				

Note. C/P = congenital/progressive; CI = Cochlear implant; dB HL = decibels hearing level; HA = hearing aids; HL = hearing loss; *M* = mean; *Mdn* = median (last four columns); NIHL = noise induced hearing loss; PTA = pure tone average; *SD* = standard deviation

*All participants had bilateral hearing aid fittings.

†Average of pure tone audiometric thresholds across 500 HZ, 1 kHz, 2 kHz & 4 KHz.

‡AB word list score (%), unaided, better hearing ear, auditory alone in quiet at 65 dB SPL (extrapolated from performance-intensity function).

§Information not available at the time of study.

‖Score assigned to participants based on the longest reported duration of training (pre-hearing loss or post-device fitting) that involved learning a musical instrument, singing lessons, music theory or general music classes. 0 = No formal training; 1 = less than three years; 2 = 3 – 5 years ; 3 = more than 5 years.

¶0 = none or not able; 1 = limited; 2 = average; 3 = above average; 4 = extensive or very able.

#As rated by participant, where: 0 = never; 1 = occasionally; 2 = sometimes; 3 = often; 4 = very often.

2.3 .Materials

In addition to the Music Appreciation Training Program (MATP), which is described in more detail below, pre- and post-training assessments were conducted, comprising tasks of instrument, ensemble and music style identification as well as music quality (pleasantness) ratings. These tests are collectively referred to as the Music Test Battery (MTB). None of the stimuli used in the test battery was used in the training program, which allowed for the generalizability of the training program to be evaluated. The MTB subtests and order of their administration, as well as the structure of the study in terms of pre-/post-training testing and training requirements, are described in the Procedure (section 2.4).

2.3.1 Music Appreciation Training Program (MATP)

The MATP program, developed by Valerie Looi and the author, with the software written by Theam Yong Chew, is a take-home, computer-based program using 'real-world' stimuli; that is, excerpts of solo instrumentalists, vocalists, or musical ensembles playing different musical styles. The original design principle of the MATP was that it should be for long-term, on-going use; something that would be used at home as a person felt was appropriate for their needs, rather than one developed for a specific time frame or training protocol. However, for the purposes of assessing the efficacy of this program, in the current study, the number of sessions and total amount of training were specified for all participants in the training groups (10 weeks, 4 sessions a week for 30 minutes per session).

A schematic of the MATP structure is shown in Figure 3.

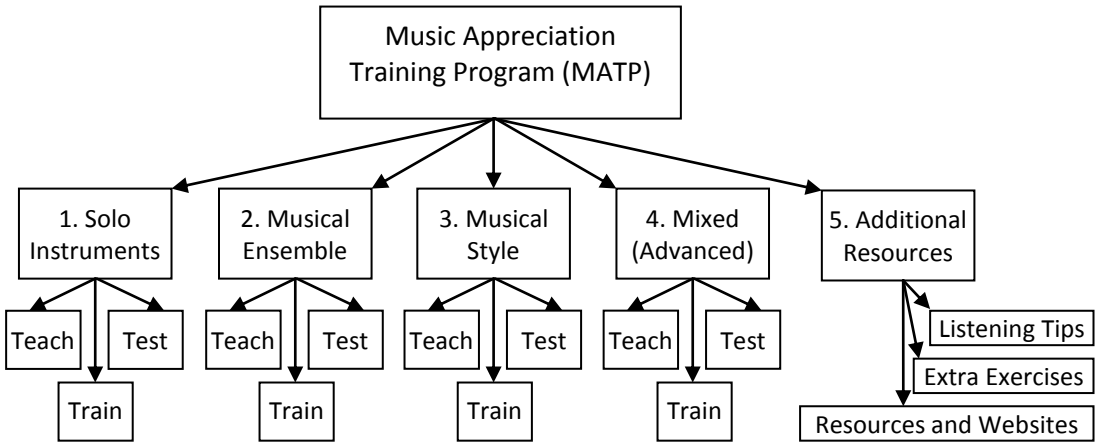

Figure 3. Schematic of the MATP showing the five modules and the phases (teaching, training and self-testing) within each of the first four modules. The fifth module, Additional Resources, is informational only.

The program was designed so that after initially entering their personal details, and setting the loudness level, trainees could immediately select which module they would like to use whenever they opened the program (see Appendix A for screenshots of these first two steps). The program comprised five modules, with modules 1 to 4 being practical modules involving structured listening tasks, and module 5 being an informational module consisting of listening tips, self-directed learning exercises, resources and websites. This latter module was designed as introductory reading before commencing the first training session, but also as a resource to return to during and after the training. It provided informational counselling to help a CI or HA user generalise the potential benefit of the structured listening exercises to their hearing experiences in everyday life. A sequence of screenshots showing navigation from the initial menu screen through to the Listening Tips and Online Resources menus within module 5 of the MATP is shown in Figure 4.

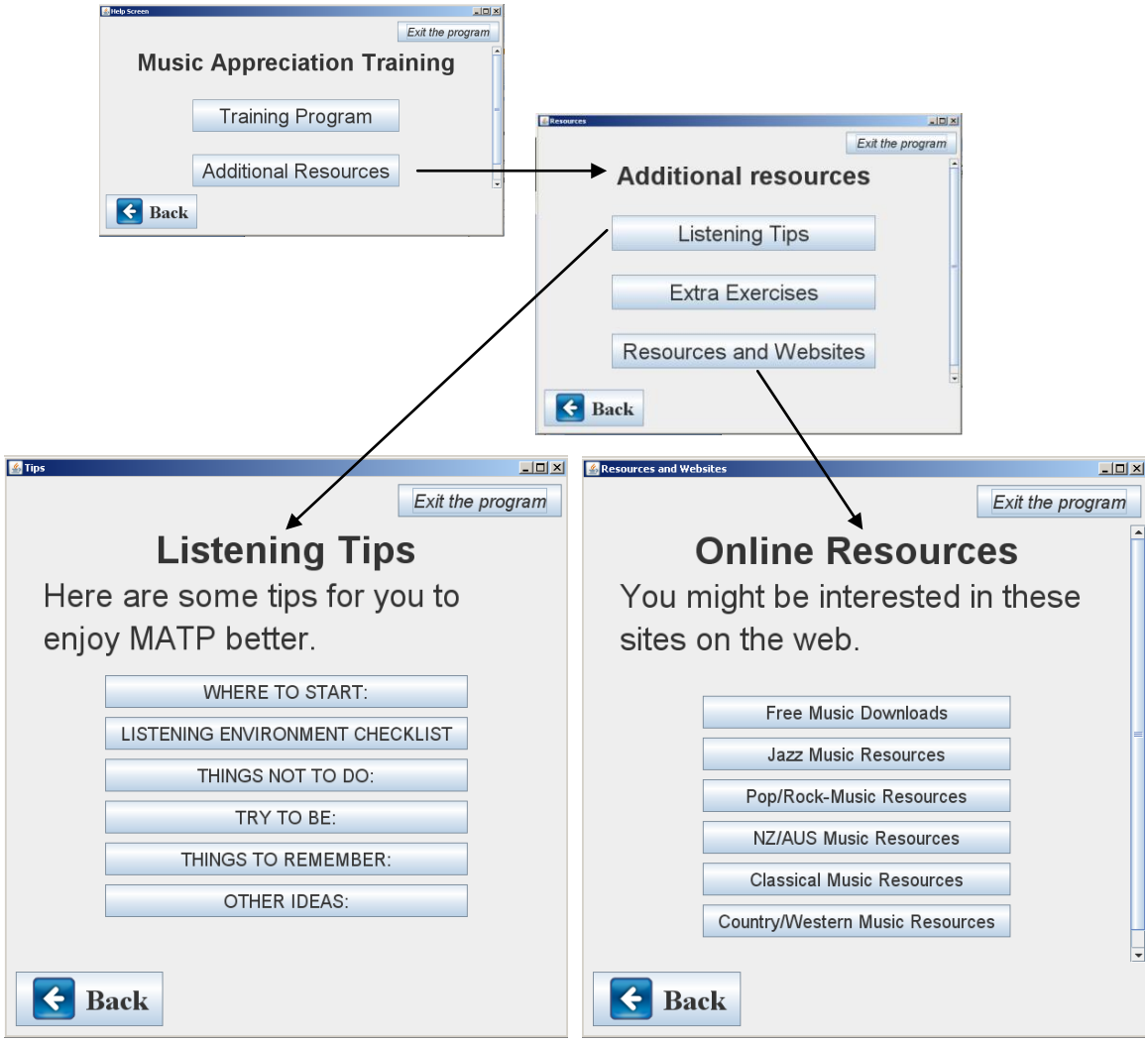

Figure 4. Sequence of screenshots showing navigation from the initial menu screen through to the Listening Tips and Online Resources menus within module 5 of the MATP.

Module 1 training focused on solo instruments, module 2 on musical ensembles, and module 3 on musical styles. Module 4 was an advanced module incorporating the skills covered in modules 1 to 3, where trainees were required to identify both the instrument/ensemble heard, as well as the musical style. In table 3 a list is provided of the instruments, ensembles and styles incorporated into the respective modules. All of the stimuli were excerpts of 'real world' music either played or sung by live performers, or extracted from commercially available compact disc recordings (in accordance with copyright regulations). Overall there were more than 1500 individual excerpts in the MATP.

Table 3
Stimuli in each module

Module 1 Solo Instrument	**Module 2 Ensemble**	**Module 3 Musical Style**	**Module 4 Instrument/Ensemble**	**Style**
1. Piano	1. Orchestra	1. Classical – solo	1. Piano	1. Classical
2. Violin	2. Rock band	2. Classical – small group	2. Violin	2. Jazz
3. Cello	3. Brass band	3. Classical – large group	3. Flute	3. Pop/rock
4. Flute	4. Jazz band	4. Jazz	4. Clarinet	4. Country & Western
5. Clarinet	5. String quartet	5. Modern/Pop (1990s on)	5. Trumpet	
6. Trumpet	6. Choir	6. 1960-1980's	6. Guitar	
7. Trombone	7. Duets – instrumental	7. Old-time music (1950's and earlier)	7. Orchestra	
8. Xylophone	8. Duets – voice + piano	8. Country & Western	8. Band (e.g. Rock, Jazz, Brass band)	
9. Drum kit	9. Instrument + orchestra	9. Eastern	9. Duet	
10. Guitar	10. Voice + orchestra		10. Trio	
11. Male singer			11. Choir	
12. Female singer			12. Solo instrument plus group accompaniment	

There were three phases within each of modules 1 to 4: a teaching phase, a training phase, and a self-testing phase. The excerpts were slightly longer (around 20 seconds) for the teaching phase than for the training and self-testing phases (10 to 15 seconds). A sequence of screenshots showing navigation from the initial menu screen through to the training module menu within the MATP is shown in Figure 5.

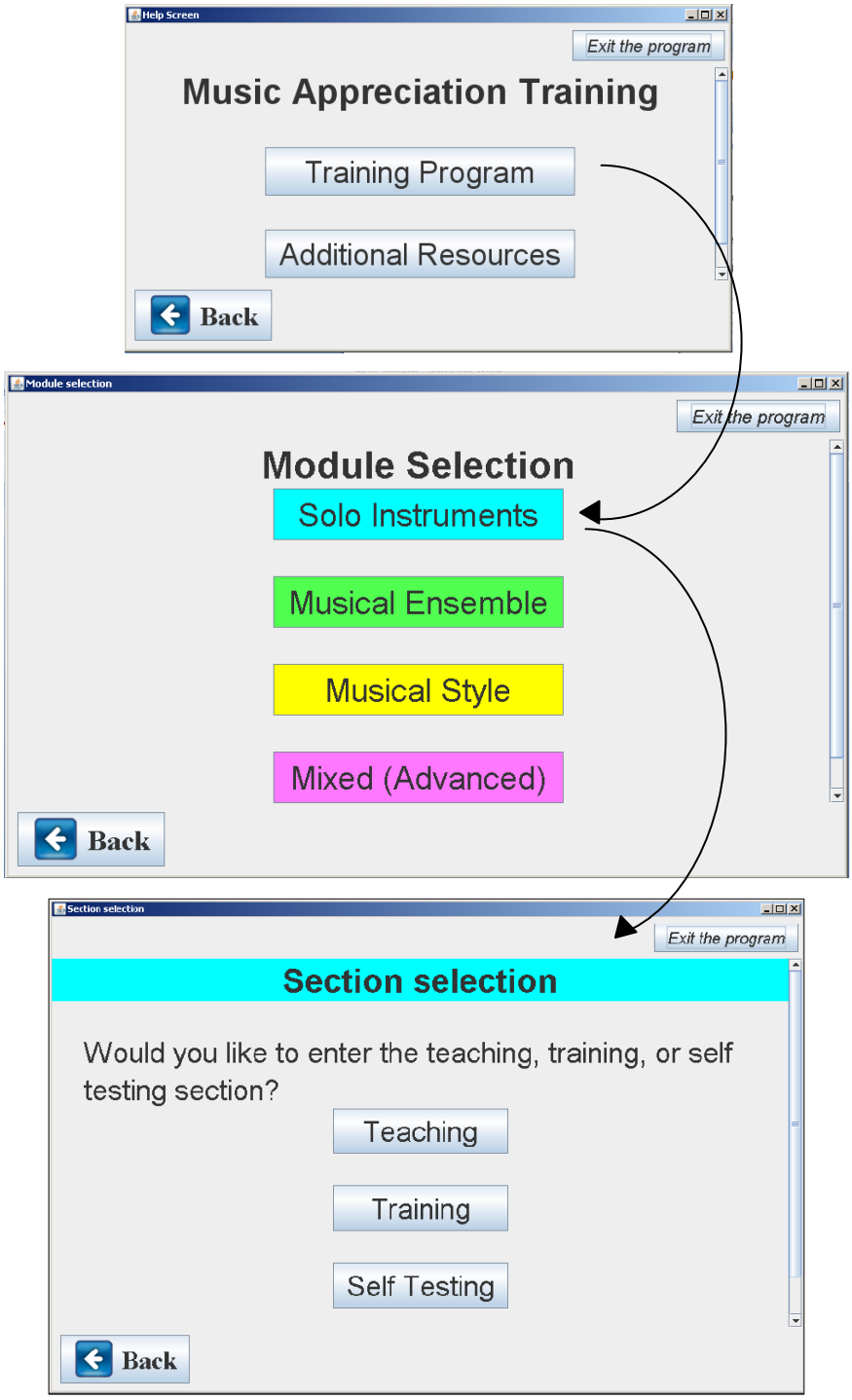

Figure 5. Sequence of screenshots showing navigation from the initial menu screen through the training modules menu and to the menu of phases within the Solo Instruments module of the MATP.

A sequence of screenshots from the **teaching phase** of the Solo Instrument module MATP is shown in Figure 6. In these screenshots an instrument is selected and an example of that instrument is selected for playback.

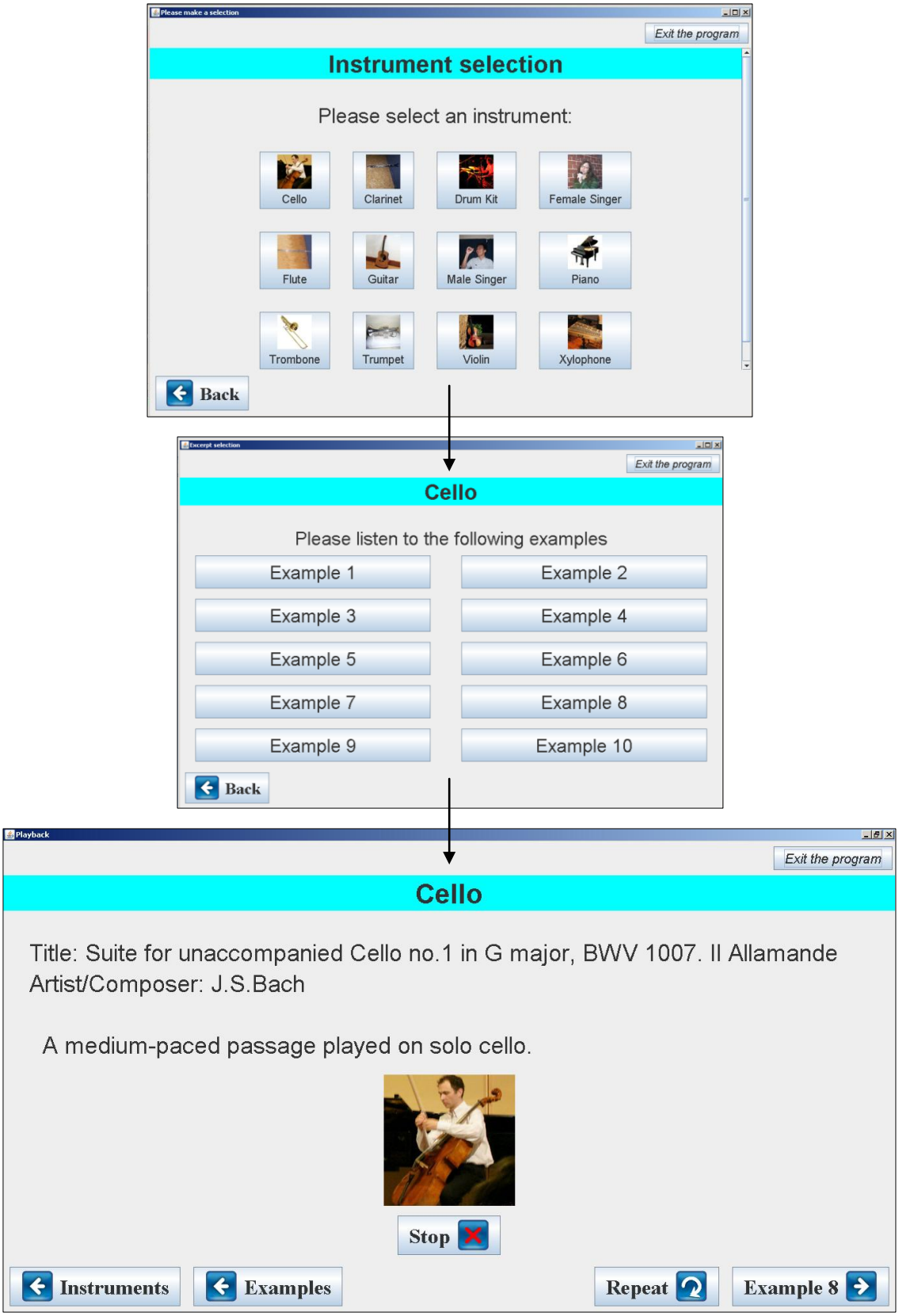

Figure 6. Sequence of screenshots showing selection of 'Cello' from the list of instruments in the teaching phase of the MATP Solo Instrument module. In this sequence the user proceeds to select example 7 from the menu for that instrument. Once the user has listened to the excerpt and read the supporting information they can use the navigation buttons at the bottom of the screen to repeat playback of the excerpt, move to the next example, return to the list of examples or return to the list of instruments.

In the teaching phase, the trainees were provided with 10 samples of each instrument/ensemble/style (henceforth referred to as 'I/E/S') to listen to, with on-screen information provided about that extract and the sounds that were being played. The goal of this phase was for the trainees to familiarise themselves with each I/E/S in that module, and its sound quality/characteristics. Trainees could repeat each excerpt as many times as they wished. On selecting the 'teaching phase', the trainees were directed to choose the I/E/S they wished to learn about. The trainee could return to this phase at any time, for example if they were having difficulty with the training phase.

Once trainees felt that they had sufficiently familiarised themselves with the different I/E/S, they could then move on to the **training phase**, where they were required to differentiate between the different stimuli in that category using a closed-set format. This phase incorporated an adaptive algorithm that started with two options on the screen. If participants correctly identified three consecutive stimuli, on 3 out of 4 consecutive trials, the difficulty level increased by having four options on the screen, then six, then eight, and finally all options on screen. For any of these levels, except for the initial two-option level, if trainees incorrectly identified three consecutive stimuli, or 3 out of 4 consecutive trials, the difficulty level decreased to the previous level (i.e. fewer options on screen).

In this phase, immediate feedback was provided to trainees regarding whether their responses were correct or incorrect. Research has shown that exposure alone does not improve the quality of music listening for recipients (Gfeller, Jiang, Oleson, & Driscoll, 2010) and that active engagement with feedback enhances training outcomes (Driscoll, Oleson, Jiang, & Gfeller, 2009). If trainees were correct, one to two sentences were also provided on the stimuli's characteristics (e.g. the number of instruments in the extract, which instruments were in the ensemble, the title and artist of the piece). If their choice was incorrect, the visual feedback was supplemented with auditory feedback where trainees could hear both an appropriate except of the correct I/E/S, as well as what they had selected in a comparative format. They were encouraged to replay both of these extracts as many times as they required, in order to learn how to differentiate between the stimuli. Figure 7 features a screenshot of a training phase closed-set task and subsequent feedback screen for a correct response. An example of a feedback screen for an incorrect response is shown in Figure 8.

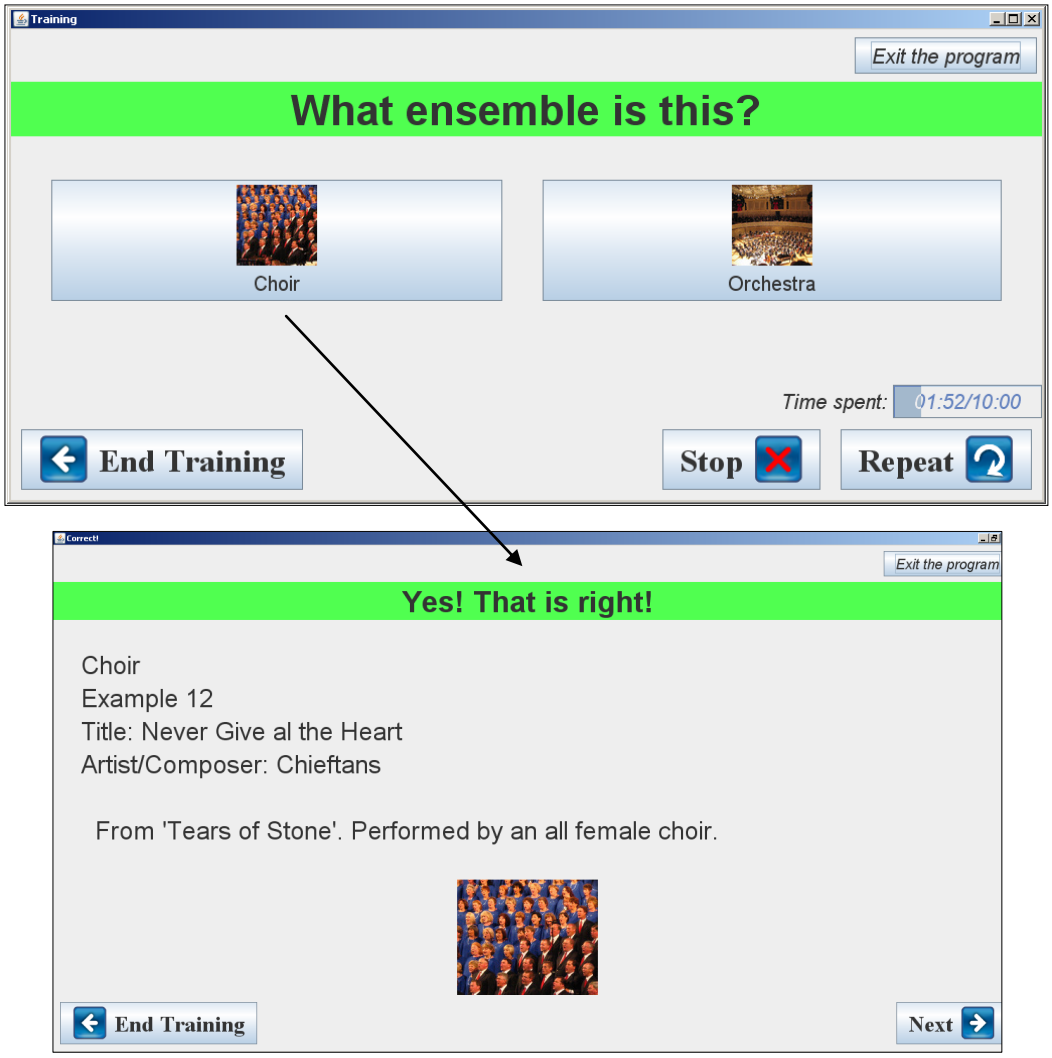

Figure 7. Screenshots from the training phase of the Ensemble module within the MATP showing a closed-set task and subsequent feedback screen for a correct response.

Figure 8. Screenshot of a feedback screen following an incorrect response to a closed-set task in the training phase of the Ensemble module within the MATP.

An example of a user's progression through screens in the third phase within each module, the **self-testing phase** testing phase, is shown in Figure 9.

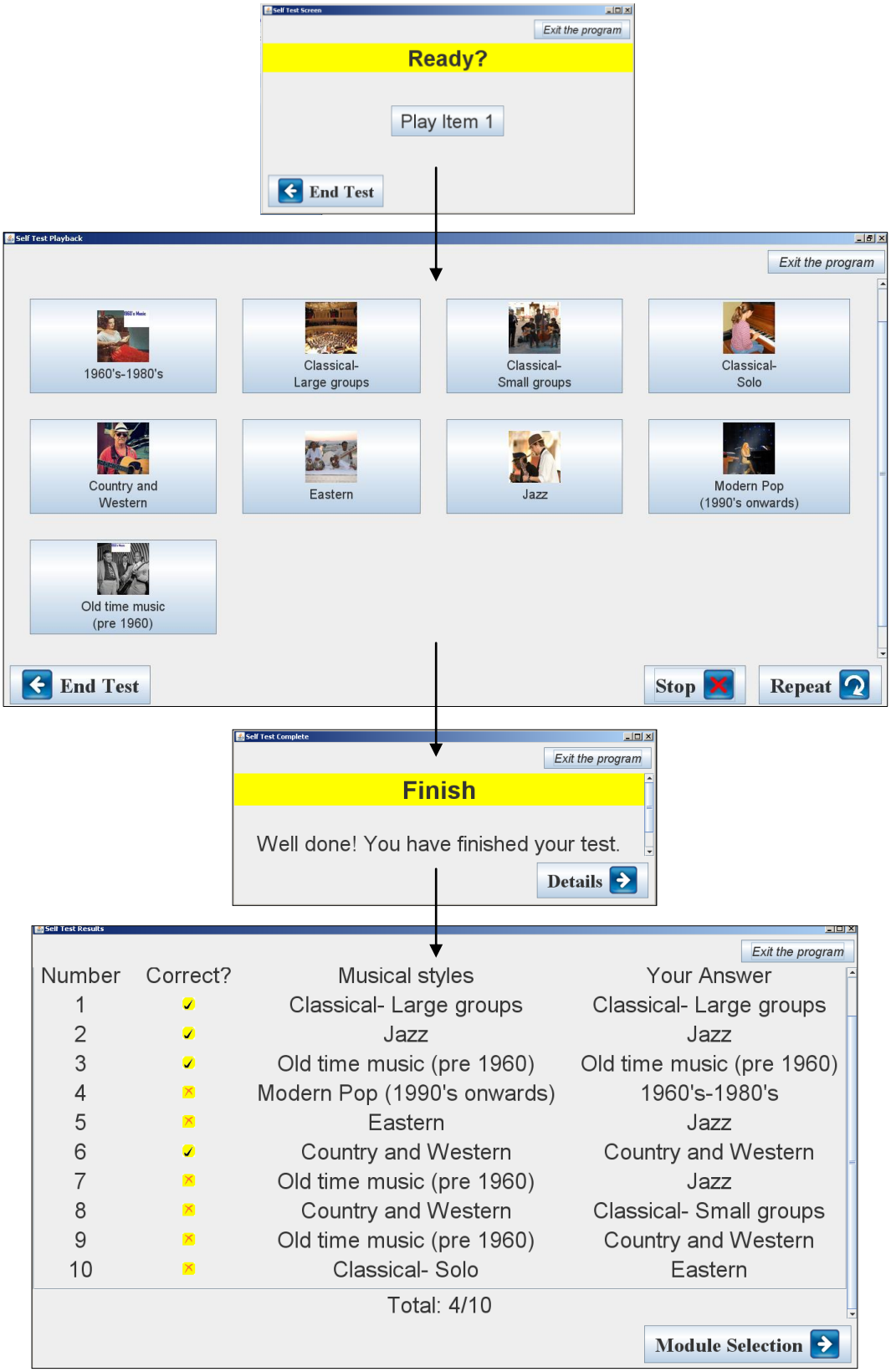

Figure 9. Sequence of screenshots from the self-testing phase of the MATP showing an example test item playback screen, closed-set response screen, end of testing notification screen and results summary screen.

The self-testing phase enabled trainees to monitor their own progress and was intended to motivate them to continue training. In this phase, 10 randomly selected stimuli were presented sequentially to participants using a closed-set format; all of the possible options were displayed on the screen for each stimulus. The stimuli in this phase were different from the stimuli in either the training or teaching phase (i.e. different excerpts of music). Immediate feedback was not provided in this phase. After completing each self-test, trainees were informed of their overall score, as well as their performance on each individual item in terms of what the item was, and what their response was. Again, this enabled trainees to go back to the teaching phase and practise with any stimuli which they had difficulty.

The program automatically recorded their scores in both the training and self-testing phases. Trainees could also access this information to monitor their progress over time. The program also kept a data log of participants' usage to allow for subsequent analysis. The logged data included information such as time spent training, dates of training, modules and I/E/S chosen, and time spent on each of these modules, in addition to their scores. A printed manual and training diary (Appendix A) accompanied the program, allowing trainees to record their progress. The manual provided explicit instructions on installing the software, adjusting settings, navigation through the program modules and phases, as well as troubleshooting information.

2.3.2 Music Test Battery (MTB)

As mentioned above, the Music Test Battery consisted of instrument, ensemble and musical style identification tasks, as well as a task rating the quality (pleasantness) of the musical sound.

2.3.2.1 Instrument and ensemble identification

These two tests assessed participants' ability to identify solo musical instruments and music ensembles respectively from sound excerpts alone. The stimuli and test procedures are described in detail in (Looi et al., 2008a, 2008b). Prior to each test, participants were asked to inspect the test screen and confirm that they were familiar with the names of all of instruments/ensembles or seek clarification on any possible ambiguities. Four 5-second extracts of each of the 12 different instruments/ensembles comprised the stimuli for each subtest (i.e. 48 stimuli per test), and participants were required to identify the instrument/ensemble they heard from a list of the 12 instruments/ensembles. A percent-correct score was calculated for each subtest.

The solo instrument test comprised the following instruments or voices: male singer, female singer, piano, guitar, bass drum (or timpani), drum kit, xylophone, cello, violin, trumpet, flute and clarinet. Each of these solo instruments can be distinguished from other instruments based upon their spectral features. The music ensemble test comprised the following groups: choir

(four-part, acapella), orchestra, jazz band (instrumental only), rock band (instrumental only), country and western band (instrumental only), string quartet, percussion ensemble (varying instrumental combinations), violin and piano duet, cello and piano duet, male singer and piano duet, female singer and piano duet, and one male and one female singer with piano accompaniment. In these cases, the excerpts were made up of blends of small to large instrumental and/or vocal excerpts. Identical versions of these two tests were used in the pre- and post-training testing.

2.3.2.2 Musical style identification

This closed-set identification test was developed as part of the study. Although more specific details on its development and validation are provided in Looi, King, & Kelly (2011), a short summary of test development is provided here. Two versions of this test were created for eventual use; for each participant, one version was randomly assigned to be administered pre-training and the other version post-training. This was to prevent recall of test items from the pre-training test at the post-training test session, given the excerpts for this test were longer than for the previous tests and potentially easier to remember.

The initial development of the two versions comprised two phases. In the first phase, 10 NH adults (age 22 – 60y; *M* = 42.2y) were presented with 80 ten-second musical excerpts extracted from commercially-available recordings. These were presented via a loudspeaker placed 1 metre from the listener at 0 degrees azimuth, at 65 dB A. There were 10 extracts from each of the following styles: i) Classical – Solo; ii) Classical – Group; iii) Instrumental Jazz; iv) Modern/Pop (1990s onwards); v) 1960s-1980s; vi) Old-Time music (pre 1960); vii) Country & Western; and viii) Eastern. Participants were asked to identify the style that best matched the extract they heard, using a closed set procedure. The two excerpts from each style group that yielded the highest numbers of confused responses were identified and removed from the test. Using the remaining 64 excerpts (8 per style), the two versions of the test were created by randomly allocating four excerpts per style to each version. Both versions, each containing 32 excerpts, were further tested on 10 normally hearing adults (aged 39 – 60y; *M* = 51.2y); half completed version 1 before version 2, and the other half using the reverse order. The mean percent correct scores were 92% and 94% for versions 1 and 2, respectively.

2.3.2.3 Quality (pleasantness) rating

The stimuli used in this task were identical to those used in the ‘single instrument’ and ‘music ensemble’ identification subtests described above. For each excerpt, the test administrator indicated the instrument or ensemble involved by pointing to the item. The participants then

rated the pleasantness of that excerpt. Before ratings task commenced, participants were advised that for the purpose of this test, 'pleasantness' was defined as their enjoyment of the excerpt itself, rather than their preference for a particular instrument or ensemble. Participants were asked to consider whether the excerpt sounded natural, sounded similar to what they would expect it to sound like to someone with normal hearing, and whether they would be happy to continue to listen to that excerpt. Ratings were made on a visual analogue scale from 0 to 10, where 0 was "very unpleasant" and 10 was "very pleasant".

2.3.3 Questionnaires

Three questionnaires were developed for this study.

2.3.3.1 Music background questionnaire

This questionnaire adapted from Jayakody, (2011), Looi et al., (2008a, 2008b), was used to gather information on participants' self-rated musical ability. Versions of this questionnaire with slightly different wording were used for CI participants (Appendix B) and HA participants (Appendix C). Participants were asked to indicate the duration of formal training that they had undertaken in singing, musical instrument performance, music theory or general music classes. A score was later assigned to each participant based on the longest duration of training in any of the stated activities, where: 0 = no formal training; 1 = less than three years; 2 = 3 to 5 years; and 3 = more than 5 years. After rating their knowledge of music history and theory, their ability to read music, and ability to play an instrument or sing, participants were asked to rate their overall music ability, where: 1 = none or not able; 2 = limited; 3 = average; 4 = above average; and 5 = extensive or very able. Participants were also asked to indicate how often (very often; often; sometimes; occasionally; or never) they chose to listen to music both before their hearing loss and after receiving their device (CI users) or starting to wear hearing aids (HA users). The participants' musical background details are summarised in Tables 1 and 2.

The questionnaire was also used to gather information regarding the age at which the device (or devices) were fitted or implanted, the type of device(s), the device experience, as well as programs and settings used. Information gathered on the participants' self-rated interest in music, change in enjoyment of music before loss of hearing and after implantation, and participation in musical activities was also gathered but not utilized for the current study. Relevant information is also summarised in Tables 1 and 2.

2.3.3.2 MATP evaluation questionnaires

A questionnaire, entitled Music Appreciation Training Program Evaluation Questionnaire (Appendix D) was developed in order to obtain trainees' feedback and ratings of self-perceived benefits and changes to their music appreciation and enjoyment levels after having used the MATP during the training period. The questionnaire was adapted by the author from an earlier questionnaire developed by Jayakody (2011). Each benefit-related item required participants to provide a rating of 'very much so', 'noticeably', 'marginally', 'unsure' or 'not at all'. Items that were included in the questionnaire are shown later in Figure 1. The questionnaire also asked participants to provide feedback on the duration of the training program and frequency of training sessions. It was intended that the questionnaire would be completed by participants immediately following the completion of the training sessions.

2.4 Procedure

Participants completed a paper copy of the music background questionnaire at the initial MTB testing session before testing commenced.

2.4.1 Musical Test Battery administration

For all participants (i.e. both the training and control groups), the MTB was administered by the author prior to the training period, and again within two weeks of the completion of training (or within an equivalent time frame for the control group). All testing was performed in quiet test rooms at audiology clinics in Australia or New Zealand. For the MTB testing, participants were asked to set their devices to their preferred program and volume for listening to music, but not to change this during the course of the testing session. The settings used in the baseline testing sessions were recorded by the author, who later ensured that the participants used the same settings during the final testing sessions. All CI recipients were tested in a CI-only condition, in that bimodal CI recipients did not wear their HA device, and their contralateral ear was plugged if their low-frequency thresholds were better than 50 dB HL (hearing level). Bimodal CI recipients were also instructed to not wear their HA while training at home. HA participants were tested using their normal listening mode (i.e. bilateral HAs). For each of the tests, MACarena software (Lai & Dillier, 2002) was used to present test stimuli in random order in the soundfield via a JBL LSR 6325P Bi-Amped 5.25" studio monitor loudspeaker placed 1 metre from the participant at 0 degrees azimuth. Each participant set their individually verified, comfortable presentation levels prior to the MTB test by adjusting the output of the computer's soundcard using the calibration slider control built into the software. For the identification tasks, the response options were presented on a laptop screen and participants selected their answer

using a mouse or laptop tracking pad. For the quality rating tasks, the researcher played the excerpts while pointing to the corresponding instrument or ensemble on a printed copy of the test screen and asked the participants to give their verbal ratings. The ratings were then entered into MACarena by the author.

Both MTB sessions took approximately one hour each. The identification (ID) and quality rating (QR) subtests of the MTB were administered in the following order: single instrument ID, ensemble ID, musical style ID, single instrument QR, ensemble QR. The stimulus order within each subtest was randomised.

2.4.2 Training procedures

After baseline testing with the MTB, participants in the two training groups were individually introduced to the MATP by the researcher and given an opportunity to use the program, with the author acting as a guide, until they felt comfortable with it. Trainees were then provided with USB drives containing the MATP software, and shown how to install it on their own computers and set the output at their own comfort level. This level could be reset by trainees as required. Printed copies of the user manual distributed to the trainees contained detailed installation instructions. Some trainees opted to bring their laptops with them to the test session in order for to have the researcher to install the software for them.

The trainees were asked to use the MATP for 30 minutes per day, four times a week for 10 weeks. There was no stipulation of the modules that were to be used or in which order, nor how much time should be spent on each module. However it was suggested that they read the listening tips section in the fifth module of the MATP prior to starting so that they could use these tips while training. They were also encouraged to move through the modules in a way that suited their own goals and interests, with the mixed/advanced module only being attempted after experience with the other modules. The author also suggested that within each module, they should begin with a teaching section to learn about the stimuli before proceeding to the training section. They were advised that they could return to the teaching section at any time to better familiarise themselves with problematic stimuli. CI recipients were asked to train in a CI-only condition, and to use the same device settings as for the MTB testing. They were also given the contact details for the researcher, should they have any problems or questions. Approximately a week after MTB testing and then again half way through the training period, each participant was contacted to check their progress and answer any questions.

Those in the control group were not provided with a training program nor were they given any specific instructions other than to continue their normal listening habits and return for the retest session that was then arranged for 12 weeks later.

2.4.3 Post-training

After the 10-week period, all participants, including those in the control groups, returned to the same clinic for reassessment using the MTB, with the author following the same methodology as that described above. Those in the training groups were emailed a copy of the MATP evaluation questionnaire beforehand, and asked to complete and return it before the testing session if possible, so that the author could clarify responses during the session as necessary. Participants either brought their laptop computers with them to the post-training session to allow for retrieval of their MATP data log files, or instead were given instructions to locate the file themselves and send it via email.

3 Results

In addition to developing the MATP and musical style ID test, the MATP was then pilot tested on HA users and CI recipients to gauge interest and benefits. The results of the pilot test are presented in this chapter.

3.1 Participant flow

As mentioned in section 2.2, the participant numbers for both device groups changed over the course of the study. Regarding the CI cohort, at the pre-training stage, the training and control groups consisted of 11 and 8 participants respectively. One participant from the training group was unable to commence training at the beginning of the training period and so joined the control group. Another member of the training group completed the training but was unable to attend the post-training test session due to bereavement. Participant #5 from the training group participated in the post-training tests but had been able to complete only 15 of the 40 MATP sessions due to computer problems and was therefore excluded from the data analysis. Eight training and 9 control group participants were included in the final analyses.

For the HA cohort, the training and control groups initially consisted of 6 participants and 7 participants respectively. One participant from the control group had a change in time constraints and was able to join the training group at the beginning of the training period. Training group participants #5 and #7 participated in the post-training tests, but as they had completed only 10 of the 40 training sessions due to occupation-related time constraints their data were excluded from the analysis. Five training and 6 control group participants were included in the final analyses.

3.2 Pre-training baseline MTB assessments

Mean percent-correct scores from the baseline (pre-training) administration of the MTB are shown in Table 4. Mann-Whitney *U* tests showed no significant differences between the CI training and control groups for any task, and a significantly higher baseline single instrument ID score for the HA control group as compared to the HA training group ($U = 4.0$, $p = .044$).

Table 4

Pre-training identification task results (% correct) and quality rating results

	CI			HA			
	Training	Control	Combined	Training		Control	Combined
Identification tasks							
Single instrument	76.83 (15.81)	75.48 (10.67)	76.11 (12.91)	75.4 (11.17)		88.57 (7.76)	82.58 (11.28)
Ensemble	54.95 (15.31)	52.79 (13.17)	53.81 (13.80)	63.36 (13.14)		78.85 (13.40)	71.81 (14.97)
Style	57.05 (20.12)	52.43 (15.84)	54.61 (17.55)	65.64 (12.31)	*	78.13 (16.76)	72.46 (15.61)
Quality ratings (/10)							
Single instrument	7.04 (0.53)	6.41 (2.02)	6.71 (1.51)	7.09 (1.53)		7.70 (1.24)	7.43 (1.35)
Ensemble	5.91 (0.98)	5.96 (2.03)	5.94 (1.58)	7.29 (1.08)		7.54 (1.63)	7.42 (1.35)

Ratings range from 0 = very unpleasant to 10 = very pleasant.

Values shown are mean (standard deviation).

CI, cochlear implant groups; HA, hearing aid groups.

* statistically significant difference between values in adjacent cells, $p < .05$ (Mann-Whitney *U* test).

3.3 Participant factors and baseline MTB score correlations

Spearman's rank-order correlations were used to identify associations between participant factors previously reported to potentially impact on music perception (i.e. age, music training, and pre-hearing loss and post-device fitting music listening levels, as reported in Tables 1 and 2) and baseline MTB scores for each device type. In order to achieve larger sample sizes for this calculation the training and control groups' scores were combined. The MTB tasks were then grouped into two categories:

(i) identification tasks (i.e. mean of each participant's single instrument, ensemble and style identification scores);

(ii) quality rating tasks (i.e. mean of the single instrument and ensemble quality ratings).

The procedure for calculating the scores for the music training and music listening levels is explained in the footnotes to Tables 1 and 2. It should be noted that correlations to speech perception scores, sourced from the participants' most recent audiological assessment, were not calculated in this study due to the ceiling effect observed in the CI participant data, in that most scored close to 100%, and the lack of available results for some of the HA participants.

For the CI group (n = 17), there was a significant negative correlation between identification task scores and pre-hearing loss music listening levels ($r_{s(15)} = -.531$; $p = .028$), with the correlation between these identification scores and device experience approaching significance ($r_{s(15)} = -.466$, $p = .059$). There were no significant correlations for the quality rating tasks.

For the HA group (n = 11), there were no significant correlations between identification task scores and the above-mentioned participant factors. For the quality ratings, there was a significant positive relationship with the time spent listening to music following HA fitting ($r_{s(9)}$ = .697, p = .017), and a significant negative relationship with device experience ($r_{s(9)}$ = -.636, p = .035).

3.4 Pre- and post-training MTB score comparisons

The differences between the pre- and post-training scores (or, for the control group, the two administrations of the MTB) were calculated (i.e. post-training score minus pre-training score). These are reported in Table 5. A positive number means that the post-training score was higher than the pre-training score, with a negative number being a higher pre-training score. Mann-Whitney *U* tests were conducted to compare this 'difference score' between the training and control groups, in order to determine whether any pre-to-post training improvement for the training groups was significantly greater than for the control group, that is, whether any improvement may be attributable to more than a task-specific learning effect or test-retest variability. These analyses revealed that the change in the ensemble QRs was significantly greater for the CI training group than the CI control group (U = 14.00, p = .034). There were no significant differences for the identification tasks. The HA training group's pre- to post-training difference scores were greater than those of the HA control group, however Mann-Whitney *U* tests did not show any of these differences to be statistically significant.

Table 5

Difference between post- and pre-test scores on identification tasks (% correct) and quality rating results

	CI			HA	
	Training		Control	Training	Control
Identification tasks					
Single instrument	1.83 (6.99)		0.46 (10.92)	7.12 (7.58)	3.1 (5.39)
Ensemble	10.16 (14.80)		4.62 (16.74)	7.90 (7.40)	5.52 (2.84)
Style	-1.18 (15.12)		-0.21 (19.96)	0.00 (13.96)	-2.08 (7.83)
Quality ratings (/10)					
Single instrument	-0.01 (0.21)		0.04 (1.65)	0.28 (0.91)	-0.17 (1.28)
Ensemble	0.99 (0.91)	*	-0.002 (1.21)	0.22 (0.66)	-0.01 (1.77)

CI = cochlear implant groups, HA = hearing aid groups.

Values shown are mean (standard deviation).

Quality ratings range from 0 = very unpleasant to 10 = very pleasant.

* statistically significant difference between values in adjacent cells, p < .05 (Mann Whitney *U* test).

3.5 Training details

Group mean and individual participant total training times, as well as the division of these times across the four MATP modules, is shown in Table 6. Proportions of time spent in the teaching, training and self-testing phases of each module are also shown for individual participants. Overall, the CI training group as a whole completed 1104 of the requested 1200 minutes of total training time. CI training group participants used the Musical Style module most often (*M* = 299 minutes) and Mixed (Advanced) module least often (*M* = 261 minutes). Percentages of time spent by the CI group training group in each of the MATP modules were: Solo instrument module = 24.5%; Musical Ensemble module = 24.7%; Musical Style = 27.1%; and Mixed (Advanced) Module = 23.7%. The HA training group completed 1094 of the requested 1200 minutes of total training time, with the Musical Ensemble module being most often (*M* = 340 minutes) and Mixed (Advanced) module used least often (*M* = 146 minutes). The percentages of time that the HA training group spent in each module were: Solo instrument module = 27.3%; Musical Ensemble module = 31.1%; Musical Style = 28.3%; and Mixed (Advanced) Module = 13.3%.

Given the variability of module-specific training durations between training group participants, Spearman's rank-order correlations were used to identify associations between pre- and post-training MTB difference scores and usage durations for each MATP module. Significant negative correlations were found between instrument ID difference scores and time spent in the Instrument module ($r_{s(6)}$ = -.719, p = .045), and between ensemble quality rating difference scores and time spent in training in the Ensemble module ($r_{s(6)}$ = -.714, p = .047). Significant positive correlations were found between style identification and time spent in training in the Musical Style module ($r_{s(6)}$ = .707, p = .015)

Table 6

Total time (minutes) and proportions of time spent in each phase (% teaching, % training, % self-test) while actively working in MATP. (The data excludes navigation time between modules, phases, and stimuli types.)

		Single Instrument Module		Musical Ensemble Module		Musical Style Module		Mixed (Advanced) Module		All Modules
Group	Participant	Duration	Phases	Duration	Phases	Duration	Phases	Duration	Phases	
CI	1	429	(51%, 33%, 16%)	396	(55%, 38%, 7%)	584	(64%, 35%, 1%)	722	(30%, 66%, 4%)	2131
	2	263	(11%, 69%, 20%)	331	(12%, 51%, 37%)	255	(12%, 59%, 29%)	154	(3%, 38%, 59%)	1003
	3	223	(42%, 45%, 13%)	217	(30%, 46%, 24%)	212	(35%, 46%, 19%)	126	(17%, 58%, 25%)	778
	4	419	(10%, 55%, 35%)	249	(22%, 11%, 67%)	284	(19%, 25%, 56%)	341	(26%, 26%, 48%)	1293
	6	182	(49%, 47%, 4%)	309	(62%, 33%, 5%)	217	(62%, 35%, 3%)	252	(65%, 35%, 0%)	960
	7	136	(29%, 54%, 17%)	185	(21%, 66%, 13%)	323	(22%, 61%, 17%	319	(3%, 87%, 10%)	963
	8	187	(72%, 24%, 4%)	282	(37%, 55%, 8%)	281	(56%, 38%, 6%)	146	(31%, 57%, 12%)	896
	9	326	(63%, 33%, 4%)	213	(55%, 42%, 3%)	236	(67%, 27%, 6%)	30	(33%, 47%, 20%)	805
	M	270.63		272.75		299.00		261.25		1103.63
	SD	97.45		62.29		106.74		188.16		391.61
HA	1	*	*	*	*	*	*	*	*	*
	2	161	(6%, 68%, 24%)	279	(21%, 56%, 23%)	289	(13%, 67%, 20%)	0	(27%, 55%, 18%)	729
	3	363	(22%, 17%, 61%)	374	(6%, 48%, 46%)	443	(8%, 35%, 57%)	217	(5%, 70%, 25%)	1397
	4	372	(59%, 27%, 14%)	367	(48%, 31%, 21%)	195	(33%, 50%, 17%)	221	(15%, 63%, 22%)	1155
	7	†	†	†	†	†	†	†	†	†
	M	298.67		340.00		309.00		146.00		1093.67
	SD	97.41		43.23		102.23		103.25		276.14

Note. CI = cochlear implant training group; HA = hearing aid user training group; *M* = mean; *Mdn* = median; *SD* = standard deviation.

*Data lost due to software/hardware error.

†Data not available from participant.

3.6 Perceived benefits following training

Six CI and four HA trainees returned the Music Appreciation Training Program Evaluation Questionnaire by email attachment prior to the post-testing session, with the remainder completing it during that session. Results from the post-training MATP evaluation questionnaire are displayed graphically in Figure 10.

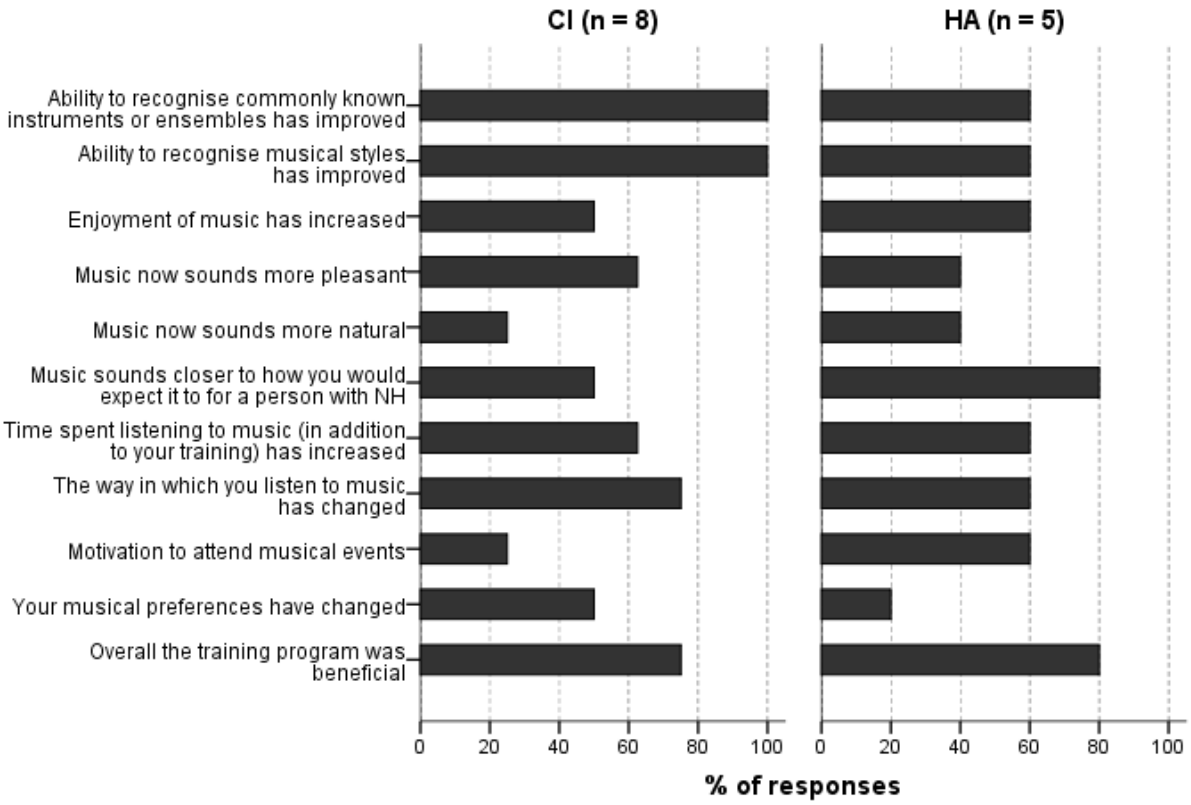

Figure 10. Percentages of participants from the CI and HA training groups that provided positive responses to questions in the post-training MATP evaluation questionnaire. Participants were asked either 'Do you feel that the training program has helped to increase your...' or 'Since using the program do you feel that...'. NH = Normal hearing.

For the purposes of this analysis, the answer categories 'marginally', 'noticeably' and 'very much so' were grouped together to form a 'positive response' category, while 'not at all' and 'unsure' were considered to be negative responses. The proportion of the CI and HA training group participants that gave positive responses are shown for each questionnaire item. All participants in the CI group gave positive responses to items that asked if they felt that their ability to recognise commonly known instruments, ensembles and styles had improved. Items that asked if music sounded more natural and whether motivation to attend musical events had increased yielded the lowest numbers of positive responses for the CI group. The HA group provided the greatest percentage of positive responses for items that asked whether music now

sounded closer to how they would expect it to sound to a person with normal hearing. Over 75% of the trainees, for both devices, found the program to be beneficial.

Participants in the training groups were also asked if they felt they could continue to improve their ability to recognise timbre and musical style after completing the MATP. Three of the 8 CI participants, and 2 of the 5 HA participants answered 'yes', with a further 3 CI and 1 HA participant(s) saying 'unsure'. Of those that were unsure, one CI participant commented that she may be able to improve further by wearing her contralateral HA during further MATP training, whilst the HA participant commented that she would like to continue to use the MATP

3.7 Relationships between participant factors and perceived benefits of training

Spearman's rank-order correlations were used to identify participant characteristics from the previously mentioned participant factors that were associated with responses to the MATP evaluation questionnaire item 'overall the training program was beneficial'. For the CI trainees, strong negative correlations were found for both the factors of participant age, and age at implantation ($r_{s(6)}$ = -.756, p = .030 for both), implying that younger recipients and those implanted at a younger age were more likely to feel that the MATP was beneficial. Strong positive relationships with perceived benefit were found for the factors of formal music training ($r_{s(6)}$ = .719, p = .044) and self-reported overall music ability ($r_{s(6)}$ = .816, p = .013).

3.8 Feedback on the duration of the MATP

As part of the MATP evaluation, participants were asked to rate the duration of the training program and sessions, as well as the frequency of training sessions, as either 'too short', 'short', 'just right', 'long' or 'too long'. For the CI training group, only 2 of the 8 trainees felt that 10 weeks was 'just right', with 5 responding that it was 'long' and the other saying it was 'too long'. Four training sessions per week was rated as 'just right' by 6 of the CI trainees; the other 2 felt this was 'long' (i.e. too many sessions per week). With regards to the length of each session, the majority (6 out of 8) agreed that 30 minutes was 'just right', with the other two feeling that it was 'short'**.** Of the five HA participants that completed the training, three said that 10 weeks was 'just right', one said it was 'short' and one answered 'long'. All participants considered the number of sessions per week to be 'just right', and 4 out of 5 felt that 30-minute sessions were the correct length; the other HA trainee said this was 'short'.

4 Discussion

The primary goal of this pilot test study was to develop a MATP to be used in clinical practice as an engaging take home tool for HA users and CI recipients to use over the long term for improving their appreciation and enjoyment of music. Part of this process was to assess whether use of the MATP would improve users' appreciation and enjoyment of music in terms of: (i) perceptual accuracy involving judgements of timbre; and (ii) perceived 'pleasantness' of music, measured using quality ratings for the purpose of this study.

For both hearing aid and cochlear implant users, the general hypothesis was that for each of the ID and QR measures tested, the difference between pre- and post-training session scores for the training group would be significantly greater than for the control group. Also of interest was whether participants in the training group reported perceived benefits of the training and if so what form these took.

4.1 Major findings

4.1.1 Perceptual accuracy

Contrary to the author's expectations, the structured use of the MATP over the training period did not result in significant improvements on any of ID tasks completed by the CI training group, i.e. there were no significant differences between the respective training and control groups' pre- to post-training period difference scores. The CI findings in the current study are inconsistent with those of Gfeller, Witt, Adamek, et al. (2002), who found significant improvement on single instrument ID tasks following training provided for CI users. There are a few notable differences between the two studies that may account for why the positive findings were not replicated in this study. Gfeller, Witt, Adamek, et al. (2002) prescribed a 12-week training program consisting of four 30-minute session per week, compared to the shorter 10-week program required for the current study. All participants in the earlier study completed the 12-week program in its entirety (1440 minutes), whereas in this study only two participants completed all of the required training sessions (1200 minutes), with the reminder of participants completing between 778 and 1003 minutes. It is debatable, however, whether this was a crucial factor, given that most CI training group participants felt the training program was too long, with two participants commenting in their evaluation questionnaire that they felt they were no longer improving at the eight-week mark. Of greater importance is the more limited scope of training material in the earlier study. The program pilot-tested by those researchers focused almost exclusively on single instruments, in terms of both instruction and excerpts, with some excerpts of a solo instrument with

accompaniment being introduced as the program progressed. Given that in the current study the participants' shorter training duration and overall training time was spread across a much broader array of categories and stimuli, it stands to reason that it is unlikely that they would perform at the same level on any of identification tasks without the same amount of time being devoted to the corresponding training module as allotted in the earlier study. It is worth re-iterating here that while participants in this study undertook a ten week training program, the MATP itself was developed for long term and flexible use by clinical patients at home, without a research-specific structured training period consisting of predetermined tasks in each lesson, as was used by Gfeller, Witt, Adamek, et al. (2002). To this end, flexibility and a wider range training options was required in order to maintain users' interest and motivation over the long term. A more in-depth comparison of the approaches to training in each program is discussed in Section 4.3.1 below.

For the HA groups, while there appeared to be a clear trend toward larger mean difference scores for the training group than the control group, statistical analyses did not show these to be significant.

Several other factors specific to the current study may have contributed to the absence of significant improvement in perceptual accuracy that was expected for both the HA and CI training groups. With such small and uneven sample sizes for training and control groups, especially in the case of the HA groups, as well as the large standard deviations in each group data set, it is unlikely that the data sets adequately captured a distribution of scores sufficient for powerful and meaningful statistical analysis. Non-parametric statistical testing was necessitated by the small and uneven sample sizes, due to the violation of assumptions of population normality and homogeneity required for parametric tests to be used. While the statistical tests chosen were the best options given the limited data sets, analysis of data with larger and even numbered sample sizes using parametric tests would have allowed for greater power-efficiency and possibly more significant findings. Attrition of training group participants may also have obscured significant findings, in that those participants that did not complete training may have found it difficult initially and so had more potential for improvement than other participants. Specifically, one participant in the HA training group whose data was excluded due to very low training times actually produced the second highest difference score on each ID task, ranging from 8.3 to 16.6. In addition to the limitations of the statistical analyses used in this study, the iteration of the MATP being pilot-tested may have needed further development to bring it to a stage where perceptual improvement could occur more readily. These factors are explored in more detail in sections 4.3 below.

4.1.2 Quality appraisal

An important finding of this study was the significantly larger improvement in ensemble QRs given by participants in the CI training group as compared to those in the CI control group. The average difference score for the CI training group represents nearly a full one-point improvement on the 10-point Likert scale measure that was used, compared to essentially zero improvement seen in the CI control group. Given most participants reported that use of the MATP had changed the way they listened to music and increased the amount of time spent listening to music it may be deduced that this improvement in ensemble QR ratings was the result of a more confident and attentive style of listening. These perceived benefit benefits discussed further in section 4.1.3. The improved ensemble QRs are encouraging when considering the potential benefit that could be translated to more 'real world' listening situations. Broadly speaking, one's daily musical listening habits typically involve a greater proportion of multi-instrument recordings or performances than those of single instruments or solo vocalists. Popular and most specialist music broadcast on radio tend to be multi-instrumental, and live performance or recital programs tend to be built around a core of ensemble-based music – rock bands, singer/songwriters accompanying themselves with an instrument, chamber groups, brass bands and so on – rather than purely solo performances. The combined CI group's significantly lower mean baseline QR score for musical excerpts performed by ensembles compared to excerpts performed on a single instrument or by a single voice at the pre-training period phase shows that there was more scope for improving the enjoyment of ensemble based music. This is to be expected given the comparatively complex nature of the frequency spectra that characterise ensemble recordings. What is seen then, when considering this significant finding, is that participants in the CI training group benefited most on an aspect of music appreciation for which they had the most to gain and the most scope for translating the said benefit to 'real word' listening situations. Again, the lack of significant improvements in single instrument identification ability compared to those observed by Gfeller, Witt, Adamek, et al. (2002) is discussed in sections 4.2 and 4.3.

While the HA training group's quality ratings of both single instrument and ensemble excerpts showed modest improvement across the training period, roughly one quarter of a QR point, the difference scores were not significantly different when compared to those of participants who had not undertaken any training. It is interesting to note that for the combined HA training and control groups' baseline data, there was no significant difference between the instrument and ensemble QR scores; the means differed by only 0.01 of a rating point. That is, the participants' judgement of pleasantness did not seem to diminish with the increased complexity of spectral content. It is possible that the participants' HAs were providing enough

spectral information from the input signal, thus allowing the output to sound sufficiently pleasant, that any gains afforded by auditory training were too subtle to significantly improve perceived quality beyond the constraints imposed by current digital processing technology. That is, the participants may have had less to gain and less room to improve.

4.1.3 Perceived benefits

Despite the absence of significant improvements on nearly all of the MTB measures in this study, most of the MATP evaluation questionnaire items on perceived benefits of the training yielded positive responses from at least half of participants in both the CI and HA training groups.

Overall, 75% of CI training group participants reported that they found the program to be beneficial in some way. Of the questionnaire items relating to more specific benefits, the two that yielded the most positive responses asked if participants felt their ability to recognize commonly known instruments or ensembles had improved, and whether their recognition of musical styles had improved. The fact that all participants in the CI training group felt that they had improved on these tasks to some degree, even though the MTB post-testing did not support this sentiment, suggests these responses may have been informed more by a sense of increased confidence with these tasks, or increased music listening in general, rather than a judgment of actual ability. Not unexpectedly, it follows then that the next highest-scoring questionnaire item asked if participants felt that the way they listened to music had changed. This finding is of importance as it relates to a key objective of the training program, namely the facilitation of 'music appreciation', or in other words helping trainees to be more aware and attuned to the different parts of the music they are listening to. A number of participants commented on such changes in their approach to listening at their post-training test session. In addition, Participant 5 from the CI training group commented in his program evaluation questionnaire: *"I think I benefited most for the solo instruments as I could train my brain to listen out for these instruments in the ensembles and styles",* a personal goal that was not necessarily testable using the MTB measures. The suggestion that participants had grown more confident with music listening is also supported by the positive responses given by more than 60% of the CI training group particpants when asked if their time spent listening to music outside of the study had also increased. Participant 2 in this group commented: *"I have often spent extra time listening to youtube tunes. 'Tis good fun…. My enjoyment of music post implantation has exceeded my expectations. I think your training course is great."* Exactly half of the CI training group participants felt that their enjoyment of music had improved in some way following the training. With the primary purpose of the current study in mind, namely that of developing a training program to help users improve their appreication and enjoyment of music, it may be argued that

the appreication-orientated benefits described above are of greater value than such accuracy-orientated outcomes as improved instrument recognition ability, or lack thereof. It is much more likely that the experience of enjoying music, rather than that of correctly identifying its elements, that will encourage further music listening or participation in recreational or social musical activities.

The general response of the HA training group to the MATP was also positive, with four of the five participants reporting that they found the program to be beneficial overall, as measured by the 'overall the training program was beneficial' MATP evaluation questionnaire item. Of the remaining 10 benefit-related items reported in this study, seven yielded positive responses from at least 60% of participants. Again, most participants reported increased musical listening outside of the program and felt they had learnt to listen to music in a different way. Participant #3 from this group explained at the post-training test session that she was a very visually orientated person who, prior to the study, had relied heavily on visual cues when listening to music. She found that during the training and teaching phases, *"being forced"* to listen without visual cues had resulted in a more concentrated style of listening following completion of the MATP. In particular, she now consciously attempted to identify the different instruments in a recording during leisure listening. The subjective benefits that the MATP provided to some participants, beyond perceptual accuracy or improvement on the MTB tests, is eloquently summarised by the following comment from participant #5 whose MTB difference scores were no better than the rest of the HA training group*: "I very much enjoyed this programme. It has helped me to recover some enjoyment for music which I lost with my hearing loss... I think overall given the level of my hearing loss and dependence on hearing aids the outcome has been excellent… it has made a huge difference to my life not just with music but also with everyday hearing with different voice levels and pitches".*

Only two participants from each of the HA and CI training groups reported that music sounded more natural following completion of the MATP. This is a somewhat understandable finding given the current DSP limitations of each device. Most participants in the HA training group did however report that music sounded closer to what they expected it to sound like to a listener with normal hearing. It is possible that the response to this latter item indicates an improvement in perceived sound quality of music that may have been too subtle to be considered an improvement in naturalness per se. It is also worth noting that 50% of CI training group participants, compared to 80% for the HA training group participants, gave a positive response to the latter item 'music sounds closer to how you would expect it to for a person with normal hearing'. This divergence between the two device groups is not surprising given the greater preservation of the sound quality of music processed by HAs as opposed to CIs. As described in

Sections 1.2 and 1.3 the output of a HA is an amplified version of an acoustic input signal delivered to the ear acoustically, whereas the output of a CI is the result of a conversion of the processed acoustic input into electrical impulses which are then delivered to the auditory nerve by electrodes.

In summary, despite the results of the MTB test battery having shown only modest improvements on only one of the subtests, that of the perceived pleasantness of ensemble-based music, it is clear that most participants, to varying degrees, derived real and meaningful benefits from participating in the program that they could transfer to their everyday listening.

4.1.4 Impact of training habits on outcomes

The findings of significant negative correlations for the CI training group between (i) instrument ID difference scores and the time spent training in the solo instrument module, and (ii) ensemble QR difference scores and time spent in the ensemble module are surprising. Rather than considering the doubtful proposition that lower scores on the instrument ID task are a consequence of spending more time on its respective training module, it is more likely that those participants who experienced greater difficulty in resolving spectral cues felt the need to spend more time training with less complex excerpts before moving on to the more demanding musical style and mixed/advanced modules. This suggests a pattern of usage based on perceived-performance or benefit that accords with the intended nature of the training program, namely self-guided learning, with the freedom to focus on problematic sounds or areas of interest. A comparison of individual MTB scores with training times for participants #7 and #9 in the CI training group supports this suggestion. Relative to other participants, participant #7, who had scored slightly below average on most pre-training MTB subtests, spent the lowest proportions of her total training time in the Single Instrument (14.1%) and Musical Ensembles (19.2%) modules in favour of more time in the Musical Style (33.5%) and Advanced (Mixed) (33.1%) modules. Following training, participant #7 showed the highest difference scores of all CI training group participants on the single instrument ID and ensemble QR MTB subtests, as well as the highest difference score on the style ID subtest (25%) and second highest difference score on the ensemble ID subtest (18.8%). By contrast, participant #9 in the same group, who had scored lowest on all pre-training MTB ID subtests, spent the greatest proportion of his time using the Single Instrument module (40.5%) rather than the Musical Ensemble (26.5%), Musical Style (29.3%) and Mixed (Advanced) (3.7%) modules. At the post-training stage, participant #9 showed the second lowest post-training difference score on the instrument ID task (-4.2%) and below-average difference scores on all other MTB subtests. These contrasting patterns of MATP usage and outcomes suggest two different personalised approaches to training that grew out of

the flexibility to train according to perceived ability. Where participant #7 may have sought further challenges in the complex modules after noting progress in easier modules, participant #9 concentrated on the modules he deemed more suitable for both his initial ability and progress during training.

In some respects, the significant positive correlation found between improvement in musical style identification ability of participants in the CI training group and time spent in training in the musical style module is to be expected. At the pre-training testing phase, many if not most of the participants expressed light-hearted apprehension when embarking on the musical styles MTB subtest. All were familiar with the different instruments and ensembles and how they sounded to listeners with normal hearing, however, aside from an awareness of the musical style names, many participants were unsure what constituted styles such as Modern Pop or Eastern music. While some of the participants reported an interest in a wide range of genres in their music background questionnaire, most tended to have more specialised interests in a much smaller number of styles, with some reporting that they listened almost exclusively to one style such as jazz or 'rhythm and blues'. For this reason, the majority of participants had more to gain from module 3 as compared to modules 1 and 2 in terms of learning about novel or unfamiliar musical structures, which may explain why is was the most popular, or at least the most often used, module in the MATP.

4.1.5 Participant factors

4.1.5.1 Age

The finding of strong negative correlations between CI training group's participant age and overall perceived benefit, as well as age at implantation with overall perceived benefit, implies that younger recipients and those implanted at a younger age were more likely to derive perceived benefit from use of the MATP. While computer-based training facilitated the adaptive nature of the MATP, enabled flexibility and allowed for self-guided navigation through the program phases, it is possible that for older participants in this study, who may be less comfortable with computers as compared to younger users, a computer interface may not have been the ideal medium for promoting motivation or enjoyment of use. Conversations with the older participants during the test sessions indicated that while all of the participants in the training group had some experience with the basic use of computers, not all were in the habit of using them frequently for leisure purposes and some found them to be frustrating. Again, given that the MATP was designed as a take home clinical application designed for long term use, the author expects that this frustration would ease over time as users' build familiarity with the MATP through continued use beyond the 10 week training period employed in this study. It is

also hoped that as earlier adoption of computers is encouraged by improvement in user interfaces, such as touch screens and the increased popularity of tablet-based computing, that older potential MATP users will seek to extend their experience with, and find the routine use of programs such as the MATP to be more enjoyable.

4.1.5.2 Musical background

Strong positive relationships were found between the CI training group's level of formal music training and perceived overall benefit, as well as between self-reported overall music ability and perceived overall benefit, suggesting that there was more scope for benefits to accrue amongst those participants that had stronger musical backgrounds. It is likely that these more musically familiar participants would have had more developed mental schemas of musical sounds to draw upon when making judgements based on timbre discrimination. It is worth reiterating here that, while no significant improvements in instrument, ensemble or musical style identification occurred, most training participants felt their ability to identify these attributes had improved to some degree. Participants with stronger musical backgrounds would also have been more familiar with the musical language and concepts used in the teaching and training phase instructional text, and more readily able to fill in the gaps where the instructional text may have not provided sufficient information for users with a limited foundation of musical knowledge.

4.2 Methodological issues

4.2.1 Limited generalizability of findings due to small sample sizes

While the current study, in addition to co-developing the MATP, was designed to be a pilot test of the MATP, the final participant numbers were less than initially envisaged due to unforeseen circumstances. Statistical analysis was thus limited due to the small data sets for both device groups. . As a population, CI recipients represent only a small subset of the Australian and New Zealand populations affected by hearing loss. At the beginning of the recruitment phase, it was decided that the study sample would be drawn predominantly from Australia to avoid the 'over testing' of available New Zealand participants, many of whom had very generously devoted their time to previous studies. Some of these previous studies would also have overlapped with objectives and concepts featured in the current study. Despite these limitations, 10 CI recipients were eventually recruited for each of the CI training and control groups. The subsequent attrition and necessary exclusions that were reported in Section 3.1 led to smaller and uneven sample sizes, which placed stricter constraints on running sufficiently powerful statistical analyses (such as parametric tests), in terms of selecting tests whose basic assumptions would not be violated.

This was even more of a problem for the HA group data set. Recruitment and retention of a suitable number of participants for this group was more difficult than for the CI group as the main location for population sampling was Christchurch, New Zealand during the 2010 and 2011 earthquakes. Given the disruption to many Christchurch residents' living situations and lives in general, exposure to recruitment material was limited and motivation to engage in the study was lower than expected. These difficulties also affected some participants' ability to complete a reasonable number of training sessions. Again, the sampling error unavoidably introduced by shrinking sample sizes made it difficult to obtain meaningful findings from the statistical analyses, and in the case of correlating participant factors with perceived benefit, prevented some intended analyses from being performed. It is also possible that the lack of random assignment of participants to test conditions may have introduced bias to the results. Given the difficulties recruiting participants who were prepared to commit to 10 weeks of training, willing participants were assigned to the training groups and participants who could not train due to time constraints were assigned to the control groups. Although, with the exception of instrument ID ability amongst HA participants, pre-training period comparisons showed no significant differences between the training and control groups, it is possible that the results of this study may have been different if the control groups were made up entirely of participants who were motivated to train. Further bias may have been introduced by the attrition seen in both training groups, albeit due to external factors such as work commitments and bereavement, leaving the already small samples potentially less representative of the HA user and CI recipient populations. Further testing of the efficacy of future iterations of the MATP should, where possible, be performed using random assignment and larger sample sizes that would offset any unanticipated attrition, perhaps by extending the registration of interest and recruitment over a longer period of time.

4.2.2 Balance between perceptual accuracy and quality appraisal measures

As discussed in section 4.1.3, more than half of participants from both device groups reported increased enjoyment of music and a noticeable change in the way they listened to music following use of the MATP. These benefits were noted despite the lack of improvement on MTB ID tests, which made up approximately half of the MTB testing time. This raises the issue of the relationship between perceptual accuracy for music based stimuli and appraisal or enjoyment of music itself, and whether the MTB measures could have been weighted more toward the latter in this study.Multiple linear regression and generalized linear mixed modelling by Gfeller et al. (2008) has shown that across a large number of factors (e.g. age, CI device, speech processing strategy, CI configuration [bilateral vs. monaural CI only vs. bimodal], months of use, music

training before and after implantation, formal music training, length of profound deafness, speech perception measures) only one factor, exposure to music post-implantation, was a common predictor of both accuracy of timbre identification and appraisal of pleasantness. This overall finding, and the finding of similar divergences between predictors of appraisal and accuracy on other measures such as song and pitch identification, led Gfeller et al (2008) to conclude that perceptual accuracy and the appraisal of pleasantness or quality were two distinct facets of music appreciation, each influenced by a largely discrete set of factors. More recently, the conclusion drawn from the aforementioned study has been supported by the findings of Wright & Uchanski (2012), which showed weak or non-existent correlations between the appraisal of instrumental or lyrical music quality and the four perceptual accuracy tests administered, two of which included timbre identification components.

Much of the input for the planning of the MATP pilot test came from large scale and in-depth questionnaire-based studies (Looi & She, 2010; She, 2008) that also informed the development of the MATP. The questionnaires focused on barriers to music enjoyment experienced by CI recipients and asked participants which musical listening skills they would most like to develop as a result of using a musical training program. The skills rated by participants as 3rd and 4th most important overall were the abilities to recognise commonly known instruments and commonly known genres respectively.The MTB ID tests used in the current study were subsequently chosen in order to focus on those skills (the skills rated as 1st and 2nd most important are not relevant to the current study). These accuracy-based skills were selected by responders from a mostly closed set questionnaire item featuring a final option to comment on 'other' goals. Given that no responses to the 'other' option were reported by Looi & She (2010), this questionnaire item may have limited the volunteering and aggregation of appreciation-based responses. While not practical for the purposes of that study, if an open-set item had been used quality-based goals such as 'hearing richer characteristics of a cello' or 'focusing on a lead voice amongst a noisy accompaniment' may have been volunteered in favour of the accuracy-based options such as 'recognise commonly known instruments' that were offered in the closed set item. The MTB that was subsequently used in this study was weighted toward these accuracy-based tests rather than appreciation-based quality rating tasks and so may not have sufficiently reflected the benefits of the MATP. With the findings of Gfeller et al. (2008) and Wright & Uchanski (2012) in mind, future pilot testing of a MATP could explore the quality appraisal dimension of music appreciation in greater depth by focusing the MTB more toward appraisal-based tasks, and also by utilizing more than one measurement scale. Specifically, researchers could administer test items QRs using bipolar instrument quality scales devised for use in the questionnaire, such as: 'emptier–fuller'; 'duller–sharper'; 'more noisy–less noisy'; 'tinnier–richer' and 'rougher–

smoother'. A greater number of descriptors would also allow for the QRs of musical style excerpts without the complication of whether 'unpleasant–unpleasant' ratings were confounded by personal taste. Such scales would then include: 'natural–unnatural'; 'simple–complex'; 'sounds nothing like I would expect it to sound to a person with normal hearing–sounds exactly as I would expect it to sound to a person with normal hearing'. These rating scales could also be administered as a pre- and post-training questionnaire items on everyday musical listening situations outside of the MATP training.

4.2.3 Utilization of a QOL measure

As an adjunct to the appraisal measures suggested above, the administration of a validated QOL measure would allow for the quantification of subjective benefits of MATP use in terms of how these may have translated into general wellbeing. As described previously, Lassaletta et al. (2007) successfully used the 18-item GBI QOL measure to establish statistically significant positive correlations between sound quality ratings for music and QOL. In their validation study of the GBI, Robinson, Gatehouse, & Browning (1996) noted the measure's sensitivity to non-surgical interventions such as an increased number of CI processing channels and recommended its use for other non-surgical interventions such as hearing aid fittings. It is therefore suggested here as a potential additional measure for evaluating MATP outcomes from a more holistic perspective, regardless of device. The GBI is, however, a post-intervention measure. Where pre- and post-training comparisons are required, the World Health Organization Quality of Life-BREF questionnaire (WHOQOL- BREF) may be considered for use (Skevington, Lofty, & O'Connell, 2004). The WHOQOL-BREF is routinely used to monitor changes in QOL over time, and while it has not been used to test the impact of a music based intervention at pre- and post-intervention phases it has been used to explore correlation associations between reported benefits of musical activity and QOL (Johnson et al., 2013).

4.3 Further development of the MATP

The additional comments made by participants on their MATP evaluation form and in their daily log, as well as verbally at the post-training MTB test session, were generally positive overall. Most commented that they found the MATP to be both challenging and enjoyable. In particular, all participants commented favorably on the wide range of instruments, ensembles and styles featured in MATP. Some participants made special mention of the adaptive difficulty level in the training phase of each module, which allowed them to work at the upper limit of their ability. All participants actively kept a daily log of their training habits, with some commenting that it helped them to keep track of their progress over time. As this was a pilot study, the researcher

was also interested in those aspects of this first MATP version that could be improved to facilitate further beneficial effects from the training. A number of participants were also forthcoming with suggestions, which will now be discussed in detail.

4.3.1 Excerpt information

In the interests of making the MATP accessible to participants with differing levels of musical knowledge and ability, and avoiding overwhelming some users with potentially difficult musical concepts, the descriptions of sound excerpts were written in a concise style using plain everyday language. Some participants commented that while the concise style of writing enabled reasonably speedy progress through phases and difficulty levels, there was room for a greater depth of detail at the teaching stage in terms of *"what to look out for"* in the training and self-testing phases. The concise nature of the written content in the teaching phases of the MATP may not have provided sufficient foundational knowledge for some participants to draw upon as they progressed to the other phases, thereby limiting their ability to make accurate distinctions between instrument/ensemble/style (I/E/S) excerpts or listen for the subtleties embedded in each excerpt. In the equivalent teaching phases of the timbre-focused training program tested by Gfeller, Witt, Adamek, et al. (2002), which yielded significant improvements in accuracy and quality appraisal scores overall, participants were initially introduced to instrument families, before focusing on individual instruments within that family. Participants were then guided through detailed information on the instrument, such as the material it was made from, the method used to play it, musical styles that often feature that instrument, and the quality and character of its sound, for example, describing the sound of a flute as 'brilliant' and a French horn as 'mournful'. Short video clips of the instruments being played were also included, a feature that two participants in the current study suggested for future MATP versions. While potentially increasing the time required for the teaching phases of the MATP, the introduction of a more structured and in-depth foundational learning component as part of the teaching phases may contribute to improving pre- to post-difference on the measures used in this study and should be considered for future inclusion in future iterations of the MATP.

Some participants also requested that feedback on incorrect answers in training phases include more in-depth details on the corresponding excerpt, as well as an opportunity for the user to listen to the exact same excerpt that was originally played (as opposed to the same I/E/S but a different piece of music, as was the case in the current version). Several participants mentioned that it would also be helpful to provide the user with the opportunity to listen to the exact same piece of music being performed by, or possibly in, the incorrectly selected I/E/S, thereby reinforcing associations made or missed at the foundational phase. Given the current study was a

small scale pilot test of software that utilised extracts of commercially available music, this latter suggestion was beyond the scope of what could have been developed for the current study and budget, but should be considered when resources for further development are available.

4.3.2 Contentious instrument/ensemble/style distinctions

On reviewing the daily training logs and verbal comments noted at post-training test sessions, it became apparent to the author that most participants found several of the I/E/S category distinctions to be *"contentious"*, resulting in a number of potentially ambiguous and therefore unhelpful excerpts. For example, some items in the style section such as excerpts of modern 'Country & Western' music that, depending on factors such as taste, listening habits and social circle, could be considered by some people to be excerpts of 'Modern/Pop (1990's on)'. Similarly, excerpts from 'Jazz' recordings were often considered to be examples of the 'Old time (pre 1960)' category, which is understandable given the long history of Jazz music and its association with older styles of music such as Ragtime. Some participants also reported that they struggled with items in the Mixed (Advanced) module where there was some overlap between both the ensemble type and musical style, for example 'Duets – (Voice + Piano)' and 'Classical – Small group'. Given that such comments were made by the majority of participants in the training groups, it is possible that some participants found these ambiguities, as one participant put it, *"just too frustrating"*, leading to diminished confidence and less motivation to persevere with the training. Indeed, one participant later reported that he stopped using the training phases for this reason.

In order to build on the potential benefits that can be accrued from use of the MATP, the next iteration should utilise categories that are even more discrete; especially in the musical style section, given that it was the most popular module in the study. Categories based on periods in the 20th century time such as 'Old time (pre-1960s)' should be removed and replaced with discrete styles that span a similarly broad enough period of time to be of interest to users with different backgrounds, for example: blues, reggae, disco, hip hop.

4.3.3 Interface design and user experience

Another possible barrier to participants achieving maximum benefit from MATP use was the relatively slow speed of the software compared to a commercially available, fully professional software. Screen transitions, especially those requiring audio samples and images to load, took longer than an average computer user would have expected, especially on older machines with slower processing speeds. This undoubtedly took valuable time away from active training over the course of the training period and likely would not have contributed to participants'

enjoyment and motivation to use the program as often as they could have. Again, as the MATP from a small scale pilot-project to a commercially available product, further development will need to involve improved sophistication of the software in order to align it with the end-user experience expected of consumer software products.

4.3.4 Duration and frequency of training

As mentioned previously, only three of the eight CI training group participants included in the statistical analyses completed the 1200 minutes of training requested of them, with one additional participant being excluded from the analyses due to having completed only 15 of the required 30 minute training sessions.. The adherence of the HA training group participants to the training schedule is less clear due to the unavailability of two participants' data-logging files, however two participants were excluded from the analyses due to having only completed 10 of the training session. This raises two questions: i) why was adherence to the training schedule so low, and ii) was this detrimental to the benefits they derived from use of the MATP? Possible demotivating factors have been described earlier in this section, namely frustration with contentiously categorised excerpts and the latency of the program. Regarding the first factor, this frustration may well have been enough to discourage enthusiastic use of the MATP by some participants. Participant #7 in the CI training group, who did not mention the categorisation problem in his feedback, gave the strongest written praise of the program of all participants, but also commented: *"I became quite despondent some days when I didn't do as well as I thought I might"*. It is possible that this sentiment may have been felt more keenly by participants who frequently encountered ambiguous items and felt that their progress in the training and self-testing phases was being hampered unnecessarily.

The extent to which the lower than expected MATP usage times had an impact on participant benefit and MTB scores is debateable at this point in time. The majority of training participants in both device groups reported that the 30-minute training sessions were just the right length, if not too short for some participants, and that four session per week was just right as well. However, the majority of participants from both training groups combined reported that 10 weeks was too long a training period. The possibility that extra time spent may have led to more significant outcomes seems to be supported by the higher overall scores seen in the Gfeller, Witt, Adamek, et al. (2002) study following participation in a relatively more intense and structured training program, as well as by the positive correlation between training time in the Musical Styles module and scores on the corresponding ID test in the current study. Conversely, some participants advised that they were not progressing further at the eight-week mark, and positive correlations between time spent on most modules and their corresponding MTB sub-tests were

not statistically significant. It must be considered then, whether prescribing a longer training period, at the risk of turning its usage into a chore rather than a motivating challenge, would be in the spirit of the MATP program and its goals: to improve musical enjoyment and ultimately the QOL. As the development of the MATP continues, further testing should include an analysis of self-testing scores, quality appraisals and measures of perceived benefit or QOL improvements at different stages of the prescribed training period so that an optimal length of training period can be recommended for enjoyable 'real world' use. Moreover, given the MATP was developed for long-term take-home use, a future study should test the program in the format it was intended for by employing a longer term training period than the current study and omitting a prescribed training regime (i.e. to determine how much the MATP would be used over an extended time period if no explicit training directions are provided). The longer and more flexible training period would create greater scope for tracking preferred user habits and benefits over time.

4.4 Summary

The objective for this study was to co-develop and then pilot test a self-guided music appreciation training program (MATP) designed to assist CI recipients and users of hearing aids to improve their ability to appreciate subtleties in musical timbre and musical style, with the ultimate goal of improving musical enjoyment, an important dimension of the QOL for many people.

The difficulties faced by these two populations in terms of musical enjoyment are well documented and have yet to be successfully overcome by technological advances in device hardware or digital signal processing. While previous research has shown that auditory training on musical timbre discrimination has increased participants' accuracy on timbre identification tasks and lifted appraisal ratings of pleasantness, no commercially available program is in routine use for this purpose. The need for a program focused on enjoyment and appreciation was identified and a computer-based pilot version was developed that could be readily used by individuals with CIs or HAs. Given that users of CIs and HAs are a heterogeneous population with varying needs, tastes, interests, abilities and backgrounds, the program needed to encompass a sufficiently wide range of stimuli and ability levels in order to cater for this diversity. It was hypothesised that 10 weeks use of the MATP would significantly improve participants' perceptual accuracy on timbre identification tasks and raise the quality appraisal ratings given for the same musical excerpts. Pre- and post-training tests showed no significant improvement on instrument, ensemble or style identification tasks for either device group, but statistically significant improvement was seen for the CI users' quality ratings of complex

ensembles in terms of pleasantness, despite these improvements not being seen for single instruments or in the HA training group.

Several factors may have contributed to the limited improvements seen on the tests of perceptual accuracy in this study compared to the positive findings reported for all tests in earlier published research that trialed a highly structured and single instrument-focused training program over a 12-week period. The widening of the scope of the current MATP to include complex ensembles and musical styles, as well as less structured and more flexible training regime required of participants in this study may have resulted in less intensive training on the single instrument timbre than was employed in the previous study. Participants in this study also trained for a shorter period of time, possibly due to frustration with ambiguous items and the slow running speed of the program. In the current study, the use of parametric statistical testing was prohibited by the small and uneven, sample sizes. However, compared to pre-and post-training test results in the current study, the self-reported benefits from use of the MATP were much more positive and reflected outcomes which may not have resulted from a more structured, single instrument program focused solely on improving instrument recognition skills. The majority of the trainees in both device groups reported that they felt the training was beneficial and, as a consequence, had been listening to music more often and with a different style of listening. These and other outcomes such as increased enjoyment of music and motivation to attend musical events may be considered of greater value to users than improvement in perceptual accuracy alone, in that they generalize well beyond the training task to 'real world' situations that are associated with QOL.

The latter findings, in conjunction with the CI group's improved ensemble QR scores, make a case for the further development of the MATP as an aural rehabilitation tool with the potential to significantly improve the QOL for people with hearing loss. Further developments to the MATP should include a more structured and foundational teaching phase and an improved user interface. The next phase of testing should place greater focus on music quality appraisal measures, given the evidence that appraisal of music quality is not dependent on perceptual accuracy, as well as QOL measures, and track these changes over time so that an optimal duration for the program may be established.

Appendix A: User Manual and Participant Daily Log

Music Appreciation Training Program

User manual and participant daily log

July, 2011

Jason King, Student – Master of Audiology

Contents

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Background

For many, if not most people, enjoyment of music is an integral part of life. Much of this enjoyment depends on the ability to appreciate certain qualities of music such as pitch and rhythm. Another important quality is timbre. 'Timbre' in music helps us to identify between different instruments playing the same note at the same volume. Hearing loss impacts on the way timbre is perceived. This is made worse by the digital signal processing in devices such as hearing aids (HA) and cochlear implants (CI). However, despite this, research has shown that music training can improve people's timbre perception skills, even if they have a hearing loss and/or use a CI or HA. The MATP has been developed to help CI and HA users improve their timbre perception

Training

This training program consists of four timbre-based activity modules: Solo Instrument, Ensemble, Musical Style, and Mixed (Advanced). Each of these modules contains a teaching section for familiarising with the chosen sound source(s), a training section with difficulty levels that adapt to your skill level, and a self testing section for you to monitor your progress.

To get the most from this program we ask that you train for 30 minutes a day, four times per week, for 10 weeks. Please read this manual for details on each module and recommendations for you training.

The following instruments, ensembles and musical styles form the basis of this training program:

Solo Instrument

1. Piano
2. Violin
3. Cello
4. Flute
5. Clarinet
6. Trumpet
7. Trombone
8. Xylophone
9. Drum Kit
10. Guitar
11. Male Singer
12. Female Singer

Ensembles

1. Orchestra
2. Rock band
3. Brass band
4. Jazz band
5. String Quartet
6. Choir
7. Duets – instrumental
8. Duets – Voice + Piano
9. Instrument + Orchestra
10. Voice + Orchestra

Musical Style

1. Classical – Solo
2. Classical – Small group
3. Classical – Large group
4. Jazz
5. Modern/Pop (1990's on)
6. 1960's – 1980's
7. Old time (pre 1960)
8. Country & Western
9. Eastern

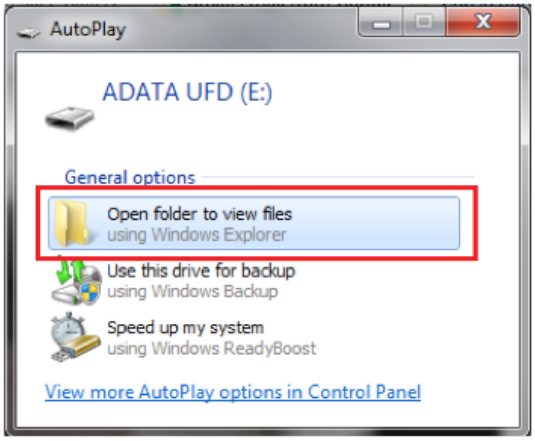
MATP Setup & Installation

System Requirements

Processor:	Intel, AMD, 1 GHz or faster
Operating System:	MAC OS, Windows XP, Vista, 7
RAM: Minimum:	512MB, 1GB recommended
Disk Space:	4GB
Sound:	Built in Windows-compatible sound card (Windows XP, Vista, 7)

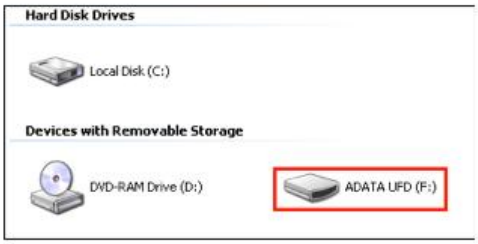
Installation for Windows

1. Insert the ADATA flash drive into a USB port on your computer.
2. An Autoplay window will appear. Double click **Open folder to view files.**



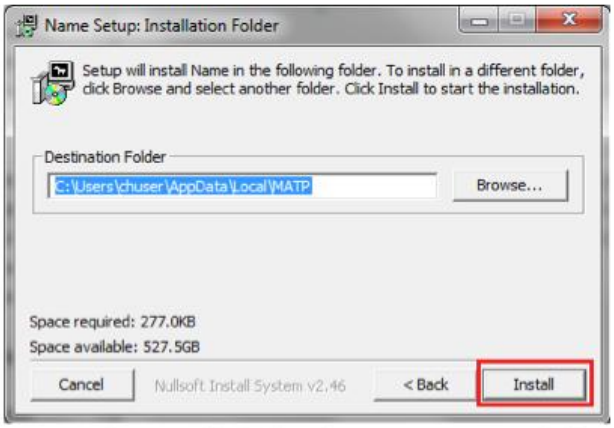
3. If an Autoplay screen does not appear click on **Start**, then **My Computer**.

4. Double click on **ADATA UFD.**



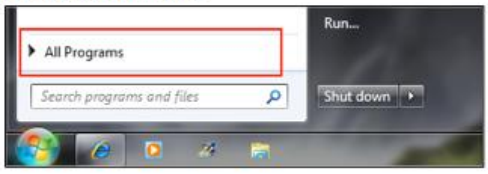
5. Double click on the **MATP** folder, then double click **MATP Setup.**

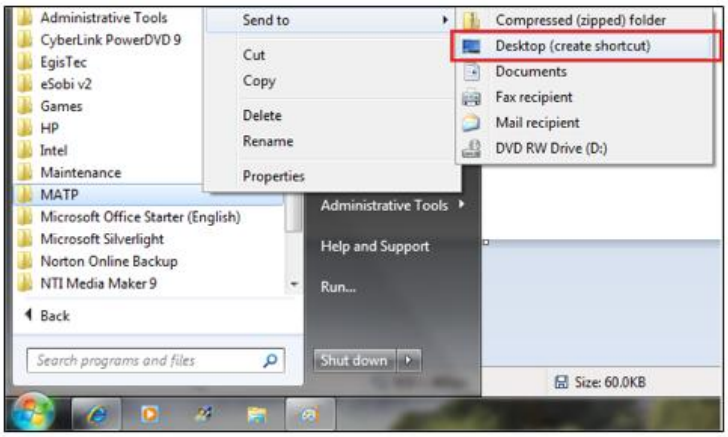
6. At the license agreement screen click **'I agree',** then at the 'Installation Folder' screen click **Install** to install MATP in the recommended location. This will take a few minutes.



7. **IMPORTANT: Eject and remove flash drive from your computer before starting MATP for the first time.**

8. Click **Start**, then **All Programs**, then right click **MATP** and click **Send to** to create a short cut on your desktop. If you cannot create a shortcut you can still start the program by clicking the MATP icon from this location.

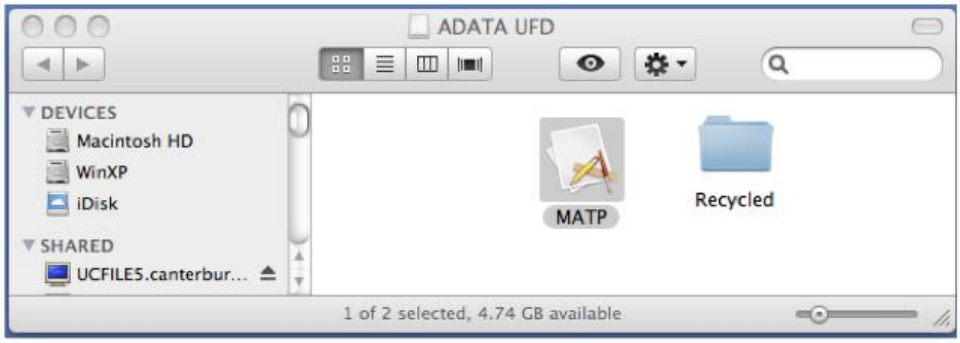




Installation for MAC

1. Insert the ADATA flash drive into a USB port on your computer.
2. Double click the **ADATA UFD** that appears on your desktop.

3. Click and drag the MATP icon to your desktop or APPS folder.



Starting MATP

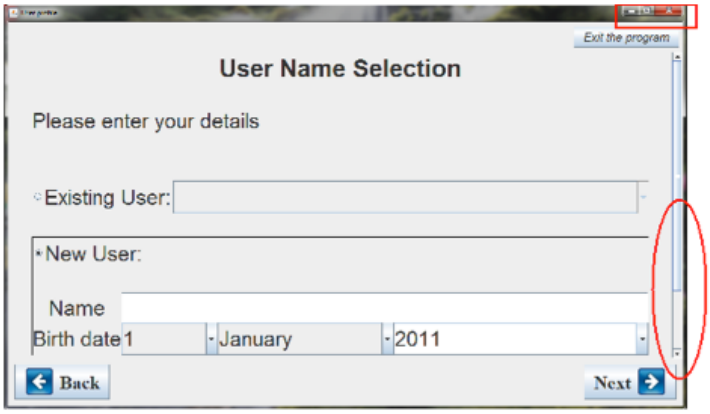
1. Double click the **MATP icon.** A dialogue box reading **'MATP is loading. Please wait...'** will appear, followed by the **'Welcome'** screen.

2. Click **Next** to proceed to the **Sound Volume Adjustment** screen. Ensure that your **Logitech LS21 stereo speaker system** is plugged into your computer's headphone jack. Click the **Play Sound** button to activate the test signal. Use the volume control on your speaker system to adjust the volume to a comfortable level of loudness. If you do not hear the signal please ensure that the volume control on your computer is not set to mute.

3. After setting the volume level please click **'Next'** to continue to the **'User Name Selection'** screen.

First time users:

Enter your name and date of birth into the spaces provided and click next. Be sure to use the **maximise screen** button (top left) and **scroll bar** (right side of screen) to ensure that you can see the full screen display. Many screens in the training program will require you to use the scrollbar to reveal important information at the top or bottom of the screen.

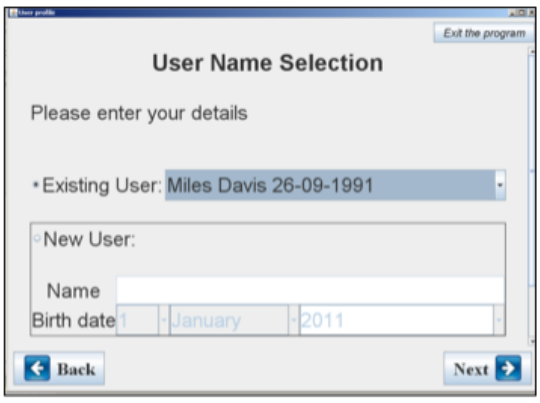


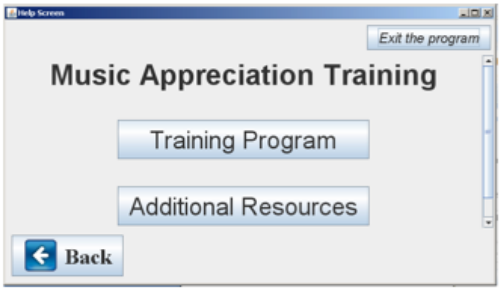
You can click the **Back** button to return to previous screens or **Exit the Program** to finish your session at anytime:

Returning users:

Select your name from the 'Existing User' drop down box.

Click **Next** to continue to the **Music Appreciation Training** menu. From this screen you can proceed to the **Training Program** or browse the library of **Additional Resources.**





Additional Resources

Here you will find a number of listening tips, websites and other useful exercises to help build on your experience using MATP. To get the most from MATP we recommend that you read through the Listening Tips section before you begin your training.

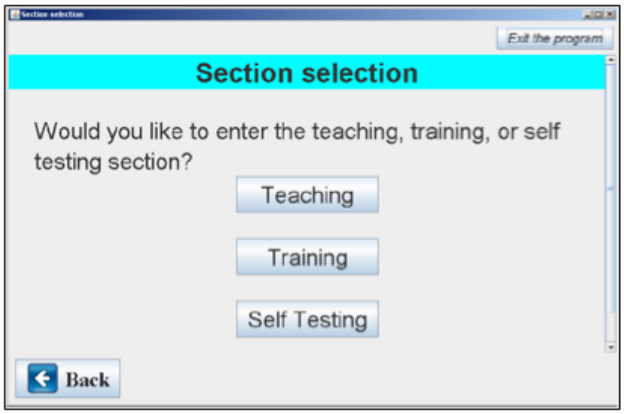
The Training Program

Module Selection

Click on the training module that you would like to work with.

Section Selection

Each module has a teaching, training and self testing section. Click the section that you wish to use.

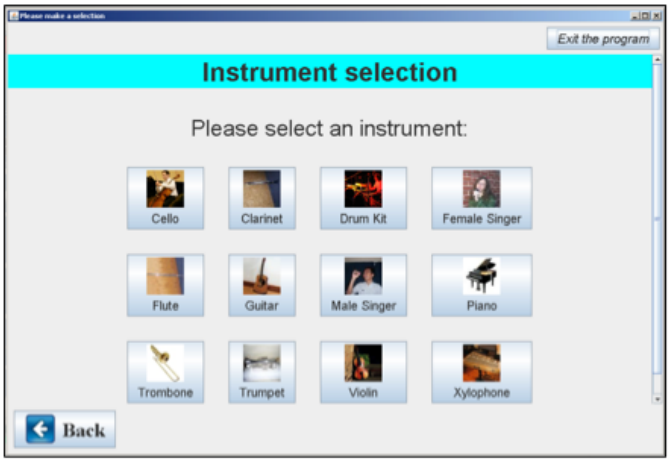


Each section has a welcome screen. Click **Next** at that screen to continue to your chosen section.

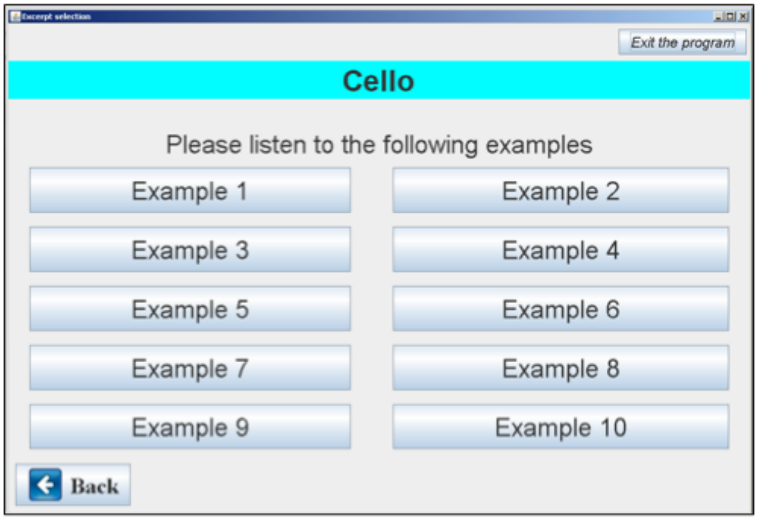
Teaching

Selection Screen

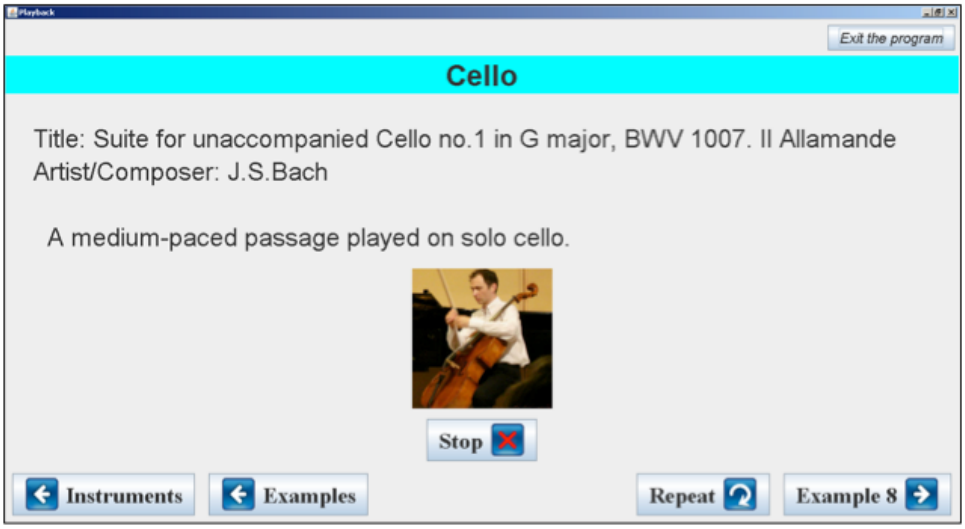
This screen shows all of the Instruments/Ensembles/Styles that are available in the teaching section of the module that you have chosen. Click the stimulus category that you would like to listen to. Summaries of all categories for the first three modules are shown on pages 41-43. The example below shows the Solo Instrument selection screen. We will select 'Cello'.



You will be presented with a list of **Examples** to listen to. Click on an **Example** to listen to the instrument, ensemble, or musical style that you have chosen.



The **Playback** screen displays title, artist/composer information and a short description of the excerpt. Remember to use the scroll bar at the right to view text that may be off the page.

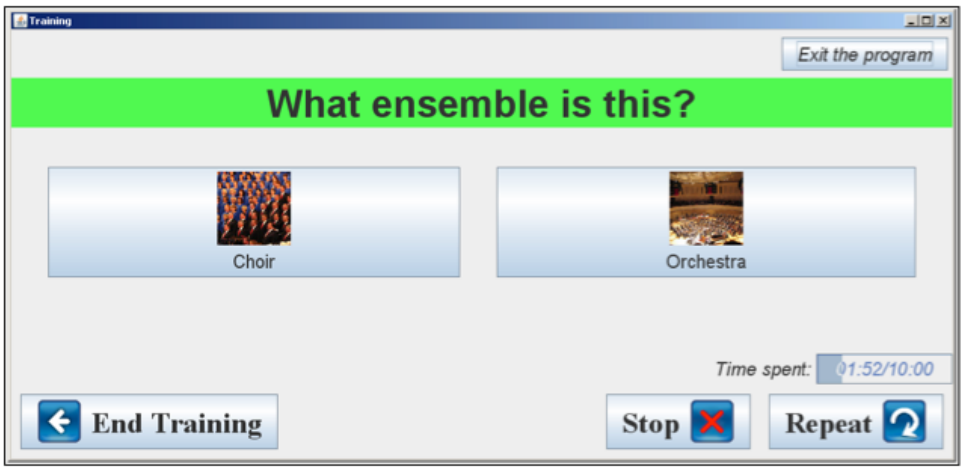


There are several buttons along the bottom of the display that you can use to operate this screen and navigate through the program.

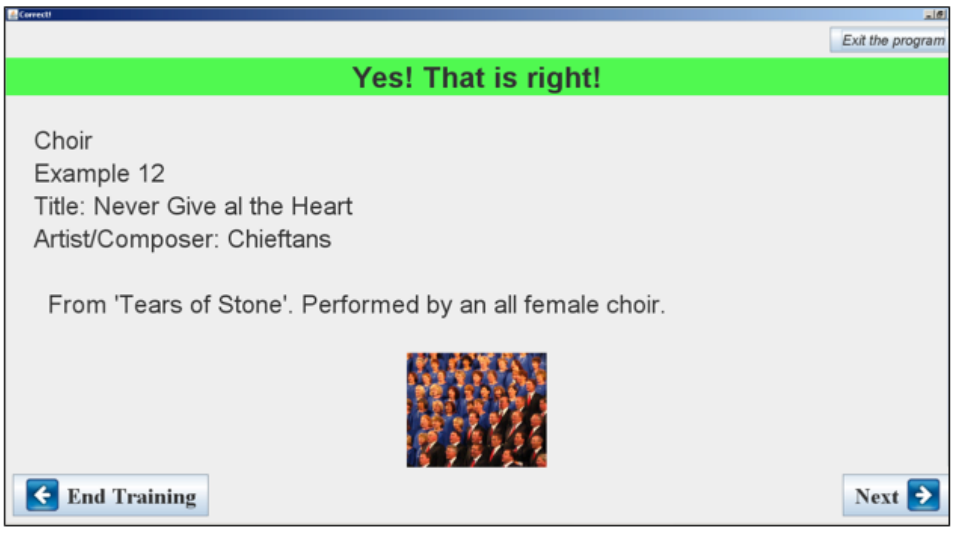
Click **Stop** to end playback.
Click **Repeat** to listen again.
The right most button (**Example 8** in this image) tells you the number of the next example that you can listen to. Click this button to proceed to that example.
Click **Examples** to go back to the list of examples for your chosen instrument/ensemble/musical style
Click the left most button (**Instruments** in the image above) to chose a different category to listen to.

Training Section

Each task in the training section will require you to listen to an excerpt of music and select the instrument/ensemble/musical style that best matches what you have heard. The example below is from the ensemble module:



If your answer is correct you will see further information about that excerpt.



If your answer is not correct you will be asked to listen to an example of the category that you chose (in this example 'Orchestra') and compare it to the stimulus that was playing. Click the category buttons to listen. When you are ready, click **Next** to proceed to the next excerpt.

Difficulty level

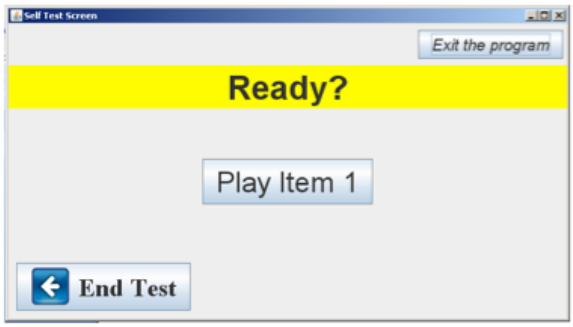
When you first start training you will be presented with only two options to choose from. As you become better at this task the difficulty level will automatically increase, meaning that you will have to make your selection from four, then six, then eight different 'stimuli' groups. The highest level of difficulty will require to you make your selection from all instruments/ensemble/musical styles in the module that you are working on. Remember to use the scroll bars so that you can see all relevant information on the screen.

As you progress you may find that the difficulty level has become too high. MATP will monitor this and automatically adjust back to a lower level so that you may practice further before once again being moved up to harder tasks.

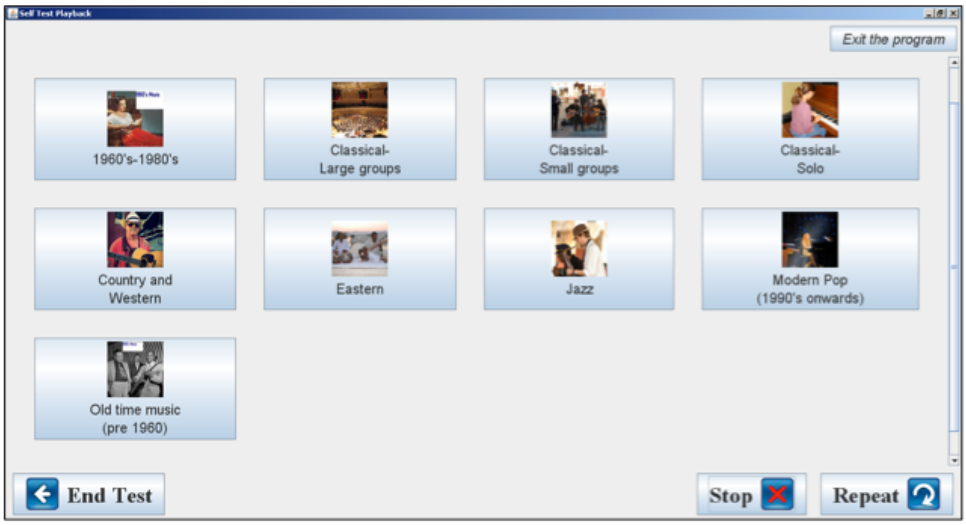
The timer at the bottom right of the 'What Instrument/Ensemble/Musical Style is this?' screen tells you how much time you have spent in your current training session. When you are ready, click **End Training** to return to the 'Section Selection' screen.

Self Testing Section

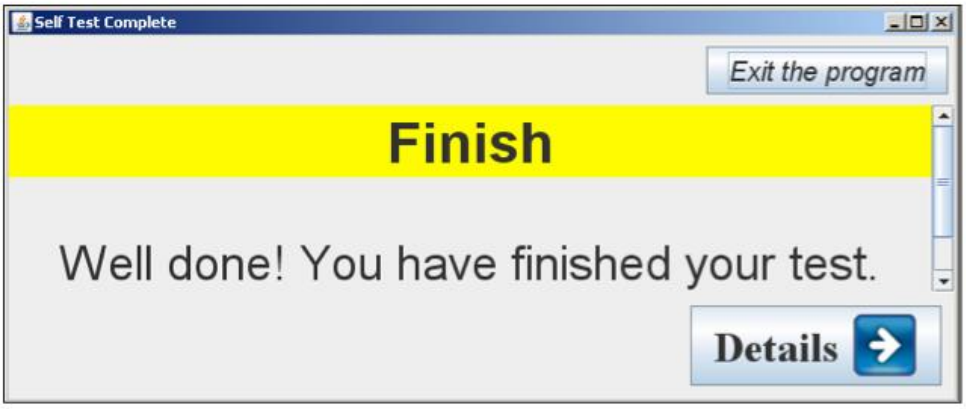
The self testing section involves a similar same task to those in the training section but is set to the highest difficulty level. Each test consists of ten items. No feedback is provided until the end of the test, at which point you will receive a score out of ten (or 20 for the Mixed Module). Double click the **Play Item** button to listen to each excerpt.



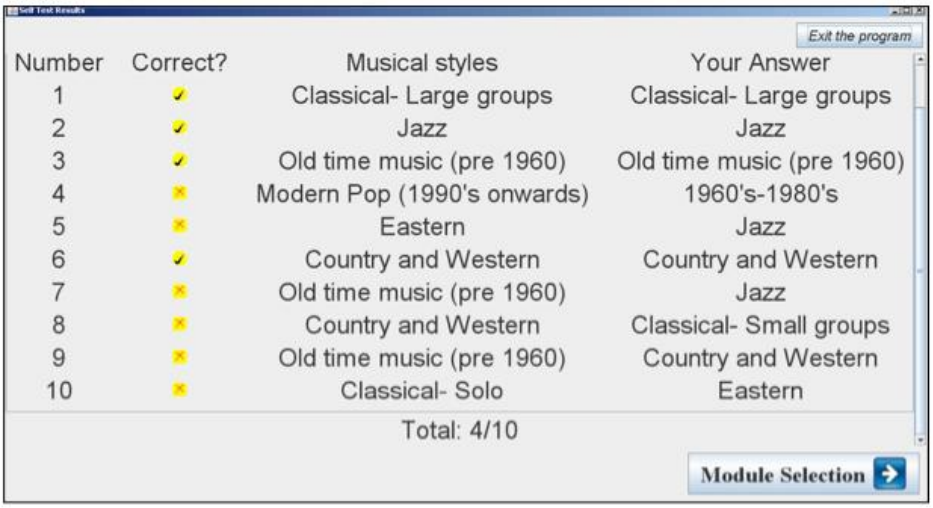
You may listen to the excerpt again by clicking **Repeat.** When you are ready click the answer that you think is correct. Remember to scroll down to see if any options are not displayed on the screen. You can end the test at anytime by clicking **End Test.**



At the end of the test click **Details** to view your results.



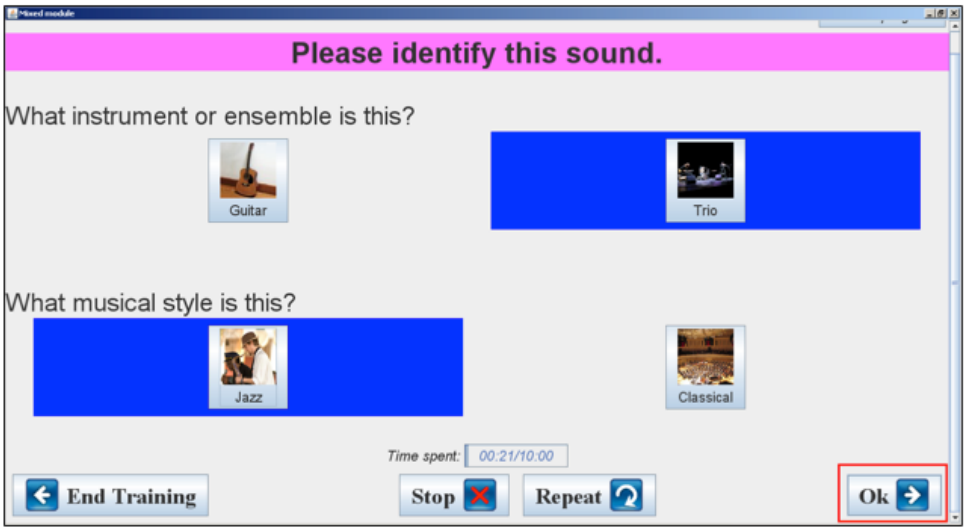
Scroll to the bottom of the page to see your score. The results compare your answers with the correct answers. This provides an opportunity for you to see the progress that you have made and identify instruments/ensembles/musical styles that you may like to spend more time listening to in the teaching section. Click **Module Selection** to return to the main menu.



Training and Testing in the Mixed (Advanced) Module

As your ability on tasks in the Solo Instrument, Ensemble and Musical Style modules improves you will become ready to try the mixed (Advanced) module. For each training or testing item in this module you will be required to identify the instrument/ensemble and also pick what style of music is being played.

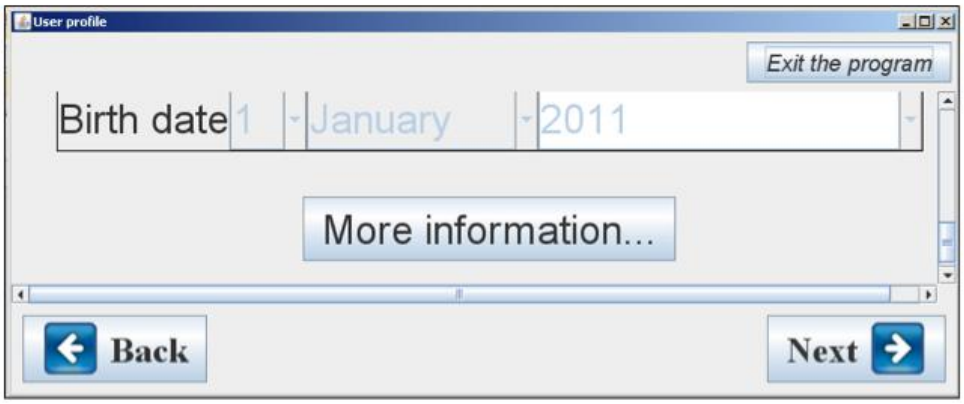
The 'Teaching Section' is grouped by instrument/ensemble. Work your way through this section to get a feel for the items that you will encounter during training and self-testing. Some tasks will be difficult, featuring unusual pairings of instruments/ensembles and musical styles. Others will be excerpts of specific instruments that are not necessarily solo recordings. Listen for the most salient features of each item, and have fun! To provide your answer in the training and self-testing sections you must select an instrument/ensemble, then a musical style, and then click **OK.**



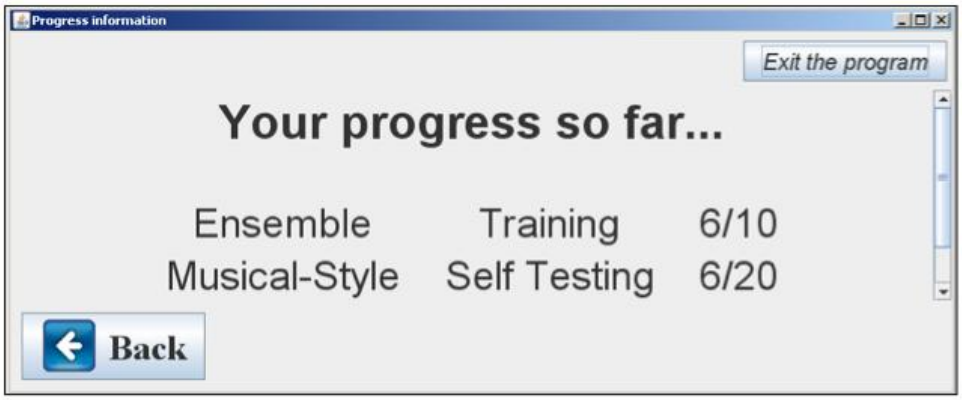
Both the training and self testing sections within this module will provide you with feedback on both the instrument/ensemble and music style answers that you have provided.

Monitoring Your Progress

A summary of your progress is available at the bottom of the **User Name Selection** screen. Scroll down and click **More Information.**



This screen shows a running total of your correct answers to date for tasks in the training and self testing tasks within each module section. This is expressed as a score out of the total number of items that you have responded to. You may like to note these totals in your training diary at the end of each training session, and calculate the corresponding percentage correct scores. You can then compare these as you move through the programme.



Practice, practice, practice!

The library of music files in MATP is extensive. You won't run out of songs to listen to! Follow your intuition and follow a training schedule that feels best for you and that suits your musical tastes. At the same time, try something different by studying instruments or styles that you would not choose otherwise. Use the feedback on training and self-testing tasks to guide the material that you wish to listen to in the teaching sections. Be sure to devote plenty of time to the training sections within each module, as this is where most learning will take place.

Remember to use MATP for 30mins per day, four times per week over the ten week training period. Please use the daily log included in this manual to keep track of your progress.

Thank you for participation in this study.

Daily Log

Please keep a record of activities after each training session. This will allow us to see the direction that your training took, and any areas that you excelled in or needed to work on. Please feel free to record any additional notes on the general comments page at the end of this book.

Example

Date: 26.05.11

Time	Module	Section	Stimuli	Comments
7.30 - 7.45pm	Style	Train	n/a	Doing great, got all nine options on screen for a while. Problems with Jazz vs. Eastern and Small vs. Large Classical Group
7.45pm - 7.55pm	Style	Teach	Eastern Jazz	Went through all examples, Ex 8 a bit tricky No errors on Jazz items
7.55 - 8.00pm	Style	Test	n/a	Style Train total now 40/60, Style Train total now 15/30

Week X – Day Y

Date:

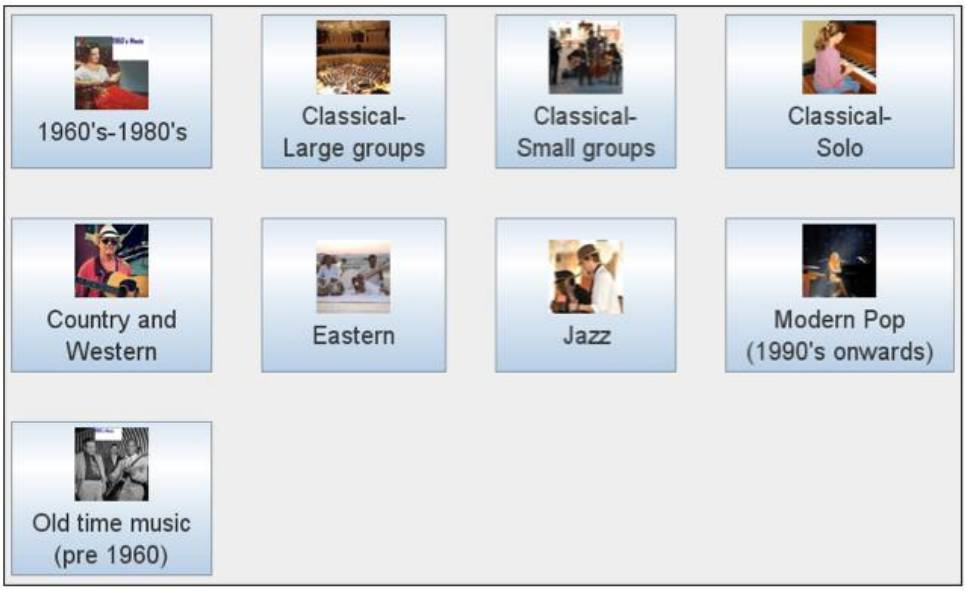
Time	Module	Section	Stimuli	Comments

Solo Instruments

Ensembles


Brass Band
Choir
Duet - Instrumental
Duet - Voice+Piano
Instrument+Orchestra
Jazz Band
Orchestra
Rock Band
String Quartet
Voice+Orchestra

Musical Styles



Program Support

Troubleshooting

Your version of MATP should install and run without error. If you are a Windows user and encounter difficulty during the installation process you may need to install the most recent version of Java. Follow steps 1 – 5 form the Installation process on page 4. Double click on **jre-6u23** in the MATP folder.

This will install the most recent version of Java on to your computer. Once this is completed attempt to run MATP again.

If this problem does not resolve or you require any technical assistance whatsoever please do not hesitate to contact the researcher, Jason King on 3102 4443 (free call from Brisbane) or jason.king@pg.canterbury.ac.nz. Please have your ADATA flash drive ready in the event of a technical difficulty.

General Comments

Appendix B: Musical Appreciation Questionnaire for Adult Cochlear Implant Users

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

DEPARTMENT OF COMMUNICATION DISORDERS

Musical Background Questionnaire: Adult Cochlear Implant Users

The following questions relate to your previous music training and experiences.

Please complete the questionnaire as honestly, and in as much detail as possible.

The information you provide will allow us to better evaluate the results of the study and will be kept confidential.

Please feel free to add in additional comments, statements or anything else which you think may be relevant or helpful. If insufficient space is provided, please use the back of each page.

If you are unsure or unclear about any of the questions, please ask for further clarification.

Thank-you for your time.

PARTICIPANT INFORMATION

NAME: ..... DATE: .....

DATE OF BIRTH: ..... GENDER: Male ☐ Female ☐

DEVICE INFORMATION

DATE OF SURGERY:..... EAR IMPLANTED: Left ☐ Right ☐

IMPLANT MODEL..... PROCESSOR MODEL: .....

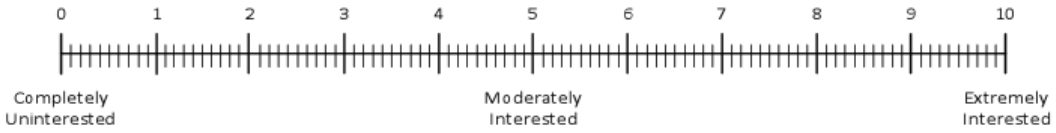
DO YOU USE A DIFFERENT PROGRAM OR SETTING FOR LISTENING TO MUSIC? Yes ☐ No ☐

IF YES, PLEASE SPECIFY:.....

IS TINNITUS A PROBLEM FOR YOU WHEN WEARING YOUR IMPLANT? Yes ☐ No ☐

MUSIC ENJOYMENT & PARTICIPATION

1. On a scale of 0 to 10, where do you rate your personal interest in music? Please mark the scale below using an 'X' to indicate where your level of interest rests.



2. Prior to your hearing loss, how often did you choose to listen to music (e.g. Radio, CD, MP3, concerts etc)?

☐ Very Often ☐ Often ☐ Sometimes ☐ Occasionally ☐Never

Approximately ..... hours per week

3. Since you received your cochlear implant, how often do you choose to listen to music?

☐ Very Often ☐ Often ☐ Sometimes ☐ Occasionally ☐Never

Approximately ……. hours per week

4. Please indicate which statement below best describes how your enjoyment of music has changed from prior to your hearing loss to the present day (with your cochlear implant).

☐ I never really listened to music before my hearing loss, and I do not listen to it now

☐ Music is not as pleasant as I recall before my hearing loss, but it is better than nothing

☐ Music is not as pleasant as I recall before my hearing loss, but I still enjoy it now.

☐ Music sounds different to what I recall, but is no less enjoyable

☐ Music does not sound any different to what I recall before my hearing loss

☐ Music is more pleasant sound than I recall before my hearing loss

5. Please indicate which statement below best describes how your music listening habits have changed from pre-hearing loss to the present day (with your cochlear implant)

☐ No change – I did not listen to music before my hearing loss, and do not do so now

☐ No change – I listened to music occasionally before my hearing loss, and listen to it occasionally now

☐ No change – I listened to music frequently before my hearing loss, and listen to it frequently now

☐ I listened to music more before my hearing loss than now

☐ I listen to music more now than before my hearing loss.

6. Which of the following styles of music do you enjoy listening to?

	Prior to implantation/before your hearing loss	**After implantation**
None	☐	☐
Classical: Instrumental	☐	☐
Classical: Vocal	☐	☐
Country	☐	☐
Easy Listening	☐	☐

	Prior to implantation/before your hearing loss	After implantation
Electronic / Techno	☐	☐
Folk	☐	☐
Hard Rock	☐	☐
Jazz	☐	☐
Pop / Rock	☐	☐
Religious (Hymns, Gospel)	☐	☐
Rhythm & Blues	☐	☐
Other (please specify below)	☐	☐

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7. On a scale of 1-5, please rate the following:

(1 = None or not able; 2 = Limited; 3 = Average; 4 = Above Average; 5 = Extensive or Very Able)

Knowledge of music history	1	2	3	4	5
Knowledge of music theory	1	2	3	4	5
Ability to read music	1	2	3	4	5
Ability to play an instrument or sing	1	2	3	4	5
Overall music ability	1	2	3	4	5

8. Have you received formal musical training? Yes ☐ No ☐

If *yes*, please complete the following as applicable. If *no*, please go on to question 8.

Activity	Training in: (i.e. piano, or classical singing, or music history)	Age Lessons Received (i.e. 8 - 12 years of age)	Duration of Formal Training (Years)	Highest Grade Level Completed
Learning A Musical Instrument	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....
Singing	.....	.....	.....	.....
	.....	.....	.....	.....
Music Theory	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....
Music Classes	.....	.....	.....	At School
	.....	.....	.....	At University
	.....	.....	.....	At Adult College
	.....	.....	.....	Other:.....

9. Have you ever participated in any of the following musical activities? Yes ☐ No ☐

If *yes* please complete the sections relevant to you. If *no*, please move onto question 10.

Activity	Age at which you started participating	Number of years of Involvement
Orchestra	.....	.....
Band	.....	.....
Choir	.....	.....
Musical Theatre	.....	.....

10. Please detail any informal music classes, activities, experiences etc. that you have been involved in (eg. 'self-taught' musician, learning an instrument 'by ear' or with friends, own 'music training program', personal research for self interest and information etc).

Please include detail regarding number of years and age at which the activity(s) was undertaken.

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11. Please rank your level of participation in the following musical activities.

Activity	Before your Hearing Loss (if applicable) / Before implantation				After Implantation			
	None	Monthly	Weekly	Daily	None	Monthly	Weekly	Daily
Solo singing	☐	☐	☐	☐	☐	☐	☐	☐
Group singing/Choir	☐	☐	☐	☐	☐	☐	☐	☐
Musical theatre	☐	☐	☐	☐	☐	☐	☐	☐
Playing/learning an instrument	☐	☐	☐	☐	☐	☐	☐	☐
Learning / playing instrument in a small group	☐	☐	☐	☐	☐	☐	☐	☐
Attending musical concerts	☐	☐	☐	☐	☐	☐	☐	☐
Listening to live or recorded music (Radio/CD/iPod)	☐	☐	☐	☐	☐	☐	☐	☐
Music Theory Classes	☐	☐	☐	☐	☐	☐	☐	☐
Reading about music history	☐	☐	☐	☐	☐	☐	☐	☐

12. Do you have any other additional information or comments?

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THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

PLEASE RETURN THE COMPLETED QUESTIONNAIRE TO THE FOLLOWING ADDRESS USING THE INCLUDED PREPAID ENVELOPE

Jason King, c/o Department of Communication Disorders

The University of Canterbury, Private Bag 4800, Christchurch 8020

Appendix C: Musical Appreciation Questionnaire for Adult Hearing Aid Users

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

DEPARTMENT OF COMMUNICATION DISORDERS

Musical Background Questionnaire: Adult Hearing Aid Users

The following questions relate to your previous music training and experiences.

Please complete the questionnaire as honestly, and in as much detail as possible.

The information you provide will allow us to better evaluate the results of the study and will be kept confidential.

Please feel free to add in additional comments, statements or anything else which you think may be relevant or helpful. If insufficient space is provided, please use the back of each page.

If you are unsure or unclear about any of the questions, please ask for further clarification.

Thank-you for your time.

PARTICIPANT INFORMATION

NAME: ..... DATE: .....

DATE OF BIRTH: ..... GENDER: Male ☐ Female ☐

HEARING AID INFORMATION

DURATION OF HEARING AID USE (YEARS) .....(L) ..... (R)

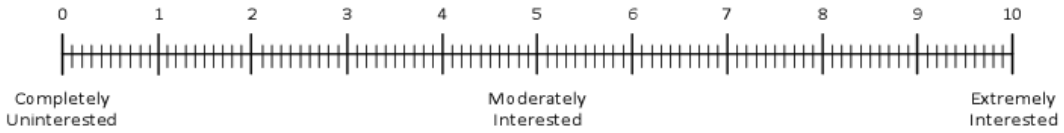
DO YOU USE A DIFFERENT PROGRAM OR SETTING FOR LISTENING TO MUSIC? Yes ☐ No ☐

IF YES, PLEASE SPECIFY:.....

IS TINNITUS A PROBLEM FOR YOU WHEN WEARING HEARING AIDS? Yes ☐ No ☐

MUSIC LISTENING INFORMATION

1. On a scale of 0 to 10, where do you rate your personal interest in music? Please mark the scale below using an 'X' to indicate where your level of interest rests.



2. Prior to your hearing loss, how often did you choose to listen to music (e.g. Radio, CD, MP3, concerts etc)?

☐ Very Often ☐ Often ☐ Sometimes ☐ Occasionally ☐Never

Approximately ..... hours per week

3. Since you started wearing your hearing aids, how often do you choose to listen to music?

☐ Very Often ☐ Often ☐ Sometimes ☐ Occasionally ☐Never

Approximately ..... hours per week

4. Please indicate which statement below best describes how your enjoyment of music has changed from prior to your hearing loss to the present day (with your hearing aids).

☐ I never really listened to music before my hearing loss, and I do not listen to it now

☐ Music is not as pleasant as I recall before my hearing loss, but it is better than nothing

☐ Music is not as pleasant as I recall before my hearing loss, but I still enjoy it now.

☐ Music sounds different to what I recall, but is no less enjoyable

☐ Music does not sound any different to what I recall before my hearing loss

☐ Music is more pleasant sound than I recall before my hearing loss

5. Please indicate which statement below best describes how your music listening habits have changed from pre-hearing loss to the present day (with your hearing aids)

☐ No change – I did not listen to music before my hearing loss, and do not do so now

☐ No change – I listened to music occasionally before my hearing loss, and listen to it occasionally now

☐ No change – I listened to music frequently before my hearing loss, and listen to it frequently now

☐ I listened to music more before my hearing loss than now

☐ I listen to music more now than before my hearing loss.

6. Which of the following styles of music do you enjoy listening to?

	Before your hearing loss	**With your hearing aids**
None	☐	☐
Classical: Instrumental	☐	☐
Classical: Vocal	☐	☐
Country	☐	☐
Easy Listening	☐	☐

	Before your hearing loss	With your hearing aids
Electronic / Techno	☐	☐
Folk	☐	☐
Hard Rock	☐	☐
Jazz	☐	☐
Pop / Rock	☐	☐
Religious (Hymns, Gospel)	☐	☐
Rhythm & Blues	☐	☐
Other (please specify below)	☐	☐

.....

7. On a scale of 1-5, please rate the following:

(1 = None or not able; 2 = Limited; 3 = Average; 4 = Above Average; 5 = Extensive or Very Able)

Knowledge of music history	1	2	3	4	5
Knowledge of music theory	1	2	3	4	5
Ability to read music	1	2	3	4	5
Ability to play an instrument or sing	1	2	3	4	5
Overall music ability	1	2	3	4	5

8. Have you received formal musical training? Yes ☐ No ☐

If *yes*, please complete the following as applicable. If *no*, please go on to question 8.

Activity	Training in: (i.e. piano, or classical singing, or music history)	Age Lessons Received (i.e. 8 - 12 years of age)	Duration of Formal Training (Years)	Highest Grade Level Completed
Learning A Musical Instrument	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....
Singing	.....	.....	.....	.....
	.....	.....	.....	.....
Music Theory	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....
Music Classes	.....	.....	.....	At School
	.....	.....	.....	At University
	.....	.....	.....	At Adult College

	.....	.....	.....	Other: .....

9. Have you ever participated in any of the following musical activities? Yes ☐ No ☐

If *yes* please complete the sections relevant to you. If *no*, please move onto question 10.

Activity	Age at which you started participating	Number of years of Involvement
Orchestra	.....	.....
Band	.....	.....
Choir	.....	.....
Musical Theatre	.....	.....

10. Please detail any informal music classes, activities, experiences etc. that you have been involved in (eg. 'self-taught' musician, learning an instrument 'by ear' or with friends, own 'music training program', personal research for self interest and information etc).

Please include detail regarding number of years and age at which the activity(s) was undertaken.

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11. Please rank your level of participation in the following musical activities.

Activity	Before your Hearing Loss				With your Hearing Aids			
	None	Monthly	Weekly	Daily	None	Monthly	Weekly	Daily
Solo singing	☐	☐	☐	☐	☐	☐	☐	☐
Group singing/Choir	☐	☐	☐	☐	☐	☐	☐	☐
Musical theatre	☐	☐	☐	☐	☐	☐	☐	☐
Playing/learning an instrument	☐	☐	☐	☐	☐	☐	☐	☐
Learning / playing instrument in a small group	☐	☐	☐	☐	☐	☐	☐	☐
Attending musical concerts	☐	☐	☐	☐	☐	☐	☐	☐
Listening to live or recorded music (Radio/CD/iPod)	☐	☐	☐	☐	☐	☐	☐	☐
Music Theory Classes	☐	☐	☐	☐	☐	☐	☐	☐
Reading about music history	☐	☐	☐	☐	☐	☐	☐	☐

12. Do you have any other additional information or comments?

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THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

PLEASE RETURN THE COMPLETED QUESTIONNAIRE TO THE FOLLOWING ADDRESS USING THE INCLUDED PREPAID ENVELOPE

Jason King, c/o Department of Communication Disorders

The University of Canterbury, Private Bag 4800, Christchurch 8020

Appendix D: Music Appreciation Training Program Evaluation Questionnaire

DEPARTMENT OF COMMUNICATION DISORDERS

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Music Appreciation Training Program Evaluation Questionnaire

Name: Date:

Please fill out this questionnaire regarding your use of the music training program. Your views are important to us, and will help us to improve MATP for future use.

1. Benefits of the program

DO YOU FEEL THAT THE TRAINING PROGRAM HAS HELPED TO INCREASE YOUR: (PLEASE CHECK BOX)	Not at all	Marginally	Unsure	Noticeably	Very much so
1. Ability to recognise commonly known instruments or ensembles?	☐	☐	☐	☐	☐
2. Ability to recognise musical styles?	☐	☐	☐	☐	☐
3. Enjoyment of music?	☐	☐	☐	☐	☐
4. Time spent listening to music (in addition to your training)?	☐	☐	☐	☐	☐
5. Motivation to attend musical events?	☐	☐	☐	☐	☐

OVERALL, DID YOU FIND THE TRAINING PROGRAM TO BE BENEFICIAL? Yes ☐ No ☐ Unsure ☐

ADDITIONAL COMMENTS:

SINCE USING THE TRAINING PROGRAM DO YOU FEEL THAT: (PLEASE CHECK BOX)	**Not at all**	**Marginally**	**Unsure**	**Noticeably**	**Very much so**
1. Music now sounds more natural?	☐	☐	☐	☐	☐
2. Music sounds more pleasant?	☐	☐	☐	☐	☐
3. Music sounds closer to how you would expect it to sound for a person with normal hearing?	☐	☐	☐	☐	☐
4. The way in which you listen to music has changed?	☐	☐	☐	☐	☐
5. Your musical preferences have changed?	☐	☐	☐	☐	☐

ADDITIONAL COMMENTS:

HAVE ANY OF THE FOLLOWING INSTRUMENTS/ENSEMBLES/STYLES BECOME EASIER TO LISTEN TO AFTER USING THE TRAINING PROGRAM? (PLEASE CHECK BOX)

Solo Instrument

- ☐ Piano
- ☐ Violin
- ☐ Cello
- ☐ Flute
- ☐ Clarinet
- ☐ Trumpet
- ☐ Trombone
- ☐ Xylophone
- ☐ Drum Kit
- ☐ Guitar
- ☐ Male Singer
- ☐ Female Singer
- ☐ Other:

Ensembles

- ☐ Orchestra
- ☐ Rock band
- ☐ Brass band
- ☐ Jazz band
- ☐ String Quartet
- ☐ Choir
- ☐ Duets – instrumental
- ☐ Duets – Voice + Piano
- ☐ Instrument + Orchestra
- ☐ Voice + Orchestra
- ☐ Other:

Musical Style

- ☐ Classical – Solo
- ☐ Classical – Small group
- ☐ Classical – Large group
- ☐ Jazz
- ☐ Modern/Pop (1990's on)
- ☐ 1960's – 1980's
- ☐ Old time (pre 1960)
- ☐ Country & Western
- ☐ Eastern
- ☐ Other:

PLEASE COMMENT ON ANY INSTRUMENT/ENSEMBLE/STYLE PAIRS THAT YOU STILL FIND TO BE CONFUSING OR THAT YOU BECAME BETTER ABLE TO DISTINGUISH:

2. Training program length

WHAT ARE YOUR VIEWS OF THE DURATION AND THE FREQUENCY OF THE TRAINING PROGRAM? (PLEASE CHECK BOX)	Too short	Short	Just right	Long	Too long
10-week training program	☐	☐	☐	☐	☐
30-minute session	☐	☐	☐	☐	☐
4 sessions per week	☐	☐	☐	☐	☐

ADDITIONAL COMMENTS:

APPROXIMATELY HOW MUCH TIME DID YOU SPEND USING THE PROGRAM DURING EACH SESSION?

_____ **MINUTES**

AFTER COMPLETING THE TRAINING PROGRAM DO YOU FEEL THAT YOU COULD CONTINUE TO IMPROVE YOUR ABILITY TO RECOGNISE TIMBRE AND MUSICAL STYLE? Yes ☐ No ☐ Unsure ☐

3. Program Evaluation

These ratings will help us to understand your views of the training programs functionality. Please rate the following qualities:

QUALITY	Very Poor	Poor	Neutral	Good	Very Good
1. Usefulness of the additional resources section	☐	☐	☐	☐	☐
2. Variety of instruments and ensembles	☐	☐	☐	☐	☐
3. Variety of music styles	☐	☐	☐	☐	☐
4. Variation of excerpts when training or testing	☐	☐	☐	☐	☐
5. Background information on the musical excerpts	☐	☐	☐	☐	☐
6. Appropriateness of images used	☐	☐	☐	☐	☐
7. Matching of difficulty level to your level of ability	☐	☐	☐	☐	☐
8. Ease of use and navigation	☐	☐	☐	☐	☐
9. Speed of the program	☐	☐	☐	☐	☐

10. Clarity of training manual	☐	☐	☐	☐	☐
11. Usefulness of training diary	☐	☐	☐	☐	☐
12. Overall usefulness of training program	☐	☐	☐	☐	☐

BASED ON THE EVALUATION ABOVE DO YOU HAVE ANY SUGGESTIONS TO MAKE THIS TRAINING PROGRAM MORE ENJOYABLE?

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE. THE TIME AND EFFORT THAT YOU HAVE PUT INTO THE TRAINING PROGRAM IS GREATLY APPRECIATED. PLEASE RETURN YOUR COMPLETED FORM BY EMAIL TO **JASON.KING@PG.CANTERBURY.AC.NZ**

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