Effect of Number of Channels and Compression Parameter in Hearing Aids on Music Perception

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Abstract

Appreciation of music is the next most commonly expressed requirement after speech by the users of hearing aids. Use of hearing aids brings about improvement in perception of speech. However, this may not apply for music. The present study attempted to evaluate the effects of varying the number of channels and compression knee-point on perception of music. This was done in individuals with flat (N=12) vs. sloping (N=12) mild-moderate sensorineural hearing loss. Music perception in these individuals was assessed using the Music Perception Test Battery (MPTB) and a five-point perceptual rating scale using the default setting for music vs. the high knee-point of compression setting, for the two and eight channel hearing aids. The results indicated that, for most of the parameters, there was no significant difference between the two groups (flat vs. sloping) or the channels (two vs. eight). However, significant difference was observed between the hearing aid settings (default vs. high knee-point of compression) for both the hearing aids (two vs. eight channels); with the performance on most of the parameters tested being better when the knee-point of compression was high. This result is in agreement with studies which stated that the compression knee-point for music should be set 5 to 8 dB higher than for equivalent intensities of speech, as the crest factor for musical instruments is 18 to 20 dB. This prevents the music from forcing the hearing aid to operate in its non-linear mode prematurely.

Key Words: *Default setting, high knee-point, quality.*

Introduction

To many people, in many cultures, music is an important part of their way of life. A sensorineural hearing loss affects the perception of sound in many ways. Difficulty in perceptual analysis of complex sounds such as speech and music is one such aspect. In individuals with hearing loss, the existence of pitch anomalies, such as diplacusis and exaggerated pitch intensity effects, may affect the enjoyment of music.

Hearing loss also affects timbre perception which depends on both spectral and temporal aspects of sounds. The aspects of timbre perception that are affected by spectral shape depend on frequency selectivity of the ear which is reduced in individuals with cochlear damage. Hence, the excitation pattern contains less information about the spectrum. This leads to reduced ability to distinguish sounds based on their spectral shape (Summers & Leek, 1994).

Studies on music perception in individuals with hearing impairment have shown that sensorineural hearing loss (SNHL) impairs the perception of musical elements. de Laat and Plomp (1985) found that participants with SNHL had greater difficulty recognizing a melody presented simultaneously with two other melodies than individuals with normal hearing. Santurette and Dau (2007) investigated melody recognition using different types of binaural pitches and found that listeners with hearing impairment performed poorly in melody recognition compared to listeners having normal hearing.

The main focus of hearing aid research and development has so far been on improving the perception of speech through hearing aid. However, a hearing aid that performs well with speech signals need not necessarily perform well with music. This is because music signals are much more variable than speech, and our perception of music is more sensitive to distortion. According to Chasin and Russo (2004) a hearing aid that is optimally set for music can be optimally set for speech, even though the converse may not necessarily be true. This is because of the four primary physical differences between speech and music. These include, the long-term spectrum, differing overall intensities, crest factors, and phonetic vs. phonemic perceptual requirements of different musicians. These serve as the basis for differing electro-acoustic settings of a hearing aid for inputs of speech and music.

Chasin and Russo (2004) have defined a set of electro acoustic parameters in a hearing aid that are optimal for enjoying music. This includes 1) a sufficiently high-peak input-limiting level so that the more intense components of music are not distorted at the front-end

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of the hearing aid; 2) a single-channel or a multi-channel system with all channels set for similar compression ratios and knee-points; 3) an RMS detector of compression scheme with knee-point set to engage at inputs 5 to 8 dB higher than that for speech; and 4) disabled feedback and noise reduction circuits.

The prescriptive fitting formulae commonly used for fitting hearing aids are based on two principles, loudness normalization and loudness equalizations (Smeds & Leijon, 2001). Loudness normalization aims at amplifying the sounds in such a way that they sound as close as possible to the way in which an individual with normal hearing perceives the loudness of the same sound. Loudness equalization maximizes the speech intelligibility for every input level without exceeding the overall loudness above the overall normal loudness for speech. This is achieved by presenting all the speech bands at equal loudness. Dillon, Byrne, Brewer, Kitsch, Ching, and Keidser (1998), and Keidser, Brew, and Peck (2003) found that NAL-NL1, being a fitting procedure based on loudness equalization, prescribes lesser low frequency gain than other fitting procedures based on loudness normalization such as DSL (i/o) and FIG 6. Music is generally more intense than speech, with larger peaks; greater crest factor and slightly more low-frequency and high-frequency energy content (Chasin & Russo, 2004). The present study uses the DSL (i/o) version5 prescriptive formula. This prescriptive formula was used as it provides slightly higher gain in the low frequencies when compared to other formulae as it aims to normalize loudness and extend the dynamic range (Byrne, 2001). This improves the perception of music in terms of quality. Also, in an unpublished study done by Chowdhury (2008), participants with hearing loss preferred the hearing aid programmed with DSL (i/o) curvilinear formula compared to NAL-NL1 for listening to music. DSL (i/o) formula was also ranked higher by adult hearing aid users with moderate to moderately-severe sensorineural hearing loss than FIG6 and NAL-NL1 for clarity, melody, and naturalness of the music sample (Fathima & Basavaraj, 2010).

Following the perception of speech, appreciation of music is next most commonly expressed requirement by the users of hearing aids. When individuals who enjoy listening to music acquire hearing impairment, it will have significant effect on music perception. Although there is improvement in speech perception through hearing aids, it is questionable whether a hearing aid could process music in a way such that the user can hear and enjoy the music to the same extent as was prior to acquiring hearing loss.

Earlier, the use of analogue technology in hearing aids limited the options of manipulating the parameters of hearing aid to optimize it for speech or music. The advent of digital technology enables manipulation of various algorithms like noise reduction, adaptive directionality, adaptive feedback suppression and compression. It also allows for sound processing in different channels having different compression settings.

There have been studies in literature on varying different parameters of hearing aids and its effect on music perception. However, majority of these have been carried out in listeners with normal hearing by simulation of hearing loss. Also, most of the hearing aid users who enjoy music have hearing impairment with a sloping configuration. Therefore, music perception through hearing aids needs to be evaluated in individuals with hearing impairment. Further, this helps the audiologist to decide whether to choose the default music program stored in the hearing aid for listening to music (default setting for music) or to manually adjust certain parameters for better perception of music. Thus, the effect of manipulating the number of channels and knee-point of compression on music perception was evaluated, using a controlled study design.

The present study attempted to evaluate the effect of varying the hearing aid parameters on perception of music, based on perceptual measures of music sample. The specific objectives include comparison of music perception through a hearing aid using the default setting for music vs. a high knee-point of compression, for a two-channel hearing aid and comparison of music perception through a hearing aid using the default setting for music vs. a high knee-point of compression, for a eight-channel hearing aid.

Method

Participants

A total of 24 participants in the age range from 39 to 59 years (Mean = 48.3, SD = 6.38) were a part of this study. They were divided into two groups. Group I consisted of twelve participants who were non-musicians. They had mild to moderate flat sensorineural hearing loss in the test ear which was the better ear. Flat configuration of hearing loss being operationally defined as the difference between the least and the highest air-conduction threshold of the test ear being less than 20 dB from 250 to 8000Hz (Pittman & Stelmachowicz, 2003). Group II consisted of twelve participants who were non-musicians with sloping sensorineural hearing loss in the test ear which was the better ear. Sloping configuration of hearing loss being operationally defined as the air-conduction thresholds occurring at successively higher levels from 250 to 8000Hz and air-conduction threshold at 250 and 8000 Hz differing by 20 dB or more (Pittman & Stelmachowicz, 2003). All the participants had post-lingually acquired hearing loss. History of otologic, cognitive or neurological problems was not there. All the participants had speech identification scores of at least 80% on phonemically balanced bi-syllabic word list in Kannada (Yathiraj & Vijayalakshmi, 2005).

Test Stimuli

Stimuli from the Music Perception Test Battery (MPTB) (Das & Manjula, 2010) were used to evaluate the efficacy of hearing aid for processing the music (Appendix A).

Procedure

Testing involved collection of data from the selected participants for the purpose of verifying the objectives of the study. A detailed case history was taken to confirm if the participants met the inclusion criteria. Music training and experience questionnaire (adapted from Looi, McDermott, McKay, & Hickson, 2008) was administered to evaluate the competency of the participant in music. Only the participants who had knowledge of the instruments and melodies used in MPTB but without professional music training were considered for the study. A cut-off criterion of 15 out of the maximum score of 25 was followed in order to consider a participant as 'experienced' in music (Looi et al. 2008). For the purpose of this study, a participant was considered as being 'inexperienced' in music if he/she obtained a cut-off score of less than 15 out of the maximum score of 25. Later, two digital behind the ear hearing aids were programmed for each test ear of the participant.

The participants were fitted with the two/eight channel digital behind the ear hearing aid. The hearing aid was connected to HiPro which in turn was connected to a PC with NOAH and the hearing aid software for programming. The hearing thresholds were entered and the hearing aid was programmed using DSL (i/o) v.5 prescriptive formula with acclimatization level of 2. This prescriptive formula was used as it provides slightly higher gain in the low frequencies when compared to other formulae as it aims to normalize loudness and extend the dynamic range (Byrne, 2001). This improves the perception of music in terms of quality. Also, in an unpublished study done by Chowdhury (2008), participants with hearing loss preferred the hearing aid programmed with DSL (i/o) curvilinear formula for listening to music than NAL-NL1. DSL (i/o) formula was also ranked higher by adult hearing aid users with moderate to moderately-severe sensorineural hearing loss than FIG6 and NAL-NL1 for clarity, melody, and naturalness of the music sample (Fathima & Basavaraj, 2010). Only the knee-point of compression was manipulated and all other parameters were kept constant between the two settings (default vs. high knee-point).

The MPTB was administered in the following settings; two channel digital hearing aid programmed for two settings/programs (default settings for music and with high compression knee-point as was permissible) and an eight channel digital hearing aid programmed for two settings/programs (default settings for music and with high compression knee-point as was permissible).

Presentation of the music

A laptop was used to play the music of the MPTB which was recorded on the CD. This was routed to the loudspeaker through the auxiliary input of the audiometer. The loudspeaker was located at 45 degree Azimuth and at one meter distance from the aided ear of the participant. The presentation level of the music was set to 45 dBHL for all participants. The music sample was presented to the participant fitted with one of the two hearing aids programmed with one of the two settings (default vs. high knee-point). This was repeated with the other setting and with another hearing aid. The hearing aids and the settings were randomly selected so that the participant was not aware of the number of channels in hearing aid or the settings within a particular hearing aid. The stimuli from the MPTB were also randomized to prevent practice effect.

Instructions for Administration of Music Perception Test Battery

Pitch discrimination task: A pair of musical notes, i.e., /sa/ note at low pitch and /sa/ note at high pitch, was played. The task was to indicate whether the given stimuli had 'same' or 'different' notes or pitches. There were 12 pairs of notes, two practice items and ten test items. For each of the two conditions (default knee-point of compression vs. high knee-point of compression) five test items were presented randomly.

Pitch ranking task: The participant was presented with a pair of musical (vocal) notes in differing pitches. The task of the participant was to identify the higher note of each stimuli pair. This was carried out for the three sub-tests; Subtests-A, B and C with stimuli pairs having a difference of one octave, half octave and quarter octave intervals between the two notes in a given stimulus pair respectively. Three items were presented randomly for each sub-test for each of the two hearing aid settings.

Rhythm discrimination task: The participant was presented with a pair of rhythm excerpts. The task of the participant was to discriminate whether the pair of excerpts was 'same' or 'different'. There were 12 pairs of notes, two practice items and ten test items. For each of the two settings (default knee-point of compression vs. high knee-point of compression), five test items were presented randomly.

Melody recognition task: The participant was presented with a melody played on a violin, one at a time. The task of the participant was to identify (name or hum) the melody perceived following presentation of each test stimuli. There were 12 melodies which included two practice items and ten test items. For each of the two hearing aid settings (default knee-point of compression vs. high knee-point of compression), five melodies were presented randomly.

Instrument identification task: The participant was presented with a musical piece of an instrument/s at a time. The task of the participant was to identify the instrument or instruments, present in a given test stimulus. This test comprised of two sub-tests**,** single instrument identification sub-test and music ensemble sub-test. In each of the two sub-tests, five items were presented in each of the two settings.

Scoring for music perception test battery

For each of the subtests on the MPTB i.e. pitch discrimination, pitch ranking, rhythm discrimination, melody recognition and instrument identification, for each item, a score of '1' was given for every correct response and a score of '0' for every incorrect or no response. Maximum score was five for each of the two aided settings with each hearing aid for the pitch discrimination, rhythm discrimination, melody recognition and instrument identification tasks while for pitch ranking task, maximum score was nine (3 sub-tests * 3).for each of the two aided settings with each of the two hearing aids.

In addition to the administration of the MPTB, in the two aided settings, with each of the two hearing aids, subjective analysis was done using a five-point perceptual rating scale for quality which is a modification of the scale given by Gabrielsson , Rosenberg, and Sjogren (1979) and used by Chasin and Russo (2004). The participant was asked to rate from 1 (poorest) to 5 (best) on five perceptual parameters. A perfect perceptual reproduction of music through the hearing aid would get a maximum score of 25 points i.e., a maximum rating of 5*5 parameters.

The participants were instructed on the five perceptual parameters used to study the perceived quality of music through hearing aids. They were told that for the parameter of *Loudness*, they were supposed to judge whether the music was sufficiently loud, in contrast to soft or faint; for the parameter of *Fullness*, they were supposed to judge whether the music was full, in contrast to thin; for the parameter of *Clearness*, they were supposed to judge whether the music was clear and distinct, in contrast to blurred and diffuse; for the parameter of *Naturalness*, they were supposed to judge whether the music seems to be as if there was no hearing aid, and it sounded as "they remember it" and for the parameter of *Overall Fidelity*, they were supposed to judge whether the reproduction of sound was with little distortion, giving a result very similar to the original.

Determining subjective preference: After listening and rating the music sample, the participant was asked to rate each of the aided condition in terms of their overall preference in listening to music. The participant had to choose between a two vs. eight channel hearing aid. Later, with the best hearing aid they had to choose between the defaults vs. high knee-point setting. This procedure was followed for each of the participant in Groups I and II.

Results

Mean and standard deviation values for the scores on the music perception test battery (MPTB) and for the parameters on the perceptual rating scale were calculated for the participants in both the groups. Mixed Analysis of Variance, a two-way repeated measure ANOVA was carried out to find out the overall interaction between the hearing aids and the settings with groups as the independent variable. Multivariate analysis of variance (MANOVA) was carried out to compare between the two groups. Paired t-test was carried out to compare between the hearing aid settings (default vs. high knee-point) and the hearing aid channels (two vs. eight). Mann-Whitney U test was carried out to compare between the two groups of participants on the five-point perceptual rating scale and for the pitch ranking task of the MPTB. Table 1 represents the summary of the findings on the pitch discrimination, rhythm discrimination, melody recognition and instrument identification tasks of the MPTB from participants in the two groups. Table 2 represents the summary of the findings of the pitch ranking task and overall findings of the MPTB from participants in the two groups. Table 3 represents the summary of the findings given by the participants in the two groups on quality perception on a five point rating scale.

From the results of the MPTB and the rating on the perceptual rating scale, the following inferences were drawn; there was no significant effect of configuration of the audiogram of the participants on music perception for all the tasks on the MPTB and the perceptual rating scale. For music perception, the scores were better for the two channel hearing aid compared to the eight channel hearing aid for the majority of the tasks on the MPTB and for quality rating. However, this difference was not significant and for the perception of music, high knee-point of compression setting was favored over the default

Table 1: Summary of findings on different tasks of MPTB from participants in the two groups

Music Perception Test Battery (MPTB)	Flat hearing loss	Sloping hearing loss
Pitch discrimination task	✓ 8 channel better than 2 channel(for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 8 channel equivalent to 2 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting
Rhythm discrimination task	✓ 8 channel better than 2 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 8 channel equivalent to 2 channel (for default setting) ✓ 8 channel better than 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting
Melody recognition test	✓ 2 channel better than 8 channel (for default setting) ✓ 2 channel equivalent to 8 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 8 channel better than 2 channel (for default setting) ✓ 2 channel equivalent to 8 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting
Instrument identification Single instrument identification test Music ensemble identification test	✓ 2 channel better than 8 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting ✓ 8 channel better than 2 channel (for default setting) ✓ 2 channel better than 8 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 8 channel better than 2 channel (for default setting) ✓ 2 channel better than 8 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting ✓ 2 channel better than 8 channel (for default setting) ✓ 8 channel equivalent to 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting

Table 2: *Summary of findings on pitch ranking task of MPTB and the overall findings of MPTB from participants in the two groups*

Music Perception Test Battery (MPTB)	Flat hearing loss	Sloping hearing loss
Pitch ranking test Sub-test A	✓ 2 channel better than 8 channel (for both default & high knee-point of compression setting) ✓ High knee-point setting > default ✓ 2 channel better than 8 channel (for both	✓ 8 channel better than 2 channel (for both default & high knee-point of compression setting) ✓ High knee-point setting > default ✓ 8 channel equivalent to 2 channel (for default setting)

Sub-test B Sub-test C	default & high knee-point of compression setting) ✓ High knee-point setting better than default setting ✓ 2 channel better than 8 channel (for both default & high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 8 channel better than 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting ✓ 2 channel better than 8 channel (for both default & high knee-point of compression setting) ✓ Default setting better than high knee-point of compression setting (for 2 channel hearing aid) ✓ High knee-point setting better than default setting (for 8 channel hearing aid)
Overall performance on the MPTB	✓ 2 channel better than 8 channel (for both default & high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 8 channel better than 2 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting

Table 3: *Summary of the findings given by participants in the two groups on quality perception on a five point rating scale.*

Perceptual rating scale - Parameters	Flat hearing loss	Sloping hearing loss
1. Loudness	✓ 2 channel better than 8 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 2 channel better than 8 channel (for default setting) ✓ 8 channel better than 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting
2. Fullness	✓ 2 channel better than 8 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 2 channel better than 8 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting
3. Clearness	✓ 2 channel better than 8 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 2 channel better than 8 channel (for default setting) ✓ 8 channel better than 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting
4. Naturalness	✓ 2 channel better than 8 channel (for default setting) ✓ 8 channel better than 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 2 channel better than 8 channel (for default setting) ✓ 8 channel better than 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting
5. Overall fidelity	✓ 2 channel better than 8 channel (for both default and high knee-point of compression setting) ✓ High knee-point setting better than default setting	✓ 2 channel better than 8 channel (for default setting) ✓ 8 channel better than 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting
Overall performance on the perceptual rating	✓ 2 channel better than 8 channel (for both default and high knee-point of compression	✓ 2 channel better than 8 channel (for default setting)

Scale	setting) ✓ High knee-point setting better than default setting	✓ 8 channel better than 2 channel (for high knee-point of compression setting) ✓ High knee-point setting better than default setting

setting by participants with hearing loss in both the groups.

Discussion

The discussion on the results of MPTB and perceptual rating scale will be on cconfiguration of the audiogram, number of channels and hearing aid settings. This is done separately for MPTB and perceptual rating scale.

Music perception test battery

Configuration of the audiogram (Flat vs. Sloping): For majority of the tasks on the MPTB, there was no significant effect of configuration of the audiogram of the participants (flat vs. sloping). The possible reasons for this could be that the tasks of pitch discrimination, melody recognition, and single instrument identification were relatively easy when compared to the other tasks. For example, in the pitch discrimination task, there was a wider difference between the stimuli pairs being used which made the task easier. Further, Olson (1967) has reported that the pitch discrimination is least affected by hearing loss. Studies have also reported that individuals with hearing impairment, including both cochlear implant and users of hearing aid, perceive musical rhythm almost as well as those with normal hearing (Darrow, 1979; Gfeller, Woodworth, Robin, Witt, and Knutson, 1997). In addition, the degree of hearing loss considered in this study was of mild - moderate degree. This degree of hearing loss relatively preserves most of the spectral and temporal cues which become more distorted as the degree of hearing loss increases.

Number of channels (two- vs. eight- channels): The scores were better for the two-channel hearing aid compared to the eight-channel hearing aid for the majority of the tasks on the MPTB. However, this difference was not significant. This could be because, use of either a single-channel or a multi-channel hearing aid (all channels set for similar compression ratios and knee-points) is optimal for music perception as it helps to maintain a balance between the lower and higher harmonics (Chasin & Russo, 2004). In the present study, there were a few parameters where there was a significant effect of number of channels. This included the music ensemble identification task wherein the participants with sloping configuration of audiogram performed better with the eight-channel hearing aid, whereas those with flat configuration performed better with two-channel hearing aid. This can be attributed to the level of difficulty with respect to the task of music ensemble identification which may require increase in the number of channels for better timbre perception in participants with sloping configuration.

Hearing aid settings (default vs. high knee-point): High knee-point of compression setting in the hearing aid was favoured over the default music program setting by participants with hearing loss, in both the groups, for all the tasks on the MPTB. As described by Chasin and Russo (2004), this could be attributed to the crest factor for musical instruments which is 18 to 20 dB, whereas it is 12 dB for speech. Therefore, higher knee-point of compression prevents the music from forcing the hearing aid to operate in its non-linear mode prematurely. Chasin and Russo (2004) recommended a compression knee-point of 5 to 8 dB higher than that for equivalent intensities of speech.

Five-point perceptual rating scale

Configuration of the audiogram (Flat vs. Sloping): For majority of the parameters on the quality rating, there was no significant effect of configuration of the audiogram of the participants (Group I with flat hearing loss vs. Group II with sloping hearing loss). This could be because only participants with lesser degree of hearing loss were considered in the present study.

Number of channels (two vs. eight): Participants with flat configuration rated the two-channel hearing aid higher when compared to the eight channel hearing aid; whereas those with sloping configuration of audiogram rated the eight channel hearing aid higher for the majority of the parameters. However, this difference was not significant. This could be because a single channel hearing aid maintains the optimal balance between the lower and higher harmonics; while a multi-channel hearing aid with different compression thresholds and knee-points in each channel may distort the information in participants with flat configuration (Chasin & Russo, 2004). For participants with sloping configuration, an eight-channel hearing aid was reported to be more suitable as gain could be adjusted for in different channels according to their needs.

Hearing aid settings (default vs. high knee-point): Hearing aid with high knee-point of compression setting was given a higher rating over the default setting by the participants with hearing loss in both the groups on the perceptual rating scale. Higher knee-point of compression prevents the music from forcing the hearing aid to operate in its non-linear mode prematurely. This is because the crest factor for musical instruments is 18 to 20 dB, whereas that for speech is 12 dB. Due to these differences, Chasin and Russo (2004) have recommended that compression knee-point for music be set at 5 to 8 dB higher than that for equivalent intensities of speech.

Thus, it can be inferred from the results of the present study that, two channel hearing aid set with high knee-point of compression provides better perception of music.

Conclusions

The results indicated that, for most of the parameters, there was no significant difference between the two groups (flat vs. sloping) or the channels (two vs. eight). However, a significant difference was observed between the hearing aid settings (default vs. high knee-point of compression) for both the hearing aids (two vs. eight channels). The performance for most of the parameters tested was better when a high knee-point of compression was used. This was true for both MPTB and five-point perceptual rating scale. The above result is in agreement with that reported by Chasin and Russo (2004) which stated that the compression knee-point for music should be set 5 to 8 dB higher than for equivalent intensities of speech as the crest factor for musical instruments are 18 to 20 dB. This prevents the music from forcing the hearing aid to operate in its non-linear mode prematurely.

Clinical Implications

The present study impresses upon the need to make special changes in the hearing aid parameters for individuals with hearing loss who like listening to music or are musicians. The parameters for optimal music perception must be manipulated based on individual requirements of the client with hearing loss.

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Appendix

The CD form of the Music Perception Test Battery (MPTB) included the following tests –

Pitch discrimination: Pairs of musical notes recorded from the harmonium was used for the pitch discrimination task. There were four pairs of ‘sa’ notes, each note having either high or low pitch. Within each pair, there was a silence interval of two seconds.

Pitch ranking: Pair of recorded musical notes was used for the pitch ranking task. The notes consisted of sustained phonation of the vowel /a/ by a trained female and male singer at different notes. The duration of each note was three seconds and the gap between the pair was five seconds. This test was further divided into three sub-tests. Each sub-test had two practice items and six test items. In sub-test A, the two notes were separated by an interval of one octave; in sub-test B, the two notes were separated by an interval of half-octave, and in sub-test C, the two notes were separated by an interval of quarter octave.

Melody recognition: A list of five recorded melodies played on the violin was presented to the participants; one melody played at a time. The melodies included were ‘Saare jahaan se achha’, ‘Vande maataram’, ‘Hum honge kaamyab’, Raghupati raaghav rajaram ’ and ‘Ae maalik tere bande hum’.

Rhythm discrimination: A recorded pair of rhythm excerpts composed on a tabla served as the stimuli for this task. There were five different rhythms of 15 seconds duration each. Between the two rhythm excerpts, there was a gap of five seconds.

Instrument identification: This test had two sub-tests. The first sub-test was single instrument identification task which consisted of identification of ten musical instruments. The other sub-test was music ensemble identification task, which consisted of identification of ten music instrumental duets.