

Response of hearing-impaired children to piano lessons: Engagement and enjoyment of music

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Abstract - This multiple single-subject research study explores how deaf children with cochlear implants (CIs) can appreciate and engage in piano lessons. Three CI children and 2 normal-hearing children received 6 months of formal individual piano lessons where aural modeling was the main teaching method. Engagement was measured by a daily practice logbook indicating the number of days of practice a week, the duration of each practice session and the number of days listening to the audio modeling CD. In addition, student and parent had to rate the quality of the practice sessions. The engagement shown by hearing-impaired children was comparable to the two normal-hearing children who had lessons during the same period of time. This study suggests that it is possible for hearing-impaired children to learn to play the piano and to enjoy music making. The proposed study represents the first attempt to study how children with a profound hearing deficit respond to piano lessons in terms of engagement and enjoyment.

Introduction

Music plays an important role in the everyday life of normal-hearing (NH) children: special lullabies and other favorite songs of comfort are part of parental nurturing; during the preschool years, children are invited to take part in informal music activities for enjoyment or as part of preschool programming; and during the elementary school years, children will sing songs and move to music. The inability to hear music may well contribute to a decreased quality of life as the pleasure derived from music and the social enjoyment of music is often missing for people with profound or severe hearing loss (Gfeller & Knutson, 2003; Lassaletta et al., 2007; Wright & Uchanski, 2012; Zhao, Bai, & Stephens, 2008).

Cochlear implants (CIs) are prosthetic devices designed to restore partial hearing to the profoundly deaf community. Cochlear implants have become the prostheses of choice for many deaf children. In general, the devices, which convert acoustic input into electrical signals that are transmitted to the brain (Loizou, 1998), enable many congenitally deaf children to acquire spoken language (Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000). The cochlear implant is primarily designed to assist with speech perception. However, when parents make the decision that their child should receive a cochlear implant,

they often have the expectation that their child will also be able to become involved in a wide range of musical activities (Gfeller, Witt, Spencer, Stordahl, & Tomblin, 1998). In fact, anecdotal reports and articles in magazines for implant users indicate that some implant recipients do enjoy music (Gfeller et al., 2000) and one survey shows that a large number of CI children are involved in some type of formal or informal music activity (Gfeller et al., 1998). For that reason, a study on how young CI recipients engage in music making and how they enjoy formal music lessons is an important research area to investigate.

The cochlear implant: A hearing device for deaf individuals

A cochlear implant is an auditory prosthesis with a microphone for receiving sounds from the environment, an external processor for converting those sounds into electrical signals, and a system for transmitting the signals to surgically implanted electrodes in the inner ear (Loizou, 1998; Zhou, 2010). The device makes it possible to bypass a damaged hearing system (i.e. hair cells in the cochlea) and deliver electrical stimulation to the auditory nerve. It does not restore recipients' hearing but rather allows them to perceive sound (Gfeller, 2009; Gfeller, Driscoll, Kenworthy, & Van Voorst, 2011). Since their inception in early 1970s, cochlear implants have gradually gained popularity (Kasturi, 2006) and the number of pediatric CI recipients has increased substantially over the past 10 to 15 years. The cochlear implant is the most effective of all neural prostheses developed to date and is successful in providing partial restoration of the hearing function (Wilson & Dorman, 2008).

There are different types of cochlear implantation: *unilateral*, in which only one cochlea receives implantation; *bilateral*, in which both cochleae receive implantation; *bimodal*, in which one cochlea receives implantation while the other uses an assistive hearing device such as a hearing aid (Cullington & Zeng, 2011). Many research studies suggest that in cases of profoundly deaf individuals, better speech understanding and production result from early (as early as six months of age) and bilateral implantation (Chen, 2012; Kasturi, 2006; Zhou, 2010). Research indicates that deaf children benefit from early implantation due to greater brain plasticity, which results in more efficient use of new information (Gfeller et al., 2011; Hsiao & Gfeller, 2012). Considerable research has been done to advance and improve

the cochlear implant technology. While speech processing is quite successful, music perception is still highly challenging. CI users are able to recognize tempo and rhythm, but have great difficulty with pitch, interval and melodic contour (Veekmans, Ressel, Mueller, Vischer, & Brockmeier, 2009). But with gradual improvement in CI hardware and processing strategies, there has been a growing interest in music making for profoundly deaf children (Spitzer, Mancuso, & Cheng, 2008).

Cochlear implants: Limitations in processing music

Because the devices were designed for speech perception, they transform the auditory input in ways that optimize cues for speech reception. However, they are inadequate for music and a large part of the problem lies in the technical limitations of the CI itself. The filter that is currently used in the cochlear implants is larger than the musical interval of a semitone so not all musical notes can be adequately perceived (Kasturi, 2006). Also, the perception of low frequencies is 20 Hz for normal hearing; for the CI, however, it is about 300 Hz, resulting in the absence of lower pitches (Drennan & Rubinstein, 2008). Depending on the type and brand of device, CIs contain 6 to 22 electrodes that can transmit frequencies ranging from 120 to 8000Hz (White, 1970). This is adequate for speech processing but too narrow for the frequencies needed for music, which range from 27 to 16744Hz (White, 1970). With the type of CI technology now available, most CI recipients comprehend and master speech with proper therapy, but struggle with music (Deroche, Lu, Limb, Lin, & Chatterjee, 2014; Nakata et al., 2005) as they are unable to develop an adequate representation of pitch information (Chen, 2012; Galvin, Fu, & Shannon, 2009; Jung et al., 2012; Kasturi, 2006), due to the sound processors currently used by CI devices (Laneau, Wouters, & Moonen, 2006).

Cochlear implant recipients and music perception

Of all the structural features of music, rhythm is most accessible to all CI users (Abdi, Khalessi, Khorsandi, & Gholami, 2001; Kořaner, Kilinc, & Deniz, 2012; Nakata et al., 2005; Petersen, Mortensen, Hansen, & Vuust, 2012; Yucel, Sennaroglu, & Belgin, 2009). Several studies report that CI recipients—both adult and children—have scored nearly as high as normal-hearing subjects in rhythm testing (Drennan & Rubinstein, 2008; El Fata, James, Laborde, & Fraysse, 2009; Gfeller, 2009; Gfeller et al., 2010; Gfeller et al., 2011; Looi, McDermott, McKay, & Hickson, 2008; Petersen et al., 2012; Vongpaisal, Trehub, & Schellenberg, 2006).

However, all studies report that pitch recognition is a highly challenging problem for CI users (Crew et al., 2012; Drennan & Rubinstein, 2008; Roy et al., 2014; Volkova, Trehub, Schellenberg, Papsin, & Gordon, 2014; Vongpaisal et al., 2006). Studies have reported low scores in tasks requiring subjects to recognize and identify melodies or familiar songs (Drennan &

Rubinstein, 2008; Hsiao & Gfeller, 2012; Kasturi, 2006; Wright & Uchanski, 2012). Various test conditions indicate that CI users have the greatest difficulty with melodic information devoid of lyrical and rhythmic cues (Petersen et al., 2012; Trehub, Schellenberg, & Vongpaisal, 2009; Trehub, Vongpaisal & Nakata, 2009; Yucel et al., 2009). In fact, because CI users do much better with rhythm, they often rely on rhythmic cues to identify simple melodies such as Happy Birthday and Twinkle, Twinkle Little Star (Hsiao & Gfeller, 2012). The pitch patterning that CI children receive is so limited that they often ignore it, focusing instead on timing cues that allow them to synchronize their dancing, tapping, and clapping with others (Kořaner et al., 2012; Vongpaisal et al., 2006).

The discrimination and recognition of instrumental timbre is also quite problematic for CI recipients (Drennan & Rubinstein, 2008; Jung et al., 2012; Roy et al., 2014; Stabej et al., 2012). The technical limitations of the CI make it difficult to perceive timbre or distinguish between different types of sound (Drennan & Rubinstein, 2008; Jung et al., 2012; Kasturi, 2006; Stabej et al., 2012; Wilson & Dorman, 2008; Wright & Uchanski, 2012; Zhang, Benson, & Cahn, 2013; Zhou, 2010). However, CI users can improve their recognition of different instruments through training and through a direct and focused exposure to musical instruments (Fujita & Ito, 1999; Gfeller et al., 2011; Kořaner et al., 2012; Yucel et al., 2009).

In conclusion, CI recipients react differently to sounds and music than do their normal-hearing peers. A CI user's stimulation might initially be perceived as tactile (i.e. feeling the rhythm) rather than auditory (Gfeller et al., 2011; Kořaner et al., 2012). With the proper training and processor programming, however, they have the ability to improve their perception of music (Crew, Galvin, & Fu, 2012; Drennan & Rubinstein, 2008; Galvin et al., 2009; Gfeller et al. 2011; Roy et al., 2014).

Cochlear implant recipients and music appreciation

For adults who became deaf later in life and who received a CI, music does not sound anything like what they were used to. They must contend with the permanent loss of music as they remember it and that interferes with their ability to enjoy the degraded musical input available to them. It is not surprising, then, that their interest in music tends to wane or disappear altogether (Gfeller et al., 2000). However, these findings with adult CI users may not generalize to children because of differences in the users' history of hearing (Gfeller et al., 1998). For congenitally deaf children, there is no comparable sense of loss, as their notion of music is primarily what they have experienced through their implant. In fact, music seems to be enjoyable for young deaf CI users who received their implant at an early age (Vongpaisal et al., 2006). Enhanced development of the central auditory system in early-implanted children may be beneficial for music processing, just as it has favorable implications for

speech processing (Sharma, Dorman, & Kral, 2005; Sharma, Dorman, & Spahr, 2002). Given greater plasticity of the brain at a young age and the importance of early stimulation for neurological development, child implant users may be able to achieve levels of musical enjoyment that are impossible for adult implant users.

The ability to identify or discriminate particular musical parameters (intervals, melodic contours, timbre) are important to music listening. However, for CI users, there seem to be no relation between their ability to successfully identify timbre or melodic contour and their rating of the pleasantness or likeability of music (Wright & Uchanski, 2012). In fact, there are a number of studies that show that congenitally deaf children with implants seem to derive considerable pleasure from music. They rate familiar music favorably, and they participate in a variety of musical activities including singing, dancing, and instrument training (Gfeller et al., 1998; Nakata et al., 2005; Vongpaisal et al., 2006). They also demonstrate high incidence of spontaneous singing (Nakata et al., 2005) and it has been reported that their singing performance often “exuded the energy and vitality that are characteristic of hearing children’s singing” (Nakata, Trehub, Mitani, & Kanda, 2006, p. 151).

Cochlear implant recipients and music learning

Despite a large number of recent studies on music and CI users, very few have investigated instrumental instruction for this population. When researchers have looked at music training, it was usually to measure the impact on improving pitch perception (Chen et al., 2010; Fu, Galvin, Wang, & Wu, 2015), timbre recognition (Gfeller et al., 2002), speech perception (Petersen et al., 2012; Yucel et al., 2009), auditory perception and phonetic discrimination (Rochette, Moussard, & Bigand, 2014; Roman, Rochette, Triglia, Schon, & Bigand, 2016). Studies are normally not looking into the success of the training as a way to learn music. Abdi et al. (2001) describe a notable exception, in an early musical intervention program in which 23 bilaterally implanted children aged 2.5 to 12.5 years were taught music using the Orff method. The study measured playing skills: number of melodies played correctly (simple and short melodies from the Orff book); number of mistakes made playing familiar melodies; rhythm understanding (repeating rhythm patterns on one tone and ability to differentiate rhythm patterns); and tone differentiation between two melodies. The results indicate that at all ages, the children made notable progress on playing, and their understanding of rhythm and melody improved (Abdi et al., 2001).

Kořaner, Kilinc and Deniz (2012) developed a custom-designed method called “Musical EARS” for a group of 25 participants, unilaterally implanted, divided in three groups according to age, duration of CI use, and general ability to follow directions and engage in conversation situations. The study lasted 18 months and included weekly group sessions of 45 min-

utes consisting of singing chants, one-word songs, and action songs, and one individual session of 20-30 minutes consisting of short pieces where the focus was on timbre, pitch, dynamic and rhythmic change identifications. Parental involvement was strongly advised. Each participant’s progress was charted using checklists, questionnaires and formal testing of auditory perception. The researchers reported a significant increase in scores over time for all groups of children, though it is important to note that all participants progressed least on singing tasks. The study also made a correlation between music skills and length of listening experience, supporting the idea that the longer children receive music training, the better they score.

Other studies that advocate music training with CI users include a multi-sensory perceptual-input program combining songs with lyrics, dancing, and rhythmic clapping (Gfeller et al., 2011), a percussion program (Chen-Hafteck & Shayner-Joyner, 2011), a singing approach (Yennari, 2010) and a basic ear-training program (Petersen, Mortensen, Gjedde, & Vuust, 2009).

Research problem

Researchers have invested time and effort to study how deaf children with cochlear implants (CIs) are affected by music. Numerous studies have looked at how these children perceive music, namely by focusing on perception of melodic contour, rhythm, pitch and timbre (Chen, 2012; Roy et al., 2014; Stabej et al., 2012), and music recognition (Nakata et al., 2005; Nakata et al., 2006; Nakata, Trehub, & Kanda, 2012; Olszewski, Gfeller, Froman, Stordahl, & Tomblin, 2005; Petersen et al., 2009; Petersen et al., 2012; Stabej et al., 2012; Stordahl, 2002; Trehub, Schellenberg, & Vongpaisal, 2009; Trehub, Vongpaisal, & Nakata, 2009; Van Besouw et al., 2011; Veekmans et al., 2009; Vongpaisal et al., 2006; Wright & Uchanski, 2012). In contrast to the rather extensive body of research on music perception of CI children, and some studies on music listening appreciation, there has been very little research on the engagement and enjoyment that CI children experience during formal music learning.

There are many reasons why it might be beneficial for CI children to study music. Aoki and Siekevitz (1988) compare neural pathways to a highway system that evolves according to the traffic: roads that are not used are abandoned while those that are most popular are enlarged and perfected; new routes can also be created wherever needed. The same concept applies to the neural pathways of the central auditory nervous system: the most widely used neural pathways develop and are refined; those that are not used deteriorate. Intensive and repeated auditory or music training has an impact on the neural auditory system, optimizing neuronal circuits by changing the number of neurons involved, the timing of synchronization, and the number and strength of the neuronal connections (Fujioka, Ross, Kakigi, Pan-tev, & Trainor, 2006; Shahin, Roberts, & Trainor, 2004). Conversely, inappropriate or absent auditory stimulation due to

hearing loss affects the development of the central auditory pathways and degrades their integrity and organization; the absence of early acoustic stimulation during the optimum periods of the central auditory system plasticity may prevent the normal maturation of children's central auditory systems (Eggermont, Ponton, Don, Waring, & Kwong, 1997; Ponton et al., 1996; Tibussek, Meister, Walger, Foerst, & Von Wedel, 2002). Neuroplasticity is at peak levels during childhood, so auditory input to the brain provided by experience, environment, and music training is crucial during early childhood development (Aoki & Siekevitz, 1988; Buonomano & Merzenich, 1998; Nataanen, 1995).

Through informal reports, we know that some children with implants are involved in music learning. To date however, only anecdotal information is available on the extent of participation, involvement and enjoyment of music making. With this study, we wish to specifically investigate CI students' engagement in the learning of a musical instrument. Using practice logbooks and simple surveys, we want to determine the music habits and objective enjoyment of 3 young CI recipients and compare their responses to 2 normal hearing children of the same age receiving music lessons during the same 6-month period with the same piano teacher.

Method

Research design

This study uses a single-subject research design that explores how participants are engaged in formal music training during a 6-month period. With this kind of design, participants are exposed to an intervention condition (i.e. weekly piano lessons and daily home practice) and the target variables are measured repeatedly over the course of the experiment (Gast & Ledford, 2009), so it is an appropriate methodological choice for the current project, which aims to investigate how young cochlear implant users are engaged in their music learning program.

Participants

Three 7-year-old CI recipients participated in this study (2 bilateral CI and 1 unilateral CI). They had all been implanted for more than 2 years prior to participating in this study and they were all successful implant users, with good speech perception and production skills. None of the participants had any formal music training and nor any overall developmental, language, learning, cognitive, neurologic, or attention disabilities. Participants were recruited through the Voice for Hearing Impaired Children organization. In addition, two normal-hearing children (one 7 years old and one 8 years old) were recruited for this project. They also fit the criterion of having had no formal music training.

Choice of a musical instrument and teaching method

To date, the piano has mainly been used with CI children for modeling or as a measuring tool for auditory perception (Abdi et

al., 2001; Galvin et al., 2009; Galvin et al., 2011; Hopyan, Gordon, & Papsin, 2011; Petersen et al., 2009; Yucel et al., 2009), and not as a musical instrument that CI children learn to play. Using the piano in this study was expected to be beneficial because of its tonal stability (pianos do not need tuning on a daily basis by student or parent) and because proper intonation (pitch accuracy) is not reliant on the student's ear. In addition, piano hand positions provide visual and tactile cues, a multi-sensory approach that is helpful (Gfeller, 2011; Van Besouw et al., 2011).

Piano lessons were taught using an approach inspired by the Suzuki method, in which the student did not read a music score, but listened to a recording of the pieces regularly in order to reproduce the piece at the piano with the guidance of the teacher. This approach is in accord with auditory verbal therapy premises that focus on aural modeling. The music pieces selected were all within CI's optimal hearing range. The piano teacher used a multi-sensory approach to teach six designated pieces, using visual cues such as looking at the piano keyboard while naming finger numbers, aural cues such as learning the pieces by ear and by singing the melody, and tactile approach such as touching the fingers while naming the notes and finger numbers.

Piano lesson procedure

All participants were offered piano lessons once a week for 6 months, for a total of 24 lessons. Lessons were each 30 minutes in length. The teacher used a 'listen-play' method of learning, with two bars of information so that the participant didn't get overwhelmed with the information given. The teaching focused on note accuracy, rhythm, tempo, dynamic accuracy and singing of the pieces. The repertoire consisted of three familiar pieces (well-known children's songs) and three original (non-familiar) songs.

Participants were required to practise daily for a minimum of 15 minutes, 5 days per week and were asked to keep a record using a practice logbook. In addition, each participant was given a CD with all six (three familiar and three unfamiliar) pieces recorded by the researcher and was asked to listen to it daily for 15 minutes, 7 days a week. The teacher clearly communicated practice expectations verbally and visually (on a practising sheet with an area for a student to check a box after completing a task) to the student as well as to a parent. All lessons were conducted on acoustic pianos in a private studio with one parent present. Each participant was required to own either an acoustic or electric piano for practising purposes.

Measures

In this study, practice logbooks and a survey were used to rate the children's music habits and engagement. Results from the CI subjects were compared to those of the 2 normal hearing subjects.

The practice logbook was completed daily (but on a weekly form) by the children and their parents. It included a practice chart (in which checkmarks indicated completion of an assigned

practice and/or listening task on each day), length of practice session (daily), and a rating of the quality of practice for each day (on a 3-point Likert scale using the symbols L, K and J). The quality of practice was entered twice: as self-assessed by the child as well as from the parent’s perspective. In addition, a survey was completed weekly by the parents. This form contained 5-point Likert scales to record parents’ impressions of their child’s practice quality and level of interest.

Results

The at-home piano practice expectation was a minimum of 15 minutes, 5 days per week. In addition, the children were asked to

listen to a pre-recorded CD with the music excerpts they were learning to play, for a minimum of 15 minutes a day, 7 days a week.

The practice and listening times are shown in shown in Table 1. Almost all of the children met the expectation of 5 days per week of practice; however, none of the children listened to the CD as much as requested. Two of the CI children practised on average slightly more than the 15 minutes expected, while the other three children (one CI and two NH) fell short of that goal. A comparison of the mean values for each group shows that the CI children invested more time practising per week (50% more time in terms of minutes per week), as well as listening to the CD (3.7 days per week compared to 3.0).

Table 1

Practice metrics for each participant and mean values for CI participants compared with normal hearing.

Practice metric							Group means	
	CI-1	CI-2	CI-3	NH-1	NH-2	CI	NH	
Days per week	4.8	5.3	5.0	5.2	5.7	5.1	5.4	
Minutes per week	69.5	37.3	58.0	40.0	33.4	54.9	36.7	
Minutes per session	16.1	8.0	16.6	6.5	7.6	13.6	7.1	
Listening (days per week)	4.0	2.6	4.5	NA	3.0	3.7	3.0	

The other survey parameters assessed the children’s overall interest and enjoyment in learning piano. The results (in Table 2) show a very positive response from the parents and children, indicating a high level of engagement and enthusiasm. The practice quality was rated by the children as well as their parents. The CI children and their parents responded similarly and very positively, with a noticeably higher mean value than the NH group (2.9 versus 2.4 on a 3-point Likert scale). The other parameters were rated by the parents only. These ratings were also high among both groups, with little difference between the two groups.

Table 2

Interest level metrics. Values shown are means from weekly forms.

Parameter*						Group means	
	CI-1	CI-2	CI-3	NH-1	NH-2	CI	NH
Practice quality (child opinion)	2.9	2.9	3.0	2.0	2.9	2.9	2.4
Practice quality (parent opinion)	2.8	2.8	3.0	2.3	2.6	2.9	2.4
Child seemed excited	4.7	4.4	4.0	4.6	4.6	4.4	4.6
Child sat at piano willingly	4.9	4.5	4.8	4.9	4.2	4.8	4.5
Child went to piano outside practice time	4.9	4.5	3.7	4.9	4.6	4.3	4.8

*Practice quality was rated on a 3-point Likert scale (3 = most positive), while the other parameters were rated on a 5-point Likert scale (5 = most positive)

By the end of the 24 lessons, the teacher reported that all CI students were able to play the six pieces they had to learn. They were also showing enjoyment and motivation at their lessons. Their diligence in practice and overall performance accomplishments were most strongly evident at a formal students’ recital in a concert hall, where the CI users played along with many other regular normal hearing students. Furthermore, according to the teacher, all parents reported increases in their children’s musical self-confidence, social interactions with peers, and singing within the home. Most surprising to parents was

that all of the CI students signed up for their school’s end-of-year talent show and performed in front of the whole school. The parents reported a positive correlation between social acceptance and piano lessons. It is also worth mentioning that at the end of the 24-week study, all CI students registered to continue their piano lessons.

A follow-up with the 3 CI children, 6 months after the end of the study, revealed that CI-1 is still continuing her piano lessons—both parents have some music training and are avid music lovers—although she was recently diagnosed with Usher

syndrome and is going blind. She performed at the International Day for People with Disabilities, a major event at the National Gallery of Canada that was organised by the Ministry of Justice. CI-3 also performed at the International Day for People with Disabilities. After the end of the study, she continued her piano lessons for a few months, but then stopped due to her daily tennis practices and her desire to become a tennis player. CI-2 continued piano lessons for 4 months after the end of the study, but then she stopped lessons due to her serious dedication to volleyball—both of her parents are sport professionals.

Conclusion

The purpose of this study was to gather information from three implant recipients that would reflect their experiences with regard to piano learning. More specifically, the study was designed to determine whether cochlear recipients would be engaged in and enjoy formal music activities. Results indicate that these children can be very motivated to learn to play the piano, at least in the early stages. More studies would be needed to find out what happens on the long run.

Undoubtedly, CI users' representations of music differ substantially from those of hearing individuals. For congenitally deaf children with cochlear implants, the pleasure derived from music probably comes more from its rhythm. It is obvious that CI children have an interest in music making, but this level of enjoyment raised interesting questions about the aesthetic experiences these children might have, since their perceptual accuracy for particular musical features is not the same as those of children with normal hearing. Future studies could try to establish the particularity of these children's abstract representation of music.

Note: This research was approved by the Office of Research Ethics and Integrity at the University of Ottawa. Experiments were undertaken with the understanding and written consent of each subject and their parent or guardian.

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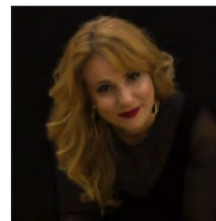
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