Department of Architecture, Design & Media Technology
Aalborg University
cyanhttp://www.aau.dk

Title:
MuCIcal Adventures: Using Virtual Reality as a Musical Training Program

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Participant(s):
Emil Sønderskov Hansen
Signe Marie Kromann Kristiansen

Supervisor(s):
Ali Adjorlu
Stefania Serafin

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Abstract:

CI-users have difficulties in perceiving primary elements of music such as timbre and pitch, and CI users have described listening to music as sounding "unpleasant" and "mechanical". Additionally, CI-users have trouble localizing the direction of sound. Musical Training Programs (MTPs) have been created to improve CI users music perception with promising results. Virtual reality (VR) utilizing head mounted displays (HMDs) has been used successfully for training and teaching in other contexts. This project aims to explore the potential of VR based MTPs. A prototype was developed containing three levels for training sound localization, melody recognition and musical instrument identification. The initial design was based on the professional experience of audiologists from 'Center for Hørelse og Balance' at Rigshospitalet. Three CI users tested the initial prototype through a user-centered design approach. Based on their feedback, the prototype was adjusted and expanded. An updated version was tested at the CoolHear Workshop and Soundcluster Workshop, leading to additional adjustments. The final version of the prototype was tested through a diary study over the course of one week with one participant from the user-centered design evaluation. The prototype was tested five times in total. Quantitative data was gathered through post training questionnaires, time used and incorrect answers made. Qualitative data was gathered through a semi-structured interview. Results indicated that the participant felt confident in the melody recognition tasks while sound localization was deemed the most difficult. However, the participant felt motivated to continue training in order to improve on this ability. Overall, utilizing VR as a platform for MTPs does show potential for this participant, but it cannot be determined whether other CI users would benefit from the prototype. Further research comparing the VR MTP to MTPs on other platforms, such as mobile devices, is necessary to determine the benefits of VR based MTPs.

Contents

1 Introduction

Cochlear implants (CI) are advanced systems used for individuals with complete or severe hearing loss to regain functional hearing by stimulating the auditory nerve with electric current [44]. Users of CIs can expect to recover recognition of speech and the ability to differentiate sounds, however, the degree of recovery differs and requires intensive training [6]. A study by Friesen *et al.* tested CI users' ability to recognize speech and found poor-performing CI users to approach around 80% of speech recognition in quiet environments, while others up to 100% [11].
Since CIs have mainly been used for recovering speech and awareness of environmental sounds [36], music perception and enjoyment has not been explored to the same degree [16], and many CI users have difficulties with various tasks within music listening [15]. Therefore, focusing on improving the listening experience for CI users could be beneficial for gaining a more pleasant listening experience with music.

Many studies have shown CI users can recognize rhythm on a comparable level as NH individuals [28] [25] [33] [19] [22]. However, CI users have difficulties perceiving some of the primary elements of music, such as pitch [21]. Since melodies are made of high and low-pitched notes played after each other, correctly perceiving pitch is essential when listening to melodies. A study by Looi *et al.* comparing CI users to hearing aid (HA) users found CI users to be unable to differentiate pitches which are a quarter octave apart [31]. As a result of this disrupted perception of pitch and other factors, CI users are only able to correctly identify approximately 19% of melodies [33], and generally tend to have more difficulties compared to NH listeners [43] [19].

Timbre refers to the attributes of a sound which causes sounds of similar frequency and amplitude to be perceived as dissimilar and can also be referred to as the tone color [33]. In order to differentiate musical instruments, it is important to be able to perceive timbre correctly [21]. A study by Kim *et al.* testing timbre perception in adolescents with CIs found the participants with CIs to recognize musical instruments notably less compared to NH individuals [26]. Additionally, more percussive instruments (e.g. piano) with a faster attack were found to be easier recognizable for individuals with CI [26].

For NH individuals, binaural hearing gives the advantage of sound localization [29]. The identification of a sounds location occurs through the brain's interpretation of perceived differences in arrival time, frequency, and intensity when arriving at each ear [37]. Unilateral CI users (i.e. individuals with a CI on only one ear) report having difficulties with localisation of sounds [29]. Bilateral users (i.e. users with CIs on both ears) generally have fewer difficulties with localisation of sounds compared to unilateral users [29], however, they still have trouble with fusing sounds from both ears [42].

When describing what music sounds like with CI, users have recollected having issues with distinguishing whether music is in- or out-of-tune [21]. Some of the words CI users have used for their perception of music include "tinny" [21], "mechanical" [34] and "unpleasant" [34], and music appreciation scores are generally lower compared to that of normal-hearing (NH) individuals [4] [36], especially compared to postlingual users [16] [35].

Based on the complications CI users have with music perception abilities and a lower music appreciation, music training programs (MTPs) have been developed for various music listening tasks. Prior MTPs have been designed in both DVD-format [32], tablet [27], and web applications [7]. However, the potential for virtual reality (VR) as a platfrom for a MTP is still unexplored to our knowledge. Other learning and training VR applications have proven effective in both enjoyment, engagement and results [2] [1] [40] [1]. Specifically for CI users, utilizing spatial audio in a VR environment [37] potentially be beneficial for sound localization tasks as well.

This paper explores the potential for Virtual Reality to be used as a platform for the gamification of music training for individuals with CIs. A prototype based on related research and a user-centered design approach will be presented and evaluated.

2 Related Work

2.1 Music training for CI-users

Whether CI-users (including both pre- and postlingual) listen to music and how often might have an influence on both their abilities in recognizing melodies [19] and their rating of music appreciation [35]. Appreciation of music has almost exclusively been researched on postlingual CI-users [34] [13]. However, some studies have shown a significant difference in music appreciation between pre- and postlingual CI users [4], where prelingual users ranked their musical appreciation slightly higher. In identifying musical instruments, the same prelingual users scored slightly lower than postlingual users [4]. It should be taken into account that there is a general lack of research in comparing the differences in music appreciation, music listening, and instrument identification for pre- versus postlingual CI users [4] [35].

Previous research in music training has included timbre recognition [14], identification of musical instruments [7], pitch perception [18], melodic contour identification (MCI) [19] and song recognition [43] among others, where CI users abilities in various musical aspects improved over time. However, Gfeller *et al.* argues that music "started to sound pleasant only after many hours of focused, attentive practice, usually over many months or even years." [12], where it was described as sounding "odd or like noise" [12] prior to extensive listening training.
Since several areas of MTPs have been explored, the specific areas of interests in music listening for CI users might be an area of interest. In a study by Looi & She, 64 CI users ranked the three most important listening skills for a training program as a) recognizing foreknown tunes prior to implantation, b) recognizing commonly known tunes and c) recognizing commonly known instruments [32]. Although the study was executed on postlingual participants (thereby the wish of recognizing familiar tunes), the wish of being able to identify common tunes and instruments could potentially be beneficial for prelingual CI users as well.

Although studies show CI users have difficulties recognizing melodies and foreknown songs, some users still enjoy listening to music [35], which applies for both pre- and postlingual CI users [35]. However, postlingual users tend to compare their current listening experience to the one they had prior to hearing loss (HL) [32] [16] [33], reducing some users' enjoyment of music drastically [36].

2.2 Gamifying Music Training Programs

The design of the prototype presented in this paper will be inspired by the model for design of serious games in therapy context proposed by Cano *et al.* [5]. The proposed model integrates the relationship between player-therapy, game-therapy, and player-game. The player-therapy relationship comprises the different therapeutic activities in the game aimed to train the player (such as sound localisation, musical instrument discrimination and melody recognition) [5]. The therapy-game relationship on the other hand covers the game-mechanics and tasks created to engage the player in the game (such as feedback and rewards) [5]. Lastly the player-game relationship comprises the elements in which the game gathers information about the players performance (i.e. measuring variables such as time and amount of incorrect answers) [5]. Storing information about the players performance can also be beneficial and time-saving for an audiologist when tracking progress [45]. Taking these relationships into account when developing the prototype proposed in this paper should aid in engaging and immersing the player not only in the game, but also in the therapy itself. The model proposed in [5] is developed targeted for children, however, the model contributed in another study presenting a MTP targeted for adult users of CI [27].

2.3 Virtual Reality for Rehabilitation and Training

As mentioned in section 1, prior MTPs have been made in various formats, including apps and DVDs. However, utilizing VR for music training with cochlear implant users is still an unexplored field of research to our knowledge. Other VR applications for therapy, learning, and training within various subjects have proven successful in user performance [2] [1] and level of enjoyment [40] [1]. Being in immersive virtual environments can give users the sense of feeling present in another world, affecting their motivation [40], engagement [1] [40] and learning experience [1]. Studies comparing participants' performance and emotional state in VR have also showed better results compared to participants performing the same tasks in normal (real-world) conditions [40] [1].

In a study by Sechler *et al.* a VR-based sound localisation testing environment was implemented and used for testing CI users' performance for localisation of sound. The study included 4 bilateral CI users and 9 NH people and found NH individuals to perform approximately 3 times better than CI users in the environment [37]. Furthermore, research indicates sound localisation to be improved through training with audio-visual tasks [42]. In a virtual experience, spatial audio is an important channel of information [3], and by tracking of head position through an HMD, it is possible to create a more realistic sound environment [37]. This is especially important when training and testing ability to localize sound. The level of realism in a VR application's audio influences its level of immersion as well [2].

Based on results from previous VR environments with the purpose of training various skills, a VR based MTP could potentially increase the enjoyment, engagement and motivation for CI users while completing musical perception tasks.

Vertigo and Imbalance with CI

'Center for Balance og Hørelse' at Rigshospitalet mentions increased imbalance and vertigo as a potential side effect after getting CI [6]. A study by Steenerson *et al.* determining the incidence of vertigo in patients after getting cochlear implants found new symptoms of imbalance and vertigo (i.e. feeling as if you or sorrounding environment is moving or spinning around you)to appear in 34% of patients after surgery [39]. Vertigo and imbalance are known side-effects of vestibular impairment [10]. The impairment CI users can have in the vestibular system seems to be independent from the cause of deafness and is oftentimes caused by trauma on the system from the operation, and to a small degree, the electrical stimulation from the implant itself [10].

When using head-mounted displays (HMDs) with VR, different side-effects can occur. The side-effects can be divided into two main categories: cybersickness and aftereffects [24]. Cybersickness includes different symptoms such as vomiting, nausea, eye-straining, disorientation, and vertigo, and occurs when real-life motion does not correspond with the motion in the HMD [24]. Aftereffects include symptoms such as disturbed locomotion and fatigue [24]. As CI users are already prone to vertigo and imbalance they might be more likely to experience these side-effects, which could potentially be an obstacle while being in a virtual environment. Therefore, possible cybersickness and aftereffects should be taken into account and measured when testing VR applications on CI users.

3 Initial Prototype

The initial design of the application was based on related work from previous MTPs (see section 2.1). A level for musical instrument identification inspired by Driscoll [7] and a level for sound localization inspired by Sechler *et al.* [37] was designed. Furthermore, the design was inspired by the model for design of serious games in therapy context (see section 2.2), implementing both therapeutic elements, and feedback on performance. This resulted in a initial, high-fidelity prototype containing a level for sound localization and one for musical instrument identification. Additionally, several audiologists from 'Center for Hørelse og Balance' at Rigshospitalet participated in a brainstorming workshop, expressing the needs and complications their CI patients have with listening to music.

3.1 Level Design

The initial prototype consisted of two levels: one for sound localization and one for identification of musical instruments. Both levels were presented in a VR environment, assimilating a real-world room.
The player was able to move back and forth, as well as rotate, by using the joystick. A laser pointer could be activated once the user placed their thumb on the joystick of the right controller, and was used for selecting objects. Once the player hovered over an interactive object, it changed color, and the user was able to select the object by pressing the button placed by their index finger on the back of the right controller.

Sound Localization

In the sound localization level the player was unable to move, and was only able to use the rotate function. A radio was placed in each corner of the room, and an instrument played from a random position once the user pressed the 'play'-button. By rotating using the snap-rotate function on the left controller, the player was required to guess the location of the sound by clicking on the radio they selected as the source.

Musical instrument identification

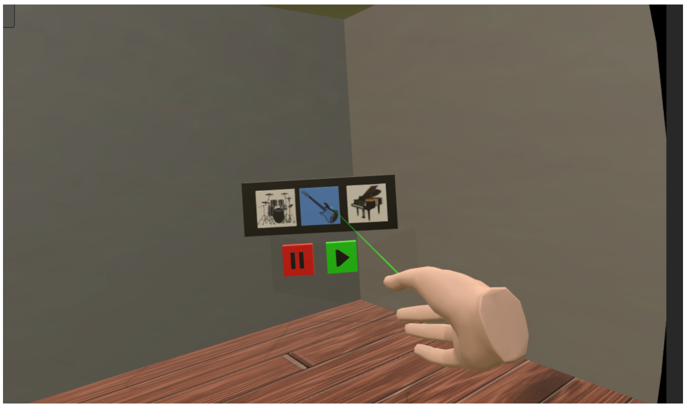

Figure 1: Design of the musical instrument identification level in the first prototype

The level of musical instrument identification included four stations placed in each corner of the virtual room, similarly to the sound localization level. Each corner contained panel with three pictures of three different instruments, as well as one 'play' and one 'pause' button (see figure 1). The player was able to move around the environment. A distance attenuation (i.e. decreasing volume depended on the distance to the player) was added to the audio sources in the level allowed for each station to only be audible while the user stood in front of a station, meaning they were unable to hear music from two different sources at the same time. The instruments playing from each station were randomized once the 'start' button had been pressed. This applied to all groups of instruments in each corner.

3.2 Method

The initial version of the prototype was tested on three CI users between 21 and 65 years of age.
Participant one was 21 years old, female, bilateral and had the first CI operated at the age of two, the second one at the age of five. Participant two was 65 years old, female, unilateral and had been a CI user for six months. Participant three was 51 years old, male, unilateral and got their CI 26 years prior.
The prototype was tested through a user-centered design approach by letting the three participants from the target group express their wishes and expectations for a VR-based MTP. Their feedback was used as a way to form a design based on the perspective of the end-users. Explicitly, the approach had the purpose of improving visuals, functionalities and usability, as well as brainstorming ideas for additional levels and further development of the current version. Whether the current difficulty level was appropriate, was measured as well.
The participants tested the prototype using the Oculus Quest 1 HMD. All participants were asked to try the prototype for as long as they wished. Prior to testing, data concerning demographics, subjective perception of listening to music and details of the participant's CI was collected through a questionnaire. After testing, the participants were asked to fill out a questionnaire concerning their experience. It consisted of four questions regarding entertainment value and difficulty level for each level, ranked through four items ranked in a likert scale. Additionally, they were asked which instruments they were able to hear, how difficult they were to identify and whether they were pleasant or unpleasant listening to. An SSQ scale measuring cybersickness (see section 2.3) was filled out as well [23].

A follow up semi-structured interview was executed by one test conductor as the final part of the evaluation, where participants were asked to elaborate on their feelings towards the product and ideas for further development.
Both the quantitative and qualitative data collected from the test results were used for the sub-sequential iterations and design of the prototype.

3.3 Results

The results from the SSQ scale showed that two out of three participants had no side effects from using VR. The remaining participant had minor discomforts concerning tiredness and fullness of head, but no issues in the remaining categories.

The four Likert items showed the following results for each participant:

1. **"I found it difficult to hear which instruments were playing in level 1."**
   Participant 1: 'neither agree nor disagree' (3/5)
   Participant 2: 'strongly agree' (5/5)
   Participant 3: 'strongly agree' (5/5)

2. **"I found it difficult to localize the direction of the instruments playing in level 2."**
   Participant 1: 'neither agree nor disagree' (3/5)
   Participant 2: 'agree' (4/5)
   Participant 3: 'strongly agree' (5/5)

3. **"I thought level 1 was fun to play."**
   Participant 1: 'strongly agree' (5/5)
   Participant 2: 'agree' (4/5)
   Participant 3: 'strongly agree' (5/5)

4. **"I thought level 2 was fun to play."**
   Participant 1: 'strongly agree' (5/5)
   Participant 2: 'neither agree nor disagree' (3/5)
   Participant 3: 'strongly agree' (5/5)

From the interview, feedback concerning the current difficulty level, visual design, audio and ideas for further developments was gathered as qualitative elaborations from the Likert items.
Overall, the participants found it relatively easy to navigate in the prototype. They had to practice a bit and get used to being in the environment, but quickly learned how to use it. Two out of three participants found the visuals good as is, while the remaining would like more visual feedback for confirming their interactions. The same participants also mentioned liking the 3D instruments used for visual feedback, but would like more visual feedback for confirming their interactions with objects. Implementing several difficulty levels was suggested as well, making it easier to adjust for individual CI users. All participants answered the drums were the easiest to recognize and most pleasurable listening to. Two participants mentioned it being an advantage to stream the audio directly into their CI instead of wearing headphones.
Concerning further development, all participants were asked to express their wants and needs for future levels. One participant suggested a level for training their listening abilities while having a conversation in a room with background noise and/or music (the "cocktail party effect" [30]). The two remaining participants wished for a level concerning melody recognition, one of them suggesting being able to choose among different instruments playing the same melody.

4 Second Prototype

Based on results from the user-centered design workshop, the initial prototype was adjusted, resulting in a second version of the prototype. The navigation functions were not adjusted. However, the level design of mainly the musical instrument identification level was altered, as well as the general design of the virtual rooms for both levels. Although one participant wished for a level focusing on listening to a conversation while in a loud surrounding, this feature was considered out of scope for an MTP, since it focuses on speech rather than music. Three difficulty levels (easy, normal and hard) were implemented for each level. After completion of each level, the player receives feedback concerning their performance (time spent and errors made).
The drums were removed completely from the application, since the test participants had no issues with recognizing them (similar to results from prior MTPs, as described in sections 2.1), indicating training this ability might be less necessary compared to other instruments.
A room functioning as a menu was added, letting the player choose between a tutorial, level one or level two, and the possibility to access their scoreboard containing the progress from each level completion (time and number of errors).

4.1 Level Design

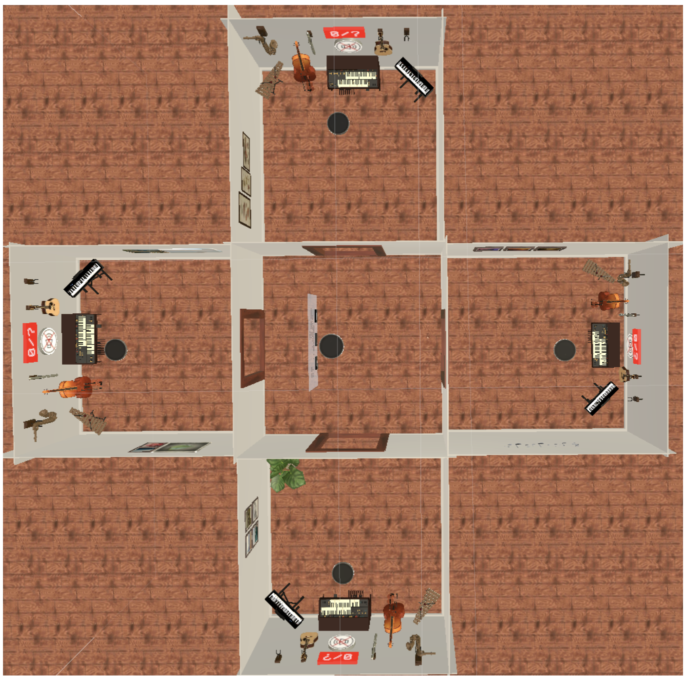

Figure 2: Overview of the separate rooms in the musical instrument identification level from the second prototype

The level for musical instrument identification lets the player enter four different rooms, all containing various 3D models of instruments (see figure 2). After starting the level, the player chooses a difficulty (easy, medium or hard) to begin. As in the first edition of the prototype, which instruments are playing and visible is randomized for each station (now placed in four different rooms rather than corners) once the player starts the level.
By pressing a mute/unmute button placed on the wall

behind the instruments, a melody containing either two, three or four instruments (based on the difficulty level) playing simultaneously. While the mute button is enabled, an animation of notes emitting from it plays, and will stop again should the player press the mute button again. The player chooses an instrument by hovering over it and clicking the 'select'-button, as described in section 8.1. While the laser pointer is hovering on an instrument, the instrument glows to give visual feedback of the player being able to interact with it. Once selected, the instrument will either light up in a green (correct answer) or red color (incorrect answer). An animation of notes emitting is played as well, if the player chooses a correct instrument.

4.2 Method

The prototype was informally tested using a pilot test during the CoolHear Workshop [1]. Since the design of the musical instrument identification level had been altered, feedback was gathered concerning the visuals and functionality. Whether participants found the purpose of the levels intuitive was noted as well.

Several Audiologists, including those from Rigshospitalets 'Center for Hørelse og Balance', attended the workshop and tested the prototype. However, no CI-users Besides the pilot test, they commented on the sound, music and purposes for both levels, in regards to whether they, including the difficulty levels, were suitable for CI users. These professional opinions were gathered using the think-aloud method [41] and a non-participatory observation methods during gameplay and the possibility of asking questions afterwards.

4.3 Results

During the test, it was noted most participants found it difficult to activate the laser pointer, since they tended to remove their thumb from the joystick. Additionally, the inability to move and rotate by using both controllers seemed confusing.
Most participants did not finish the musical instrument identification level. The participants did not feel the need to enter each station room. Some participants were unsure how many instruments were playing at the same time as well, meaning they left stations without knowing they were to choose one or more additional instruments before receiving feedback for completing the task.

[1]https://melcph.create.aau.dk/coolhear-workshop/

Some participants tried to start the levels before choosing a difficulty, since they were able to move and rotate before starting the level. This led to confusion, since they were unable to hear any music when they thought the game had started.
One audiologist asked whether CI users were able to solve the sound localization task, and was concerned whether it was too difficult to differentiate between three sources to six sources. In general, the difficulty of both levels was deemed too high by most participants, even though they consisted of NH audiologists. Many were unsure of the exact number of instruments playing, noting that this would exceed the listening capabilities of CI users, thus making them unable to complete the level.

5 Final Prototype

The final version of the prototype, with the title 'MuCI-cal Adventures', consists of three levels based on prior evaluations.

1. Level 1: Sound localization
2. Level 2: Musical instrument identification
3. Level 3: Melody recognition

The first two levels were altered based on results from the second evaluation (see section 4). Rather than having four different rooms for each station in level two, a UI with a 'replay' and 'back to menu' button was implemented, meaning users only have to identify one set of instrument to complete the level. The difficulty levels were changed to have either one (easy), two (normal), or three (hard) instruments playing simultaneously.
In level one, the number of possible sources of audio was reduced meaning the player could either choose between two (easy), three (normal), or four (hard) origins. Similarly to level two, the player can press a 'replay' button immediately rather than being required to complete the task several times to finish the level.
A new third level was added to the prototype where the user is able to train recognition of melodies. This level was added to train the CI users disrupt perception of pitch (see section 1), which makes it difficult for them to identify and differentiate melodies.
When designing the music for the prototype it was important to assess whether the different levels of difficulty in the game (i.e. the combination of instruments and the alterations of melodies) matched the

abilities of a CI-user. To do so all music in the prototype was run through a Cochlear Implant and Hearing Loss simulator called Angelsim[2]. All the audio was simulated and small changes were made to the music (e.g. changing more notes from the melodies). Besides using the simulations for assessing the difficulty, all the simulated audio was also saved and added to the prototype. A button for changing all of the audio to the 'simulated version' was added, enabling NH individuals to use the prototype and hear it as a CI user would. A study by Embøl *et al.* suggests a virtual experience with simulated audio can help create empathy from parents and NH peers to CI users. With this in mind, this addition might add another use case for the prototype [8].

5.1 Technical Description

The prototype was designed and implemented using the Unity[3] game engine.

Music Implementation

The Digital Audio Workstation (DAW) Logic Pro X[4] was used for creating the music in the prototype. The DAW offers an extensive suite of software instruments emulating various musical instruments. Based on prior MTPs, the implemented instruments represented the four music families (brass, woodwind, strings and percussion) [7] [14] [31] [19] [17] [9].
The instruments used in the game audio were:

1. Woodwind: flute, saxophone and organ
2. Strings: cello and violin, guitar and bass
3. Percussion: piano and xylophone
4. Brass: trumpet

FMOD and Steam Audio Integration

The middleware FMOD[5] with Steam Audio integration[6] was used for rendering 3D positional audio in the game. The Steam Audio Specialization plugin includes Steam Audio's own built-in Head-Related Transfer Function (HRTF) which allows the user to perceive both the height of the audio source and whether the source is in front or behind. In FMOD the audio files are organised in different events, which are placed inside of a soundbank. The soundbank is then exported to be dynamically controlled using FMOD methods and components within Unity. In Unity the different events are attached to game objects placing the audio within the 3D scene.

VR Implementation

For easy implementation of VR the prototype was developed utilizing VRTK's Tilia Packages[7]. VRTK provides a range of prefabs for easy implementation of different interactions. For movement the Axis Move prefab was used enabling the user to move and rotate using the joystick on each controller. The Object Pointer prefab was used to implement a laser pointer from the hand of the player. The laser pointer enables to player to choose between different options from a distance throughout the game. The laser pointer is set to be always active, as choosing different options from a distance is the only interaction required in the game. Furthermore, the results from testing the second prototype (see section **??**) found activating the laser pointer too confusing for the pariticipants. The prototype was exported as an Android Application Package and loaded to an Oculus Quest.

Data gathering

To track the participants performance which is part of gamifying MTPs (see section 2.2), the prototype was developed to gather data about the following:

- Amount of times used on each task
- Amount of incorrect answers
- The chosen difficulty level
- The instruments which were played

The data was gathered utilizing Unity's PlayerPrefs class which can store strings, floats and integers between sessions. PlayerPrefs stores the data in an xml file on the device, which can be retrieved to analyse the data afterwards. PlayerPrefs was also used to implement a scoreboard for the user to track his/her own performance between sessions.

[2] http://www.tigerspeech.com/tst$_{t}igercis.html$
[3] unity.com
[4] https://www.apple.com/logic-pro/
[5] https://www.fmod.com/
[6] https://valvesoftware.github.io/steam-audio/doc/fmod/index.html
[7] https://www.vrtk.io/tilia.html

5.2 Level Design

Each level consists of one single room. The player is able to control the avatar using the joystick on the controller. In level one, the player is able to rotate while 'locked' in position in the center of the room, whereas they are able to both rotate and move around in levels two and three using. After completing a level, a UI panel appears in front of the player, informing them of finishing the level and giving them the possibility to either replay or go back to the main menu by pressing one of the two buttons placed on the UI (see figure 3).

Figure 3: Design of the sound localization level in the final prototype

Level 1: Sound Localization

The sound localization level was divided into sounds coming from two (easy difficulty), three (normal difficulty), or four (hard difficulty) locations, shown as radios, placed in the virtual environment. The user is able to identify the location of the sound as the sound specialization (see section 5.1) alters the sound based on the position and rotation of the HMD. Once they press a radio, it will turn either red (incorrect answer) or green (correct answer). If they answer correctly, an animation of notes will emit from the radio as well.

Level 2: Musical Instrument Identification

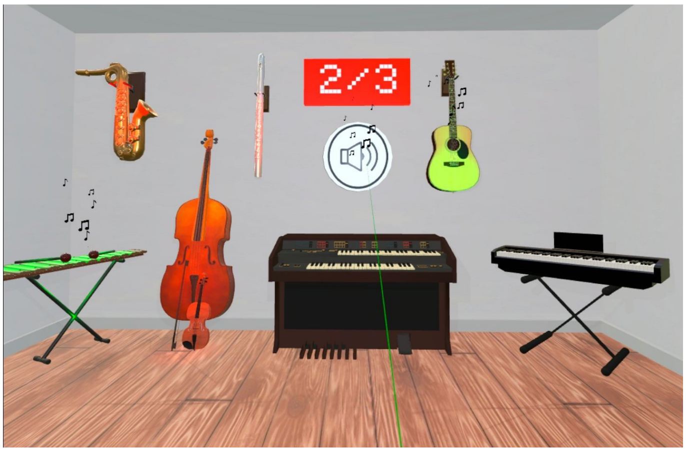

Figure 4: Design of the sound localization level in the final prototype

Identification of musical instruments consisted of melodies being played from either one, two, or three instruments. Each instrument is assigned its own melody, which plays well with melodies from the other instruments. A mute/unmute button is placed in front of the player, as well as a scoreboard above indicating how many instruments are playing in the melody; either one, two, or three, according to the chosen difficulty level. The number of instruments the player can choose from is limited according to the difficulty level, meaning either four, five or seven 3D instruments are visible in the scene. As in level one, the instruments will turn either green or red, depending on their answer, and choosing a correct instrument will result in notes emitting from the instrument as well.

Level 3: Melody Recognition

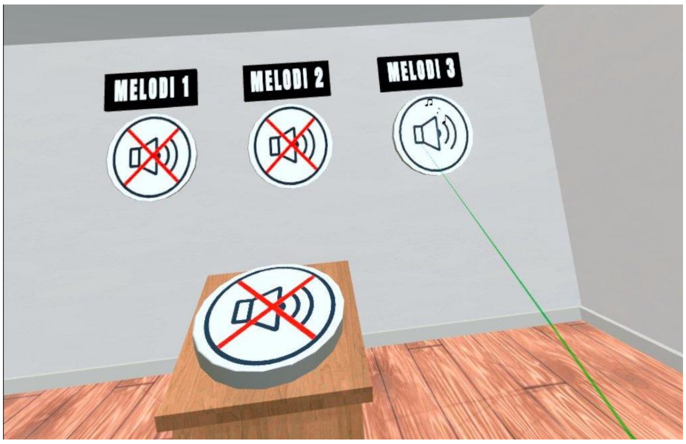

Figure 5: Design of the sound localization level in the final prototype

The level for melody recognition consisted of altered versions of the melody "Happy Birthday" (inspired by a previous study by Looi *et al.*) . Every other tone was changed either one octave, half of an octave or a quarter of an octave, based on the chosen difficulty level. One mute/unmute button is placed on a podium in front of the player, as well as three similar button on the wall behind. While a button is activated (i.e. unmuted) and starts its respective melody, a note animation emits from it. The player can listen to each melody, compare them and then choose the one they think matches with the original.

5.3 Method

Prior to the final evaluation, the prototype was presented as a part of a demo playground at the Future Sound Forum by Danish Sound Cluster[8]. Several audio engineers and students in this field of work attended the event and informally tested the prototype. Similar to the evaluation of the second prototype (see section 4), a think-aloud method was used along with non-participatory observations. The goal of the preliminary test was to confirm whether the visuals and functionalities had improved after adjustments were made from the second to the final prototype. The participants did not seem to have any issues using the prototype, and no major functionality issues were observed. Based on these results, the prototype was deemed acceptable for final testing without further changes.

The final version of the prototype was tested on one of the CI users who participated in the first iteration as well. The participant was 51 years old male, unilateral and had been a CI user for 26 years. Additionally, he used to be a classical pianist prior to losing his hearing. Although he did not play the piano for approximately 20 years while having a CI, he still listened to music often (see notes in appendix 8.1).

The final evaluation of the prototype consisted of a diary study[20], including a questionnaire and a follow-up interview. The test participant was given an HMD for one week, where he was asked to play as many times as he would like. The participant was asked to answer a questionnaire following each session. The questionnaire included following items:

1. System Usability Scale (SUS)
2. Three Likert items, ranking his physical state (from one to five/'strongly disagree' to 'strongly agree'), including whether he felt tiredness, fullness of head and/or being uncomfortable by wearing HMD and CI at the same time.
3. One closed-ended question asking what levels he played
4. Five open-ended questions concerning his experience
5. Two Likert items, ranking his entertainment value and whether he wanted to play the game again in the future (both from one to five/'strongly disagree' to 'strongly agree')

The follow-up semi-structured interview consisted of open-ended questions regarding his opinions on the overall experience, entertainment and replay value, further development and the potential of using the application as an MTP for a longer period of time. Additionally, he was asked whether he could imagine the prototype functioning on other platforms (apps, video games etc.), and what could be improved in each level.

5.4 Results

The participant used the prototype five times over the course of one week. The first and the fifth (i.e. the last) time the participant used it was conducted as a non-participatory observation with two test conductors present. The other three of these were at home.

Questionnaire Results

Seven out of the ten questions in the SUS part of the questionnaire were answered with the highest score possible (5/5). The question “I think that I would like to use this system frequently” had a lower average rating since it was rated two out of five after the first, second and fourth sessions and three out of five after the third and fifth session. To the question "I felt very confident using the system", the participant answered 'agree' (4/5) in all sessions. In session three, the participant answered 'disagree' (4/5) to the question "I found the system very awkward to use" and 'strongly disagree' (5/5) in the four remaining sessions.

The SUS scores from the first four sessions were 90/100 and 92.5/100 for the fifth session (all categorized as a 'best imaginable' score estimate).

The participant answered 'disagree' three out of five times, 'strongly disagree' one time and 'neither agree nor disagree' one time to the question concerning whether it was uncomfortable wearing an HMD with

[8] https://danishsoundcluster.dk/the-future-sound-forum/

CI. The remaining questions in this category were answered with 'strongly disagree', except for one session where the participant answered 'neither agree nor disagree' in regards to his level of tiredness.

Level one (sound localization) was described as the most difficult in all sessions. The participant answered level three (melody recognition) was the most entertaining in sessions one, two, three and four, whereas level two (instrument identification) was equally entertaining during session two. Level one (sound localization) was described as the most entertaining in session five with the participant describing it as being more difficult compared to the previous session, resulting in them being more motivated.
The participant answered 'agree' to whether he found the game easier this session compared to the previous after sessions three, four and five and 'neither agree nor disagree' after session two. The answer to this question was disregarded in session one, since it was the first time the participant played the final version of the prototype, meaning he was unable to compare it with a previous session.
To the question asking whether the participant wanted to play the game again, he answered 'agree' after sessions one, three and four, and 'strongly agree' after sessions two and five.

Measurements of Time and Incorrect Answers
As mentioned in section 5.1 data about the performance was gathered by measuring which difficulty level the participant plays along with time used in seconds and amount of wrong answers. Non-parametric Spearman calculations were performed to examine any correlations in the data as the assumption for the data being parametric was not met [38]. A p-value of ($p \leq 0.05$) will be considered as significant.

The participant played the musical instrument identification level a total of 59 times (19 times on easy difficulty, 15 times on medium difficulty and 20 times on hard difficulty).
Number of times played was correlated with the amount of time used, using Spearman's ranked correlation coefficient. No significant correlation ($p \leq 0.05$) was found when measured from all collected data, i.e. without differentiating between results in each difficulty level. However, when isolating data for each level of difficulty, there was a significant moderate negative correlation (easy: r = -0.5695 , normal: r = -0.5887 , hard: r = -0.4743 - see figure 6). Increasing the difficulty from easy to hard showed a slight decrease in the negative correlation. When correlating number of times played with amount of incorrect answer, no significant correlation was found for all the data and difficulty levels easy and normal. However, a significant negative correlation in the hard difficulty level (r = -0.4580 - see figure 7).

Instrument	Time	Errors
Percussion (n=18)	13.72 s. (σ = 9.26)	0.5 (σ=0.6)
Woodwind (n=21)	23.23 s. (σ=22.82)	1.1 (σ=1.1)
Brass (n=7)	21.00 s. (σ=10.61)	1.14 (σ=1.7)
String (n=14)	22.71 s. (σ=23.9)	0.4 (σ=0.8)

Table 1: Musical instrument identification mean values for each instrument family.

The amount of time used and incorrect answers appeared to be influenced by the type of instrument playing, since percussion instruments had a significantly lower average compared to the remaining instruments (see table 1).

Difficulty	Time	Errors
Easy (n=20)	6.70 s. (σ=3.9)	0.05 (σ = 0.2)
Medium (n=20)	16.95 s. (σ=5.9)	0.40 (σ=0.6)
Hard (n=19)	33.05 s. (σ=19.6)	1.78 (σ=1.5)
All (n=59)	18.7 s. (σ=15.9)	0.7 (σ=1.2)

Table 2: Musical instrument identification mean values for time used and incorrect answers in each level of difficulty.

The participant played the sound localization level a total of 38 times (16 times on easy difficulty, 12 times on medium difficulty and 10 times on hard difficulty).
Number of times played was correlated with amount of time used showed, which showed no significant correlation when measured from all collected data. For easy and medium difficulty there was no significant correlation, however, there was a significant strong positive correlation in the hard difficulty level (r = 0.8424), meaning the amount of time used for completing the level increased slightly the more the participant played (see figure 8). There was no significant negative correlation between amount of incorrect answers and number of times played (see figure 9).

Difficulty	Time	Errors
Easy (n=16)	19.56 s. (σ=5.9)	0.38 (σ=0.6)
Medium (n=12)	25.00 s. (σ=7.3)	0.75 (σ=0.9)
Hard (n=10)	28.50 s. (σ=12.9)	0.80 (σ=1.03)
All (n=38)	23.60 s. (σ=9.2)	0.60 (σ=0.8)

Table 3: Sound localization mean values for time used and incorrect answers in each level of difficulty.

The participant played the melody recognition level a total of 54 times. The participant played the level 19 times on easy difficulty, 15 times on medium difficulty and 20 times on hard difficulty.
Number of times played was correlated with amount of time, which showed a significant moderate negative correlation for easy and medium difficulty (easy: r = -0.5766 , normal: r = -0.5979 - see figure 6). Number of times played correlated with amount of incorrect answers showed a significant moderate negative correlation only for hard difficulty (r = -0.5414) (see figure 11).

Difficulty	Time	Errors
Easy (n=19)	24.78 s. (σ=20.6)	0.11 (σ=0.3)
Medium (n=15)	29.26 s. (σ=27.5)	0.60 (σ=1.8)
Hard (n=20)	28.35 s. (σ=9.8)	0.45 (σ=0.7)
All (n=54)	27.35 s. (σ=19.5)	0.37 (σ=1.1)

Table 4: Melody recognition mean values for time used and incorrect answers in each level of difficulty.

Interview

The transcript of the final evaluation interview was divided in to three different categories:

1. Overall Experience and Opinions
2. Feedback on the Current Version of the Prototype
3. Further Development and Potential

For each of these categories, the following are key points gathered from quotations within these subjects. The full transcript can be found in appendix section 8.2.

Overall Experience and Opinions

The participant generally felt as if he got better at the game gradually. He started paying attention to how training and potentially improving the tasks in the prototype could influence his listening habits in the real world. Training sound localization was mentioned specifically, since the participant had "given up" on learning to identify the direction of sounds. However, while playing this level, he felt a difference in perception of the music according to his head rotation. Although he had to guess when playing at normal or hard difficulty level, he did feel as if he were able to detect the sound localization at the easy difficulty level.
The participant mentions losing track of time, and feeling as being in a "new world" when using the prototype, making one "concentrate in a completely different way compared to playing on your phone". However, he also felt using the prototype was more like completing a task i.e. training, rather than playing a game.

Feedback on the Current Version of the Prototype

The participant described a desire for having more variation in the melodies in the prototype. In level two (musical instrument identification) the participant felt as if he were able to "cheat" by recognizing the varieties in the instrument's individual melodies, rather than identifying the timbre of the instrument. In level three the participant missed having more melodies to choose from.
The difficulty of level two (musical instrument identification) was deemed appropriate while either one (easy) or two (normal) instruments were playing simultaneously. However, at the 'hard' difficulty level, the participant found it "hard to hear the third instrument", and was unsure whether a third instrument was playing at all.
The participants mentions the volume of the instruments to differ too much (especially the organ), and feels as some of the instruments sounds 'unnatural' to him (especially piano and guitar).

Further Development and Potential

The participant suggested having the possibility to choose a musical genre, then having three melodies to choose from in this category. Identifying instruments within a specific instrument family (e.g. woodwind, percussion etc.), thereby learning to differentiate sounds, was suggested as well.
It was suggested adding more game-like features, such as winning trophies and getting a notification once the player beats his highscore, to make the application more entertaining and appear less as training.

The participant saw potential in creating an edition of the prototype as a mobile application rather than VR, making it possible to e.g. play the game in the train. However, at the same time, he did not think he would use it this way, but rather scheduling training sessions at home. The participant also mentioned, in relation to losing track of time in VR, being distracted or notified by ones surrounding if using the prototype as a mobile application.

The participant mentioned that he was "very excited that someone was working with music for someone like them. I'd really like to be able to listen to some music again.". The participant told he "went from normal hearing to no hearing in 24 hours and four months after I got CI.". When the participant got his CI, he already knew "how everything is supposed to sound like", giving them a reference point for adjustments. Compared to his own experience, he could see potential for CI users with other backgrounds, using it for other tasks than music listening. For example, it was mentioned making a VR playground environment for prelingual children to learn common sounds (e.g. a bucket falling to the ground, a squeaking swing etc.), since he do not know how these objects "usually" sound like.

6 Discussion

The following will discuss tendencies and biases found by analyzing the results gathered from both the questionnaires, data measurements, and interviews. The prototype is compared to previous MTPs containing similar tasks, but made on other platforms than VR. The potential for using the framework of this prototype to develop MTPs on other platforms than VR is touched upon briefly as well.

Regarding level 2 (musical instrument identification), the participant mentioned having trouble hearing the third instrument. This is reflected in the data measurements, where the difference in scores between two instruments (normal difficulty) and three instruments (hard difficulty) is 16.1 seconds and 1.38 errors. Compared to the difference between the easy and normal difficulty levels, the amount of time increased by 10.25 seconds and 0.35 number of errors. This could indicate the hard difficulty exceeded an appropriate level, since the participant described feeling as if he only had difficulties hearing a third instrument, but felt confident in identifying one or two instruments.
There was a high standard deviation in this level, especially in the hard difficulty (19.6 for time, 1.5 for incorrect answers). These variations in performance might be caused by which combinations of instruments were played. In the interview, the participant mentions having issues differentiating piano and guitar from each other, as well as saxophone and trumpet. When looking at the performance for each instrument family (see table 1), music including a percussion instrument caused the participant to perform better with a lower standard deviation compared to the other instrument families. This fits well with related research (see section **??**). During the interview, the participant was informed that the melody of the guitar and the piano were similar to each other. This seemed to add up with his difficulties with differentiating the two instruments, since he felt as if he was recognizing the individual melodies of the instruments, rather than the sound characteristics of that specific instrument. After having played several times, he started remembering the melody, resulting in him feeling he could "cheat", explaining how this led to not necessarily training his capabilities in musical instrument identification. In regards to differentiating between the saxophone and trumpet, he thought it might be difficult due to the instruments sounding similar in general (i.e. in the real world as well). He did, however, recognize the trumpet playing higher notes compared to the saxophone, which he knew from listening to them in the real world, meaning he was able to identify them based on some of the characteristics of these specific instruments.
Significant correlations for all difficulty levels were found when comparing the number of times played with the amount of time used for completing the level. In the hard difficulty level, there was a negative correlation between the number of times played and errors made as well (see section 5.4). This indicates the participant was able to progress and perform better the more he played. However, as mentioned earlier, the participant was unsure whether this was due to recognizing the melody rather than the timbre of the instrument (see section 5.4). Therefore, it cannot be determined whether this might have affected the participants' progression more than an increase in the ability to identify instruments. A solution for this would be randomizing which melody the instrument, making the user unable to guess the instrument by melody.

In level three the difference in mean values for amount of time used and number of errors increased from easy to medium difficulty (4.8 s. and 0.49 errors in difference), but stayed roughly the same going from medium to hard (slight decrease with 0.91 seconds and 0.15 errors in difference). This suggests the participant was able to hear a difference when the modification of the melody changed with one octave, however, modifying the melody with half or quarter an octave appeared to be approximately equally difficult (as described in section **??**). As seen in Figure 10 significant negative correlations were found between the number of times played and amount of time used (for easy and medium difficulty) and with the number of times played and amount of errors made in the hard difficulty level. This indicates that the player was able to progress and perform better the more he played. In the interview, the participant mentioned “not guessing at all”, also mentioning “there is always something” he can hear to differentiate the melodies 8.2. This legitimizes the progression found in the measurements, as he was actually listening to the melodies and finding slight differences before making a certified guess. The participant also had significantly less incorrect answers in melody recognition compared to the other levels. Furthermore, the participant found this level the most fun to play in four out of five sessions, suggesting feeling self-assured in his answers and progression could potentially increase enjoy-ability.

In the questionnaire, the participant answered level one (sound localization) was the most difficult in all sessions. The participant described playing this level as being “the one where I’m guessing the most. And again, I don’t understand why it’s that difficult.” in the interview. There was no negative correlation between time used and number of errors with number of times having played, meaning there was no significant progression over time. The standard deviation in the results was less for the sound localization level compared to the others (9.2 in time measurements, 0.8 in number of errors), meaning the results fluctuated less for each time played.
As described in section 1, the participant being unilateral (as mentioned in the questionnaire from the first evaluation, see appendix section 8.1) most likely influenced these results strongly. The level was also played fewer times (38, whereas the other two were played 54 and 59 times), which might have been a result of the participant feeling as if he was uncertain with his guesses most of the time and it being something he had “completely given up on learning” since getting his implant 26 years prior. He did, however, feel more confident while he could only choose between two sources of audio (easy difficulty), and felt less uncertain guessing. During session four, he especially felt some progress in his performance. This resulted in them feeling motivated to play the level again after session five, since he felt a decrease in performance and wished to see whether he was able to improve as a result of additional training. The possibility of learning a skill the participant had previously given up on might increase the likelihood of them continuing to train sound localization in general.

One of the chosen measurements of performance was time used to complete each task. However, using less time to complete a level does not necessarily indicate the participant performed better, as the prototype does not encourage the player to finish as quickly as possible. The participant mentioned feeling as if he was guessing without being completely sure if he was correct (consistently in level one, occasionally in level two, and rarely in level three), which could potentially have an influence on time spent. Since the answers from the questionnaire showed the melody recognition level was the most entertaining in four out of five sessions, and the participant was confident in his answers with identifying melodies, he might have been more inclined to spend more time completing this task.
Other confounding variables, such as the user wanting to explore the environment or listen to the music out of personal interest, might have affected the time used, rather than the actual performance. The negative correlations found in level two (see figure 6 and level three (see figure 10) when comparing amount of times played with amount of time used might be more affected by these other variables, since these level encourage the user to listen specifically to music, rather than the direction of it. As a result, measuring the amount of incorrect answers should be considered as a more reliable measurement of performance. Comparing the number of errors with the time used also shows relevance to performance, since there is no consistent correlation in all levels between using less time to complete the task and number of errors made.

In the first evaluation, this participant mentioned he had an interest in video games and felt experienced with playing them, but had never tried VR prior to testing the prototype. He also answered ‘strongly agree’ when asked whether he found the levels fun to play in the post-test questionnaire given after testing the initial prototype during the first evaluation.
One of the other participants from the first evaluation, who did not have experience with nor an interest in video games, answered ‘disagree’ to level one and ‘neither agree nor disagree’ to level two when asked the

same question. Additionally, this participant needed more guidance while playing and seemed to have issues navigating the environment, as described in the interview.
Comparing these participants, an interest in and experience with video games could potentially have an influence on both performance and motivation with the prototype.
Whether the training application could be adjusted and used on other platforms (e.g. a mobile app for smartphones and tablets) is uncertain, but would most likely prevent excluding CI users uninterested in an MTP as a VR application. This could also make the prototype more accessible, since most people have access to either a smartphone or tablet, while owning an HMD is less likely. It makes it more physically accessible as well, meaning it can be used in more places with less limitations. The participant in the final evaluation could also imagine the prototype as a mobile application and use it (as described in the interview, see section 5.4), although it was not determined whether this would be as an additional tool or a replacement for the VR application. However, it should be considered that the sound localization level would likely not be suitable for a mobile application. Whereas the tasks of musical instrument identification and melody recognition do not require the player to navigate or rotate in a specific way in the VR environment, rotation as a part of detecting the direction of the sound is required in this level. The two remaining levels only require the player to listen to pieces of music and click on buttons, which would be relatively easy to recreate on a 2D interface, using 2D models or images of instruments and the mute/unmute-buttons instead. Even though a mobile app could be more accessible and practical, the participant specifically described playing in VR as: "You concentrate, maybe, in a completely different way compared to when you're playing on a phone that takes up two percent of your field of vision". This indicates having the MTP in a VR environment feels more immersive for this user, compared to using a mobile application. However, the goal of an MTP is to train the users listening abilities, not to immerse the player in a visual experience. It could be argued that being immersed in a visual experience might even distract the player too much, and make it hard to concentrate on the music. If the prototype was in the form of a phone or tablet based application, some users might concentrate more on the music, and only use the visuals when answering questions and gaining feedback. During the interview, the participant was asked whether they could imagine continuing training with the prototype would have an effect on his perception of music in the real world. He described being able to complete the tasks as somewhat surprising, described as: "There are actually some things in it (i.e. the prototype), where I am able to distinguish, which I was not really aware of before." and "You kind of get more attentive to that it is actually possible to get better."
This indicates that this participant was able to translate parts of the VR experience to listening situations in the real world. However, it is uncertain to what degree this was influenced by training in a virtual environment, meaning it cannot be determined whether the participant would have had a similar experience with training on another platform.

The participant saw potential for having other VR environments for training different aspects of perceiving sound as a CI user. The example he gave (i.e. creating a VR playground for children with CIs) would most likely not be suitable for a mobile application, since it relies on sound localization and being immersed in a true-to-life experience. Therefore, some of the musical training tasks would be easier to translate to a mobile application, whereas other potential aspects, especially when requiring sound localization, would be more suitable training in a virtual environment.

7 Conclusion

Even though this research project only gave insight into one participant's experience for a limited duration, there might still be potential for using the framework of this prototype as an MTP. The listening experience and sound quality for CI users differ greatly, and will always be individual, depending on influences such as whether they are uni- or bilateral, post- or prelingual, the type of CI they have, and for how many years they have had it.
Compared to previous MTPs, this prototype was not tested over a sufficient period of time (five sessions over the course of one week) and only on one participant. MTPs have shown gradual progress, but with training sessions being more consistent and over months or even years (as mentioned in section 2.1). Therefore, even though some of the correlation values of this project showed a slight improvement over time, it cannot be determined whether this would translate to results showing actual improvement in performance, especially affecting the listening abilities

outside the training sessions.

The tasks of melody recognition and musical instrument identification were inspired by previous MTPs. However, the results indicated the musical instrument identification task was not completed as intended, so it can not be determined whether training in the VR prototype could improve this ability. A solution could be randomizing which melody the instrument plays, so it will be possible to guess the instrument by recognizing the melody instead.
The task of melody recognition seemed more successful, since results showed it was both more entertaining, motivating and had less incorrect answers. There was no indication the level was completed in other ways than intended, implying it was implemented correctly, and there might be potential for users improving their results in this task, should they train it over a longer period of time.

Implementing more gamification elements was suggested as an improvement, if the player continues to be intrigued and motivated. This especially applies to them being able to follow their progress, being notified of getting a new high score and creating an award system, such as gaining trophies and/or medals as a reward for improving their results. Additional feedback elements would be beneficial as well, since the participant did not feel as if the existing ones were sufficient. Should CI users not feel entertained, and lose interest in playing, it is unlikely they would continue using the prototype over the course of time that could lead to actual improvement in music listening abilities.

Sound localization and spatial awareness of audio seems the most suitable for VR, since it mimics the movement and spatial sound of the real world. This is not as intuitive to translate to other platforms (e.g. mobile applications), since it requires tracking rotation and being able to answer from more than one location. As suggested by the participant, sound localization as training in a VR environment is not limited to this way of implementation. Being immersed in a virtual environment could have the potential for creating realistic settings, where the inability to localize the direction of sound is an issue in the real world as well. This could be (as mentioned by the participant) a playground, but earlier suggestions from participants in the first evaluation also concerned training the "cocktail party effect". Training the ability to hear and participate in a conversation while being surrounded by background noise or audio seemed to be a general issue. This issue could have potential for being created in a virtual environment, since it has an intuitive relation to experiencing this issue in the real world.

Although this prototype did receive positive feedback from the participant, other CI users with different types of complications with music listening abilities and level of interest in VR and video games, might not be engaged and/or motivated to use an MTP based in a virtual environment. Adjusting the prototype by adding more difficulties and gamification elements, as well as changing the melodies in the musical instrument identification level, would improve the current prototype significantly. As an alternative to VR, the musical instrument identification and melody recognition tasks could most likely be translated to other platforms, making it possible for a larger sample of CI users to use this MTP. However, making training programs for CI users in VR still shows potential in regards to immersion in the current levels, but also with training tasks which will benefit from being set in an environment mimicking situations in the real world where they are affected by limitations with listening abilities. Therefore, VR based training programs do not only show potential as MTPs, but has potential for training other listening abilities as well.

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8 Appendix

8.1 Notes from evaluation of initial prototype

Participant 1.

PRE:

1) **Kan du prøve at forklare hvad din oplevelse af musik er?**

   Elsker musik rigtig meget. Før hun fik CI kunne hun mærke musikken i gulvet.

2) **Bliver du påvirket af (e.g. distraheret), hvis der er musik omkring dig i din hverdag? E.g. i film, på restauranter, radio i baggrunden etc.**

   Høj musik når hun er ude og spise, så har hun svært ved høre hvad folk siger. Hun har en app på hendes CI til at filtrere baggrundsstøj fra som hjælper.

3) **Oplever du til tider at have problemer med at holde balancen? Beskriv hvordan, og i hvilke scenarier**

   Hun har svært ved at holde balancen - hun har dyspraksi -
   Hun danser meget - det kan være en udfordring da hun skal holde balancen

4) **Hvad er din motivation for at deltage i forskningsprojektet?**

   Meget spændt på hvordan det kommer til at foregå og en lille smule nervøs. Hun har svært ved lokalisere, hvor folk snakker fra.

5) **Hvordan kunne du forestille at VR-applikationen kunne se ud?**
   a) **Hvad den skal kunne?**
   b) **Hvad du gerne vil "træne" i den?**

   Hun har ikke rigtig deltaget i musikprogrammer før - måske har hun - men ikke noget hun kan huske.

POST:

POST TEST INTERVIEW

1) Var prototypen nem at anvende og navigere i?
   a) Var det åbenlyst, hvad du skulle gøre, og hvad målet var?
2) Meget sjovt og meget anderledes - Det var anderledes end det var hun var vant til. Hun skulle lige vende sig til hvordan det var at navigere. Det var meget nemt. Hun synes ikke at det skal være svære.

SPØRGSMÅL FRA RANGERING

1) Hvorfor var det instrument, du har rangeret lavest, sværest at høre?
   Bass'en var lidt svær - det svært at kende forskel på guitar eller bass. Trommerne var nemme at høre.

2) Hvorfor var det instrument, du har rangeret lavest, sværest at høre retningen på?
   Det var meget nemt - den hun hørt først valgte hun

3) Hvad gjorde nogle instrumenter mindre behagelige at lytte til?
   Tromme, bas og guitar - klokken var meget behagelig at lytte til.
   Mindre behagelig var fløjte.

SPØRGSMÅL TIL VIDEREUDVIKLING

1) Hvilke elementer fungerede godt?
   Forskelligt - det var meget fint at høre med hovedtelefoner.

2) Hvilke fungerede mindre godt?
   Hun skulle lige finde ud af det - men efter det fungerede det meget godt.

1) Hvad ville du helst kunne træne i et VR-miljø?
   a) Hvad synes du om hvert level af prototypen?
   At skulle høre nogen snakke mens man hører musik.

3) Hvad ønsker du, der skal tilføjes til prototypen fremadrettet?
   At kigge på det

4) Er der et andet fokuspunkt/opgave, du ønsker vi implementerer i prototypen?

Participant 2

PRE:

1) **Spillede du musik inden du mistede hørelsen/inden du fik cochlear implant?**

   Spillede guitar du hun var barn, men stoppede da hun blev teenager. Hun har dog været gift med en musiker, så hun ved en del om musik.

2) **Savner du at lytte til musik? Uddyb gerne hvorfor, og i hvilke situationer.**

   Savner det enormt meget. Musik og følelser/erindring har meget med hinanden at gøre. Hun savner lykkefølelsen det kan give når man høre et nummer hun kendte.

3) **Kan du prøve at forklare hvad din oplevelse af musik er med cochlear implant?**
   a) **Hvordan er den sammenlignet med inden du fik cochlear implant?**

   Det lyder forfærdeligt.

4) **Bliver du påvirket af (e.g. distraheret), hvis der er musik omkring dig i din hverdag? E.g. i film, på restauranter, radio i baggrunden etc.**

   Især når hun ser fjernsyn og der er baggrundsmusik. Koncerter. Det lyder forfærdeligt.

   Hun udsætter ikke sig selv for musik - hun undgår musik, i sin dagligdag - men træner meget musik.

   Hun er glad for det meste musik (ud over rap), klassisk bliver nævnt.

   Hun er stadig i en fase hvor hendes CI bliver tilpasset.

   Hendes hjerne ved hvordan musikken burde lyde, derfor kan hun godt genkende gamle sange. Men nye melodier hun ikke kender, vil hun gerne arbejde med!

5) **Oplever du til tider at have problemer med at holde balancen? Beskriv hvordan, og i hvilke scenarier**

   Generelt ingen problemer - udover når hun har anfald - det har hun dog ikke haft i et stykke tid.

6) **Hvad er din motivation for at deltage i forskningsprojektet?**

   Hun ønsker at træne så meget hun kan. Hun vil virkelig gerne træne musik. Der er mange folk som slet ikke lytter til musik.

POST:

1) **Var prototypen nem at anvende og navigere i?**

a) **Var det åbenlyst, hvad du skulle gøre, og hvad målet var?**

Det var det - da hun først fandt ud af det. Det var kompliceret fordi hun ikke var vant til at spille spil.

Instruktionerne var klare.

Det var uklart at - når man går ind og vælger 'Play' så manglede der et visuelt feedback.

1) SPØRGSMÅL FRA RANGERING
    a) **Hvorfor var det instrument, du har rangeret lavest, sværest at høre?**

Lyden var anderledes end det hun var vant til høre. Hun var i tvivl om det var den gamle eller den nye lyd.

Det kom bag på hende, at hun var dårlig til at høre de forskellige lyde.

Hun tænker om det spiller en rolle hvor langt der er mellem tonerne. Hvis en guitar slog an flere gange.

Hun har produceret musik i garageband. Mere end melodi med en tone af gangen frem for en akkord.

Trommerne var nemme at gætte.

Det vil ikke gøre det nemmere hvis trommer spillet på samme tid.

b) **Hvorfor var det instrument, du har rangeret lavest, sværest at høre retningen på?**
c) **Hvad gjorde nogle instrumenter mindre behagelige at lytte til?**

Klokkespillet var meget rart at lytte til. Der var ikke noget der var ubehageligt.

Bassen var meget svær at lytte til.

Klaveret var lidt svært.

SPØRGSMÅL TIL VIDEREUDVIKLING

1) **Hvilke elementer fungerer godt?**

Det var et godt rum. Det var godt med at instrumenterne kom op og så stod i 3d når man valgte rigtigt.

2) **Hvilke fungerede mindre godt?**

Usikker på om hun har trykker på ‘Play’ og usikker på om det var alle radioerne spillede.

1) **Hvad ville du helst kunne træne i et VR-miljø?**
    a) **Hvad synes du om hvert level af prototypen?**

3) **Hvad ønsker du, der skal tilføjes til prototypen fremadrettet?**

4) **Er der et andet fokuspunkt/opgave, du ønsker vi implementerer i prototypen?**

    At lære nye melodier -

    En bestemt melodi og høre den blive afspille det på forskellige instrumenter. Og man har mulighed for at gå frem og tilbage imellem.

    En app med - at man kunne tage et stykke musik og så piller instrumenterne fra en efter en og lægge dem på igen.

Andre ting:

Man skulle måske få flere niveauer og flere sværhedsgrader som passer til forskellige CI-brugere.

Der var noget ved radioerne som var lidt kedelige - de var forskellige farver, men der kunne være lidt mere visuel variation.

Participant 3

PRE:

1) **Spillede du musik inden du mistede hørelsen/inden du fik cochlear implant?**

   Ja - klassisk klaver - meget tit på kons - minigites - gik fra normal hørelse til ingenting på en nat - fik CI efter 4 måneder - han prøvede at spille musik efterfølgende, men det gik. Kunne fx i kende forskel på dur og mol. Droppede klaver og begyndte at undervise i teori.

   Droppede det dog og tog på universitet i stedet.

   Det er svært at lære musik udenad uden at kunne høre det ordentligt.

   Han kan ikke høre hvis han spiller forkert.

2) **Savner du at lytte til musik? Uddyb gerne hvorfor, og i hvilke situationer.**

   Ja det må man sige - det var en udtryksform - en maler der er blever farveblind - en masse detaljer man må undvære - musik vækker også følelser. I hans datters musikudvikling kan han ikke følge med i.

   Han lyttede mest til klassisk - men høre også meget andet.

   Symfoniorkester er meget dårligt - det er en stor blanding.

   Lytter meget til trommer.

   Harmonierne kan han ikke høre

3) **Kan du prøve at forklare hvad din oplevelse af musik er med cochlear implant?**
   a) **Hvordan er den sammenlignet med inden du fik cochlear implant?**

4) **Bliver du påvirket af (e.g. distraheret), hvis der er musik omkring dig i din hverdag? E.g. i film, på restauranter, radio i baggrunden etc.**

   Det er meget svært med skilneevne - fem mennesker max - mere end det så er der for mange samtaler i gang og så kan han ikke følge med.

   Det er næsten helt umuligt at genkende retning.

   Han var en af de første der fik i det ene øre.

   Der gik 15-20 år indtil han fik tilbudt den til det andet øre, dog har han ikke haft lyst til at få nummer 2, da han skal igennem operationen igen.

5) **Oplever du til tider at have problemer med at holde balancen? Beskriv hvordan, og i hvilke scenarier**

   Så snart det bliver mørkt, så skal han kigge helt ligeud ellers slingre - eller hvis han lukker øjnene.

   Han havde super god balance før, men der forsvandt fuldstændig.

   Han har fået det meste af balancen tilbage.

   Stå på et ben kan han lige nøjagtigt.

6) **Hvad er din motivation for at deltage i forskningsprojektet?**

   Motivation er at være ærgerlig over ikke at kunne høre musik og vil gerne være med til at hjælpe ting.

7) **Hvordan kunne du forestille at VR-applikationen kunne se ud?**
   a) **Hvad den skal kunne?**
   b) **Hvad du gerne vil "træne" i den?**

POST:

1) **Var prototypen nem at anvende og navigere i?**
   a) **Var det åbenlyst, hvad du skulle gøre, og hvad målet var?**

   Det var nemt at bruge - det var til at finde ud af.

   Det var også nemt at finde ud af hvad formålet var.

1) SPØRGSMÅL FRA RANGERING
   a) **Hvorfor var det instrument, du har rangeret lavest, sværest at høre?**

      Rumklang på guitar og fløjte forvirrede ham rigtig meget. Det lød som et stort et stort tomt musiklokale.

   b) **Hvorfor var det instrument, du har rangeret lavest, sværest at høre retningen på?**

      Det var svært at høre hvad det var. Det var irriterende.

   c) **Hvad gjorde nogle instrumenter mindre behagelige at lytte til?**

SPØRGSMÅL TIL VIDEREUDVIKLING

1) **Hvilke elementer fungerer godt?**

   Det var sjovt - det var også første gang.

2) **Hvilke fungerede mindre godt?**

   Det var for svært at retningsbestemme i level 2.

1) **Hvad ville du helst kunne træne i et VR-miljø?**
   a) **Hvad synes du om hvert level af prototypen?**

3) **Hvad ønsker du, der skal tilføjes til prototypen fremadrettet?**

   Genkende intervaller - lytte til en melodi og så gengive den efterfølgende -
   Fløjten kan han sagtens høre forskel på intervallerne.

   Nogen som fløjter.

   Enkelte toner og akkorder går rent ind.

   Skelneevne vil være meget godt at træne

4) **Er der et andet fokuspunkt/opgave, du ønsker vi implementerer i prototypen?**

Han er helt sikker på at hvis det var i virkeligheden ville han ikke kunne kende forskel.

8.2 Final Interview Transcript

Transcribe

A: Interviewer 1

B: Interviewer 2

C: Interviewee

A: Vi har lige sådan nogle overordnede emner. Det første er sådan, i forhold til det her som et træningsprogram. Hvordan det ville kunne fungere. Og så hvordan din oplevelse med det har været, og så underholdningsværdi. Men det kommer til at være, altså, meget ustruktureret, det her interview. Vi har bare nogle ting, vi gerne vil komme ind på, men vi vil egentlig gerne høre, bare sådan…

C: Det er kvalitativt.

A: Ja.

B: Lige præcis, meget kvalitativt.

A: Det er meget kvalitativt! Nu har vi jo alt det gode kvantitative data fra spørgeskemaet. Så vi vil jo bare gerne have uddybet det, og se, sådan, især hvordan det ville… hvordan det kunne videreudvikles, spillet. Hvad der skal ændres for at det ville gøre det federe at bruge over en længere periode. Men ja. Vil du ikke bare starte med at fortælle om, ja, hvordan det har været at have med hjemme, og hvordan det har udviklet sig undervejs for hver gang, du har prøvet det?

C: Jeg synes… jeg føler i hvert fald, jeg har fået bedre resultater, jo længere frem, tror jeg nok. Det føles sådan. Jeg har været inde og kigge på scoreboardene, jeg kan ikke huske hvordan jeg scorede sidst, men det føltes lidt sådan. Og nogen gange, det har jeg skrevet et eller andet sted i en bemærkning, der tror jeg, jeg blev bedre til… jeg synes jeg var bedre til retningsbestemmelse i går. Og det har jeg jo, hvad skal man sige… jeg synes også jeg var blevet bedre til nogle af de andre, men der er forskel på man bliver bedre til spillet fordi man har regnet det ud eller man rent faktisk bliver bedre. Jeg tror faktisk, og det er derfor jeg formulerede mig som jeg gjorde, at, jeg tror nok jeg har skrevet at det, at det føles som om… Nu kan jeg ikke engang huske det, det er også ligemeget.

A: Jeg tror du skrev noget med at det var som om at du i højere grad vænnede dig til, hvordan melodien fungerede, i instrument level'et der.

C: Ja. Det er rigtigt. Det er det der med, det føles lidt ligesom om at alle instrumenterne, ligesom i et partitur, så har de deres melodi, og lige fra man har lært den, så er den nemmere at høre, eller så er det jo ikke fløjten jeg hører, men så hører jeg den der lyd der kommer, når der nu skulle være en fløjte, men det er jo selvfølgelig også en måde.

B: Det er også sådan, det er lavet, at det level, hvor man gætter instrumenter, så har hvert instrument sin egen melodi. Så hvis du kan gætte melodien frem for selve lyden af instrumentet, så kan du jo ligesom gøre, ligesom gå imod hvad der egentlig er intentionen af at du skal blive bedre til– ligesom "snyde" spillet.

A: Ja, præcis.

C: Og der ville, sådan, variation i, lige sætte, fuldstændig nulstille den der, og så kan man måske udlede et eller andet om, hvor meget man egentlig er blevet dygtigere.

A: Altså, forskellige melodier i hvert fald. Flere melodier, så man ikke… ja, kan "snyde" sig igennem, eller i hvert fald sådan…

B: Ja. Ja, sådan at det var tilfældigt hvad for en melodi instrumentet havde, måske.

C: For det var, ja, fordi jeg kunne godt høre, jeg lærte at identificere, det der, det var ligesom et akkompagnement. Og så klaveret eller guitaren eller måske kontrabassen nogen gange, og den der lyd, der kommer der, den kommer altid, den kom også når fløjten kom da den kun var sammen med klarinetten, du ved, eller med trompeten, og så ved jeg, nå, men så er det fløjten, ikke.

A: Jeg synes også du nævnte, da du prøvede det nu, at du havde svært ved at kende forskel på guitar og klaver?

C: Ja.

A: Eller hørte jeg forkert? Fordi, de spiller også mere samme melodi, så vidt jeg husker.

B: Ja, lige præcis.

A: Så det giver måske meget god mening.

B: De spiller begge to den samme akkord.

A: Ja.

B: Klaveret er en akkord, og guitaren er bare den samme akkord oveni hinanden, så det er jo klart, at de har måske lidt forskellige toneklange, men det er nogenlunde det samme.

C: Er det rigt– okay! Fordi, det var det eneste, jeg kunne, jeg tænkte på i går, det var at den, det er, at der bliver slået an. Bum eller bom! Og så kan jeg udelukke den og den og det og det og det, men kunne fandeme ikke høre forskel på klaver og guitar, og jeg tænkte også på, er det en rigtig klaverlyd? Er det en rigtig guitarlyd? Er det det?

A: Ja. Eller…

B: Altså, det er jo… det er en computergeneret emulation, eller en computergenereret guitar.

C: Det er jo det, fordi, det lyder ikke som når jeg spiller på klaveret.

B: Det er ikke helt rigtigt, men altså, man kommer jo så tæt på som muligt, man ligesom kan. Så der er forskellige lyde til dem, men det er ikke et ægte klaver, nej. Det er det ikke.

A: Computerklaver.

B: Ja.

C: Fordi man kan sgu da godt… det må da være muligt at sætte den rigtige lyd ind.

A: Ja, i princippet kunne man jo godt sørge for at få optaget noget rigtig lyd på det. Eller lede længere tid efter nogle lydfiler, der er mere akkurate. Det ville bare være mere tidskrævende, selvfølgelig, men det ville give god mening, altså, til videreudvikling.

C: Jeg ved heller ikke, altså. Ja. Altså, hvis, så længe den computer simulerer to forskellige som man kan høre forskel på, så er det jo selvfølgelig også godt nok, ikke? Nu er det bare mig der tænker “det lyder ikke ligesom mit klaver derhjemme. Det lyder forkert!”, ikke?

A: Hvordan med level 3, med melodien? Ville det også være rart, hvis der var flere forskellige melodier?

C: Ja.

A: Ja. Det samme med at, ja, flere, og det så er random, hvilken en der kommer frem hver gang?

C: Ja. Hvis der, ja, altså, “Happy Birthday”, det er lidt mange gange. Og hører altid kun den første halvdel.

B: Ja, det er jo det.

C: Så gider jeg ikke høre resten.

A: Var det egentlig– hvordan var det med mængden af, altså, at du havde mulighed for at vælge mellem så mange instrumenter? Der i, ja, da du skulle høre happy birthday. Sådan, brugte du mange forskellige instrumenter, og var der nogen, der var sværere end andre?

C: Ja, altså, jeg har prøvet alle instrumenterne. I går tog jeg alle instrumenterne igennem på alle sværhedsgrader [inaudible]... Hvad fanden var det nu, du spurgte om?

A: Om der var nogen, der var sværere end andre?

C: Ja. Det er super svært at høre forskel på trompeten og saxofonen. Det er virkelig svært, synes jeg. Og så synes jeg orgellyden er meget lav. Meget lav. Og måske også guitaren og klaveret, der når de akkompagnerer. Altså, når man skal sætte to og tre instrumenter sammen, ikke? Jeg kan næsten ikke høre selve lyden. Er der et tredje instrument? Og så må jeg jo bare, så er det jeg kan høre, det der, det er nogle strenge, der bliver slået an og så er det bare at gætte på en af dem, for jeg kan fandeme ikke høre forskel. Det er svært at høre det tredje instrument.

A: Det var faktisk også lidt… det leder fint over til det andet spørgsmål fordi, altså… du snakker om her i første level at det var svært at høre generelt. Følte du at der var nogle gange hvor du bare gættede fuldstændig, for bare at komme videre?

C: Ja.

A: Ja. Specielt i level 1 eller?

C: Ja, retningsbestemmelsen der?

A: Ja.

C: Ja. Nogen gange, ja. Det er den hvor jeg gætter mest. Og igen, jeg forstår ikke hvorfor det er så svært. Fordi, jeg synes, i går der havde jeg mange rigtige på den. På den nemme, hvor der bare står en i hvert hjørne, ikke. Der synes jeg, den… ja, det må I jo så tjekke. Jeg synes helt bestemt, det gik bedre med den i går. Og lige nu her, ja, der var det sværere.

A: Ja. Så det svinger lidt fra gang til gang?

C: Ja. Ja, det synes jeg. Men så var det også det der med at jeg ikke kan… det der med, jeg bliver forvirret over, er det så, når jeg nu står foran en, er det så den, fordi… eller er det på grund af den der, så begynder jeg, så begynder jeg jo så også at gætte lidt.

A: Godt. Nu skal jeg lige se–

C: Den der med at genkende ‘Happy Birthday’, der gætter jeg næsten ikke.

B: Nej, okay.

C: Der er ikke gæt med. Der er altid et eller andet. Jeg kan godt høre, der bliver spillet– bliver der spillet decideret falske toner nogen gange? Eller tager I bare den rigtige tone en oktav højere eller?

B: Ja. Der bliver spillet decideret falske toner, især, man kan sige, der er den i den mellem sværhedsgrad, der er det en halv oktav. Hver anden tone er simpelthen transponeret en halv oktav, hvilket i princippet er en helt forkert tone. Altså, den er ikke, det lyder ikke rigtigt.

C: Nej.

A: Det er også det, når vi hører det, så lyder det også helt, altså…

C: Okay. Nå, men det var også den fornemmelse jeg havde, så det–

B: Der er noget, faktisk, der faktisk er helt skævt. Men det er jo også spørgsmålet, det tænkte vi også på, altså, hvorvidt det overhovedet er muligt for dig at kunne genkende, at det er… at det er dissonans, ikke?

A: Ja.

C: Ja. Den er– når jeg sidder foran et rigtigt klaver, ikke? Et perfekt Steinway flygel, det lyder pivfalsk. Fuldstændig falsk, i mit hoved. Det gør det til gengæld ikke med et elklaver, der lyder det… anderledes.

B: Der lyder det bedre?

C: Det er mærkeligt. Ja, men så er der nogle akkorder, som jeg godt kan høre sådan ret rent. Næsten. Jeg kan godt, jeg kan næsten lære at genkende. Altså, jeg spiller jo stadigvæk, eller, jeg er begyndt at spille igen. Jeg ved ikke om vi snakkede om det. Jeg spillede ikke i tyve år, og så købte jeg et klaver her for tre år siden, og begyndte igen. Og så… Ja, så opdagede jeg, der nogle akkorder, som jeg tror jeg godt kan høre. Der er nogle toner, jeg godt kan identificere. Men ellers så lyder det… sådan generelt ad helvedes til, egentlig. Hvor fanden var det, vi kom fra? Hold kæft, jeg er helt væk i dag, sorry.

A: Det var lidt sådan, det skal bare være en samtale det her, så det skal du ikke tænkte på. Det er lige, hvad vi ikke er kommet ind på… Ja. Så, hvis nu at prototypen blev videreudviklet på baggrudn af noget af det vi snakkede om, sådan, altså, at lave flere forskellige melodier og randomize mellem dem, kunne du så forestille dig at det ville have en påvirkning på, hvordan du hører musik i virkeligheden?

C: Ja, det er jo så det.

A: ALtså, hvis du brugte den i længere tid, ikke?

C: Ja. Altså, det tror jeg. Fordi, nu så er jeg også blevet– altså, jeg er aldrig… jo altså, jeg har også selv siddet og leget derhjemme, hvordan lyder det og hvordan lyder det her, hvorfor kan jeg ikke høre en oktav og alt sådan noget, ikke? Men det er jo bare sådan noget man sidder og gør løst og fast, ikke, og her er det jo sådan en rigtig øvelse, hvor man bliver opmærksom på, at der rent faktisk er nogle ting i det, hvor jeg kan skelne, som jeg egentlig ikke har været klar over før. Også sådan noget med retning, jeg har aldrig gidet at… det har jeg bare fuldstændig opgivet, ikke? Og nu sidder jeg og finder ud af, nå, men jeg kan faktisk godt høre… der er faktisk forskel på lyden, om jeg drejer hovedet og sådan noget. Og det er jo også det samme med de andre, der kommer sådan nogle ting, man bliver opmærksom på, jeg kan sgu ikke lige sætte ord på det, synes jeg, men… Der er sådan nogle ting, hvor jeg tænker "hov, det her, det kunne jeg godt lige være opmærksom på ude i den virkelige verden", ikke? Det kunne også være man simpelthen vænner sig til at høre lidt mere nuanceret, og så sætter det ligesom en ny standard, sådan helt overordnet, for hvordan man går ud i den virkelige verden og hører lydene, ikke? Altså, alene det kunne jo være en hjælp, ikke? Ja, at man… ja, at man ligesom bliver opmærksom på, at der er faktisk– man kan faktisk godt blive bedre i den der retning, det er jo det man oplever, sidder og oplever her. At der er en forskel fra den ene gang til den anden.

A: Så er det lidt, altså, motivationsfaktor, det her med om det ligesom… Hvis du tænker, det kan overføres til den virkelig verden, hvis du blev ved med at fortsætte i det. Altså, ville det så motivere dig til at blive ved med at træne det?

C: Klart.

A: Fedt.

C: Det er også mange udsigter, tænker jeg. Fuck, det har mange udsigter, fordi jeg tænker– nu skal jeg jo heller ikke sidde og… Jeg sad og tænkte på de der partiturer der. Alle de her instrumenter, der nu hænger på den der væg, og jeg skal så gætte, hvilke nogen af dem det er. Og hvis især også de havde den samme, ligesom, melodistump, ikke? Det er det, jeg forestiller mig, hele det der paracetur, så har vi guitarmelodien og saxofonen og alle dem der. Og så er det bare de to der er sammen, og de to der er sat sammen. Og så kan man genkende… hvor jeg så kan begynde at regne ud. Og så hvis jeg så skal væk fra det der med at regne ud, jamen så skal jeg have et nyt partitur, ikke? Og så er vi ligesom ude i sådan en uendelighed eller, så ved jeg ikke, så bliver det lige pludselig stort, ikke?

B: Ja, det er også det, det bliver det også nødt til at være, hvis man skal videreudvikle på det her.

A: Ja.

C: Så er der niveauer og seks ugers kurser i det her nu og det her– I kan tjene så mange penge på det her.

A: Outsources! Ej, men altså, det er jo… Det er også, altså, sådan, det tidligere research vi har læst og musiktræningsprogrammer, der er nogle, hvor efter to måneder er der forbedringer, og for nogen, så går der to år. Det er så individuelt. Og selvfølgelig også alt efter hvilken applikation det er, om det er motiverende Men også fordi det er individuelt hvordan ens CIs fungerer, ikke. De andre forsøg vi har kigget på med det, der kommer der en udvikling, der kommer en forbedring i resultater. Så det er jo også– men det er meget det der med, om det kan blive overført til den virkelige verden.

C: Ja.

A: Men ja. Apropos det, så… det er jo meget anderledes, det her med, at det er i VR. Og det er via headsettet og det skal man selvfølgelig have tilgængelig, og at man kan ikke bare lige sidde i s-toget og træne det.

C: Nej!

A: Det har vi i hvert fald snakket om, det ville være lidt underligt.

C: Ja, det ville se lidt vildt ud. Ellers, ja. Man skal jo have surround til, og hvis ikke man… hvis man ikke kunne.

A: Ja. Men kunne du forestille dig, hvis du skulle bruge det i længere tid, om det ville fungere ligeså godt på andre platforme? Altså hvis det var en app eller hvis det var et computerspil.

C: Ok ja. Jeg kunne sagtens forestille mig for eksempel at sidde og gætte melodien på telefonen i toget, det kunne man jo sagtens.

A: Men ville det være, altså–

C: Jeg tror ikke, jeg ville gøre det for sjov. Jeg tror ikke jeg ville sidde og gøre det i toget. Så ville jeg vælge et tidspunkt derhjemme og så gøre det der.

A: Så, tænker du at det stadig er mere underholdende, i hvert fald, når det er med et headset?

C: Næ. Der er jeg sgu også ligeglad, egentlig. Om… ja. Det ville være ligesom hvis man spiser noget god mad, så er jeg sgu egentlig også ligeglad med hvordan omgivelserne er, når jeg sidder og spiser den, ikke? Det gør ikke mig noget. Der er en ting, jeg tænkte på, det er jeg mister tidsfornemmelsen fuldstændig tidsfornemmelsen. Fuldstændig! En timer oppe i hjørnet eller sådan et eller andet halløj eller… eller en eller anden form for tæller; “nu har du lavet den her opgave ti gange” eller sådan noget. Ja, men sådan hvor man ligesom ved, hvor fanden er vi henne i verden. Ja. Jeg mister fuldstændig tid– jeg har ingen fornemmelse om… Jeg har ingen fornemmelse af, nu har jeg siddet tyve minutter eller en time. Men, ja, sådan er det nok generelt med computerspil. Ja. Altså, jeg ser mere det her som læring end som underholdning, som sådan. Der er nogle af de der ting, hvor jeg tænker “det kunne jeg sgu godt lige sidde og”... jeg tror godt, jeg kunne finde på at sidde og gætte melodien eller gætte på instrumenter bare for sjovs skyld, af en art, tror jeg. Men ikke på samme måde som hvis man sidder og spiller et eller andet. Det vil jeg gerne spille fordi eller hvad fanden man nu spiller for. Så der er, ja… Det er nok det.

A: Men når du nu, altså, mister tidsfornemmelsen med headsettet, tror du så du ville bruge kortere eller den samme tid, hvis det var på en app?

C: Det ved jeg sgu ikke. Altså, der kan man jo se, hvad klokken er og sådan noget. Så tænker jeg “nu skal jeg ind og se tv-avis” eller hvad fanden det nu er, der, der sidder man bare i en helt anden verden, ikke.

A: Ja. For det er jo også…

C: Det er måske meget, nej, det kunne måske også være sådan noget, hvis man tænker gud, det føles som om, man har siddet en time, men der er kun gået et kvarter, og det er på den måde noget belønning [inaudible], det ved jeg ikke.
Jeg blev lidt kulret i går til sidst, fordi jeg tænkte I skulle have en hel masse data i går. Og så var det jeg tænkte da jeg var færdig, gud, gad vide hvad jeg egentlig… Fordi jeg glemte faktisk at kigge hvornår jeg startede, så jeg ved faktisk ikke, hvor længe jeg sad der. Men til sidst så, der kunne jeg godt mærke, der gik jeg sgu lige sukkerkold i de sidste øvelser der.

A: Ja. Ja, det kan jo ske. Det tror jeg faktisk også godt vi så inde i survey’et. At du havde scoret højere på ‘træt’, så vidt jeg husker, i hvert fald, end du havde gjort de andre gange. Men det er også, altså, der er også noget, der hedder after effects, fx, hvor at det er svært at justere sig til den virkelige verden, når man tager dem af. Hvis man har siddet derinde længe.

C: Det kunne jeg godt forestille mig, specielt hvis man står op.

A: Ja.

B: Det er klart.

C: Nu har jeg bare siddet ned. Ovre i det andet lokale der, der sad jeg jo og drejede rundt på en stol, og så tænkte jeg: “gud, jeg har ikke nogen kontorstol”, kom jeg til at tænke på, nå, men det kan man jo bare gøre, heldigvis, ikke?
Så sidder man jo bare der, ikke, og så skal hjernen ikke til at fokusere på balance og sådan nogle ting. Jeg har overhovedet ikke oplevet noget med svimmelhed eller at jeg skulle til at justere mig tilbage til virkeligheden eller sådan noget. Jeg synes, det var meget fint.

A: Det var godt.

C: Det mest spooky det var på et tidspunkt hvor jeg stoppede spillet, så blev det bare sådan et sort rum med sådan nogle ternede, nej, kryds.

A: Ja.

C: De der krydsfelter, sådan fem meter længere ned. Det føltes som om man kom ind i sådan en dimension.

B: Nå ja!

C: Man var helt alene. Det var det mest uhyggelige ved det.

A: Jamen, der er jo også nogen, hvis du skal have sådan nogle briller en dag, der er masser gyserspil, hvis det er. Det er helt forfærdeligt.

B: Nej, det er ikke sjovt. Det har vi prøvet.

A: Det kan jeg faktisk ikke anbefale.

C: Nej, altså, jeg gad godt prøve et racerspil eller et flyverspil eller sådan noget. Det kunne være super cool at kigge i et eller andet.

A: Altså

[35:00]

A: Hvad vil du sige generelt er nogle fordele og ulemper ved at have sådan noget her i VR eller VR generelt?

C: Jeg er jo bare super begejstret fordi jeg synes det er pisse fedt. Jeg synes bare det er sjovt. Det er okay. Som vi snakkede om før, så skal man jo bruge det til retningsbestemmelse, med mindre man sidder med noget surround-sound som kan kobles på. Ja. Klart. Ja. Man koncentrere sig måske også på en anden måde i forhold til når man spiller på en telefon som fylder 2 procent af synsfeltet. Det er jo en helt anden verden man er inden i, ikke?

A: Det er mere immersive på en måde

C: Hvad betyder det?

A: Det er et fagterm inden for VR.

B: Man er en del af spillet på en anden måde. Du er en del af spillet.

A: Du er mere investeret på en eller anden måde

C: 100 procent. Det er jeg enig i. Man er helt med på en anden måde.

C: Måske kunne det også være sjovt hvis man kunne se sin egen statistik. I stedet for bare at kunne se ens hurtigste tid.

B: Den gemmer faktisk det hele. Så vi kan godt sende det til dig. Hvis du vil have det.

C: Når nej. Det var ikke så meget derfor. Det er mere hvis man er interesseret mens man sidder og spiller. Det er jo sådan noget der kan komme på senere.

A: Vi kommer også til at sidde og analysere alle resultater og hvilke instrumenter der er nemmest. Hvordan du forberede din tid løbende og sådan noget. Vi kommer også til at sende rapporten til dig, når den er færdig, Hvis du har lyst til at se den. Jeg glæder mig virkelig til at se de her tal.

A: Det er jo kun dig vi har testet på. Men nu er det jo også over 5 gange.

C: Hvis jeg skal spille det her en uge så bare sig til. Det er okay.

[37:30 - 40:00] Bla bla bla

C: Jeg synes altså også I skal tænke over det jeg sagde at der ikke er nogen, når man kommer ud på hospitalet og får det her på, at der ikke er nogen standardiseret procedure. Hvis der virkelig stadig ikke er det, så kunne det være et fantastisk udgangspunkt. Fordi det er målbart. Så har i alle hospitaler i hele verden, som har med CI at gøre, som potentielle brugere.
A: Ja. Det er jo netop det. For det første så kræver det jo færre ressourcer fordi man ikke behøves at sidde med en audiolog, men at man selv får kontrol over det. Plus der er jo altid den her 'bias' ved at det primært tiltaler folk der er interesseret i spil og folk der er interesseret i VR. Men på den anden side er det jo mere motiverede for folk der har en interesse for det, i stedet for at sidde med en audiolog og de så spiller de samme lydfiler, som vi egentlig har implementeret. Så det er jo lidt det om det kunne være en motivationsfaktor for nogen, og så selv have lidt kontrol over det. Det er jo meget forskelligt fra person til person, hvad man finder motiverende. Men det kunne være fedt, hvis det kunne være en mulighed under genoptræningen.

C: Det kunne også være andre ting end musik. Jeg er meget begejstret for at der nogen som arbejder med musik til sådan nogen som mig. Jeg gad virkelig godt at kunne høre noget musik igen. Det kunne også være børn hvor rummet er en legeplads, hvor så “det her er en spand” og “det her er en gynge når den knirker”. Jeg forestiller mig pludseligt at man kunne bruge det til alle mulige andre ting og træne sin hørelse, når man får sådan et apparat på og ikke ved hvordan det skal lyde. Fordi der er jo mange lyde man skal lære. Jeg gik fra normal til ingen hørelse på 24 timer og 4 måneder efter fik jeg CI. Jeg vidste hvordan det hele skulle lyde, så jeg kunne bare sige “skru lidt op for den” og “skru lidt ned for den”. Så prøvede vi lige og raslede med noget som jeg godt ved hvordan skal lyde og justerede derefter. Men de forældre som har et døvt barn. De forældre aner jo ikke hvordan det lyder det der. De ved ikke hvad fanden...

A: Det ville også være mere sikkert i forhold til teenagere og barn eller voksne. I steder for at sætte dem fysisk ud på en legeplads, og så skal se en hund og ikke ved hvordan det lyder.

A: Yes.. øhm.. Lige lidt om genre. Nu har du jo spillet musik før. Så vidt jeg kan huske, så er du jo glad for klassisk musik, ikke?

C: Ja.

A: Vil det være en fremtidig forbedring måske at implementere forskellige genrer af musik?

C: Det vil da være en god idé. Jeg sad også at tænke på måske at kunne høre forskel på forskellige instrumenter i et orkester. Beethoven symfoni for eksempel, ikke. Så kan i jo spille de instrumenter man nu har lyst til.

A: Så med klassisk musik måske?

A: Vi vil gerne komme inde, hvis der skulle være flere levels, hvad kunne så være fedt at have med?

C: Jeg er helt sikker på at det vil være mere motiverende, hvis det ikke kun var “Happy Birthday”. Som udgangspunkt. Og bagefter så er der jo nogle folk som har forskellige præferencer. Hvad kan de bedst li’ for noget musik. Og så er det jo sjovest med den genre de bedst kan lidt. Hvis de overhovedet har en foretrukken genre. Med sådan nogle apparater. Det ved jeg sgu ikke hvordan andre mennesker har det.

A: Så vidt vi ved så er det meget afhængigt af hvornår folk mistede hørelsen og hvor længe de har haft implantater. Fordi der er nogle som vi hørte om fra en audiolog som vi snakkede med. Hun havde en patient som var kæmpe Kim Larsen fan og var meget dedikeret til det. Hvor vedkommende har mistet rigtig meget ved ikke høre Kim Larsen specifikt længere. Så jeg tror helt klart, at det er meget forskelligt. Vi har også snakket med en anden CI bruger, som også. Jeg kan ikke huske hvad det var om det var Jazz eller et eller andet, som han også savnede at lytte til. Fordi det lød ganske forfærdeligt, blev det beskrevet som.

C: Det må jo komme med tiden. En lille jukebox med forskellige genre. En forbedring ville jo bare være tre forskellige melodier at vælge i mellem, i stedet for happy birthday. Noget i den stil. Det kunne også være tre popmelodier, tre klassisk og tre heavy-rock. Det kunne være sjovt.

A: Nu skal du høre Rammstein.

C: Det ville helt sikkert være mere motiverende, og børn de ville nok også foretrække noget Gurli Gris musik.

C: Den der med at komme væk fra 'pligten' og så mere over til... Det kræver jo egentlig eller anden form for motivation og så et lille skud endorfin en gang imellem.

A: Måske nogle notifikationer. Sådan hvis man har slået sin rekord, at man så får det af vide.

C: Det kunne det være. Ja.

A: "Du gjorde det 2 sekunder hurtigere end du gjorde det sidste gang". Eller et eller andet. Man kunne jo også bare i menuen have at der altid er tre øverste highscores.

B: Top tre eller et eller andet.

A: Eller de instrumenter du har nemmest ved at gætte. "Du har altid nemmest ved at gætte fløjten". For eksempel.

C: Det er rigtigt.

A: Måske mere at man - der er en app der hedder duolingo hvor man skal lære sprog - der også hele tiden informerer om hvor godt du klarer dig sammenlignet med sidste gang og sådan.

C: Det motiverer. Det er jo helt sikkert. Der må være en masse teori om sådan noget. Ja. Nå. Et eller andet. En stor guld pokal som kommer. "Du har slået din rekord". Det kunne være motiverende. Bare sådan et afbræk. Det en sådan meget flad oplevelse, kan man sige. Og man sidder hele tiden: "Jeg føler jeg bliver bedre, men jeg ved det sgu ikke rigtig, det kan være jeg bare er i godt humør i dag". Ja. En eller anden motivation.

A: Man kunne også have sådan. Jamen. Et medalje system. Hvis du klarer dig inden for den her tidsramme, så får du en guld medalje. Inden for den her en sølv, og inden for den her en bronze. Der er jo mange forskellige motivationsfaktorer, man kan inddrage med computerspil.

C: Sådan som det er lige nu med sociale medier. Deling. Hvordan var det, i slog det op i Cochlear Implant Danmark gruppen. Det var der hvor jeg så det, ik. Der kunne sagtens sidde nogen. Hvis det var sådan en almen ting. Del med de andre i gruppen, eller hvordan fanden det kunne være. Jeg ved da godt at det er lidt langt ude. Men det er jo sådan det fungere nu. Del. Så er der en der giver et like. Endorfiner. Høj. Jeg skal dele noget mere.

A: Så kommer der lige en notifikation. "Jesper har lige slået din rekord" - "Oh, så skal jeg blive bedre end ham". Det er der også på Beat Saber.

A: Ja. Jeg tror vi er kommet ind på det hele egentlig.

B: Det synes jeg også. Jeg synes at vi er kommet godt rundt omkring.

A: Ja. Men ja. Har du andre kommentare? Andre forbedringer?

C: Nej. Egentlig ikke. Det er også nogle udmærket instrumenter. Jeg tænkte på om man kunne inddrage nogle andre instrumenter. Men det kan man altid.

B: Det kan man altid ja. Det er jo bare udvide det. Det ville også klart være en del af det hvis man skulle udgive dette mere kommercielt. Så vil man tilføje alle de instrumenter, man kunne komme på. Så der er mest mulig frihed.

A: Der hvor man høre forskellige instrumenter kunne man også sige, at man kan vælge en bestemt genre. Så vil det jo være genren som bestemmer udvalget af instrumenter. Så vil det være mere specialiseret til hvilken genre man høre.

C: Man kunne måske også hvis det skulle udbygges, vælge mellem strygeinstrumenter, blæseinstrument. Så er vi ude i nogle detaljer lige pludselig. Fordi den der med saxofon og trompet. Nogle gange så kan jeg godt - regne det ud. Fordi det ligner lidt en bass saxofon. Trompeten har nok et højere register. Det vil sådan lige. Det ved jeg faktisk ikke. Men jeg tænker. Okay. Den der høje tone, det kan saxofonen ikke spille. Så. Bang. Så trykkede jeg trompet. Og så var trompet rigtig. Og jeg kan faktisk stadig ikke høre forskel på dem. Det kunne være en nuancering egentlig. Så kunne man også tilbyde et bredere udvalg til, hvis nu der sidder en pianist, så forskellige slagtøj og strengeinstrumenter. Eller hvis der sidder en trommeslager, som ikke kan høre forskel på sine trommer, så kan man sidde og lege med trommelyde. Der er uendelige udviklingsmuligheder med sådan noget her. I har en lang karriere med det her.

A: Øhm, ja. Det sidste jeg tænke. Var sådan i forhold til det funktionelle. Men også i forhold til hvordan det ser ud. Du havde ikke nogen problemer med hvordan det rykkede rundt, eller hvordan det ser ud,

C: Det eneste jeg synes der var lidt spøjst. Var når jeg ser lige ud. Så er menuen tit lige ved siden af. Så må jeg kigge den anden vej der. Jeg ved ikke om det bare er mig. Ellers så ved jeg det sgu ikke. Det forekommer at man kun behøver en controller. Men hvis jeg ligger den anden frem, så kommer der sådan en hånd der begynder at svæve foran en.

B: Det er fordi den bruger controllerens position. Så den svæver hvis du lægger den væk.

A: Der er måske nogen der synes det er rart at have det opdelt. Så du styrer med den ene, og peget med den anden.

C: Grafik kan man også altid arbejde på.

B: Det er nok noget man kunne bruge mange timer på, med mange mennesker til at designe alt muligt lækkert. Det er nok noget med noget mere kommercielt med nogle flere penge i det.

A: Det tager tid sådan noget. Nu ved jeg ikke hvor meget du kan huske fra første gang du prøvede det. Ja. Vi har virkelig prøvet at gøre det pænere. Men man kan altid gøre det pænere. Vi har prøvet at gøre det lidt hyggeligt i hvert fald.

C: Jeg synes det er okay. Der hænger et instrument på væggen. Jeg kan ikke finde ud af hvad det er.

A: Det er en fløjte.

C: Er det en fløjte?

A: Ja. Den der lange sølv en?

C: Det ligner næsten en halvanden meter lang tværfløjte. Jeg var lidt i tvivl om det var en oboe eller en clarinet eller sådan noget.

C: Nu sidder jeg og kommer i tanke om noget andet. Om jeg kunne se noderne. Jeg behøver ikke at se noderne.

8.3 Final Prototype Data Visualization

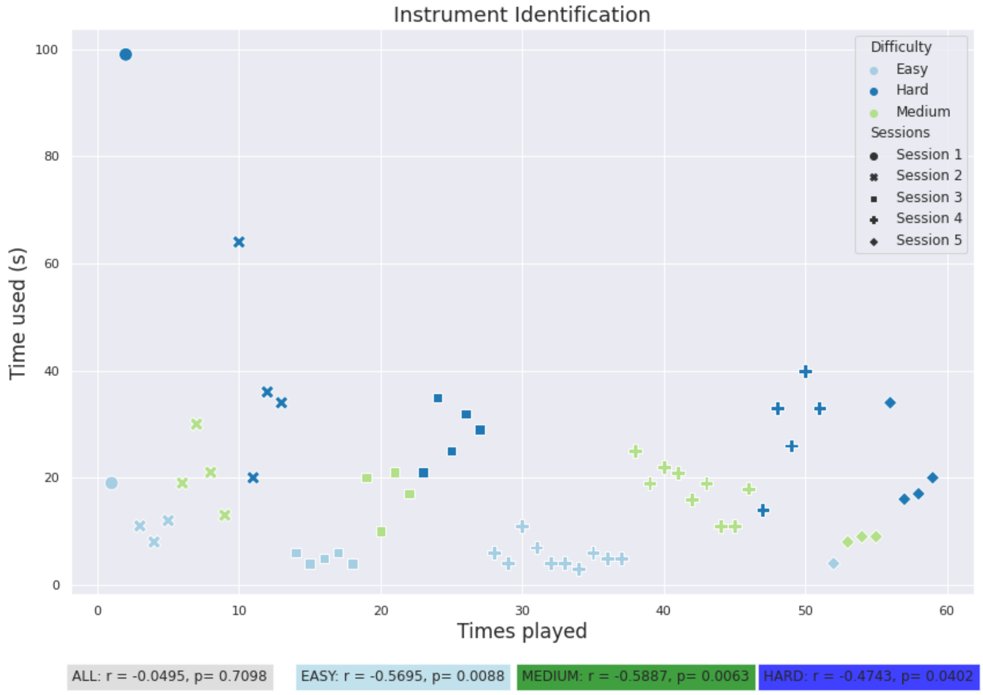

Figure 6: Scatter plot showing correlation between time used in seconds and number of times played when playing the instrument identification level.

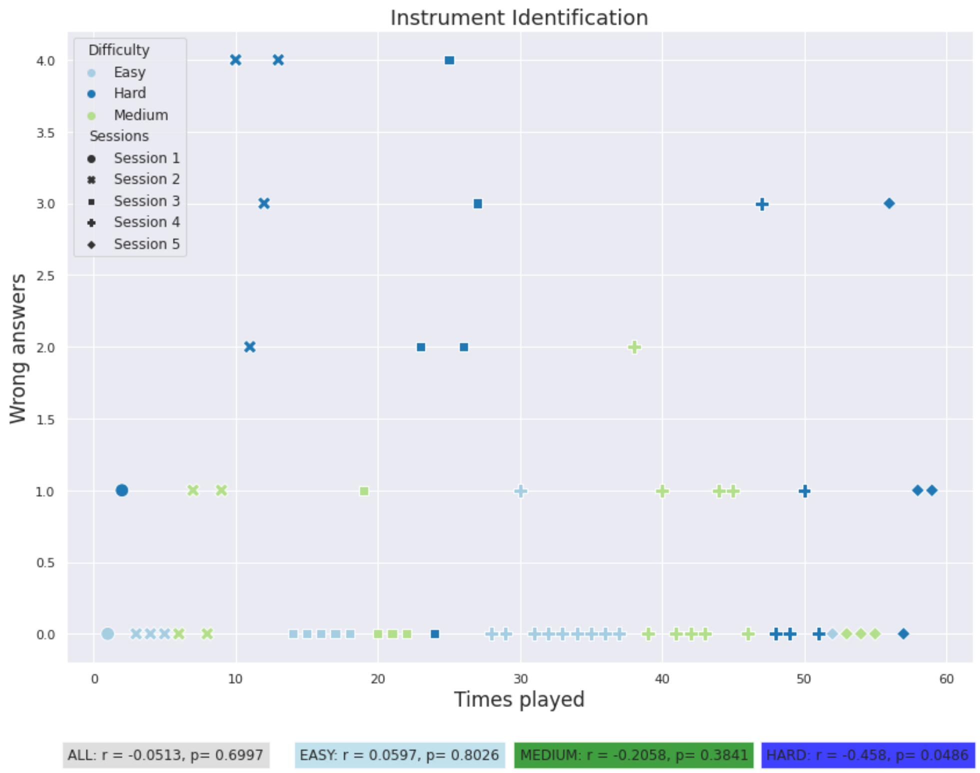

Figure 7: Scatter plot showing correlation between time used in seconds and number of times played when playing the instrument identification level.

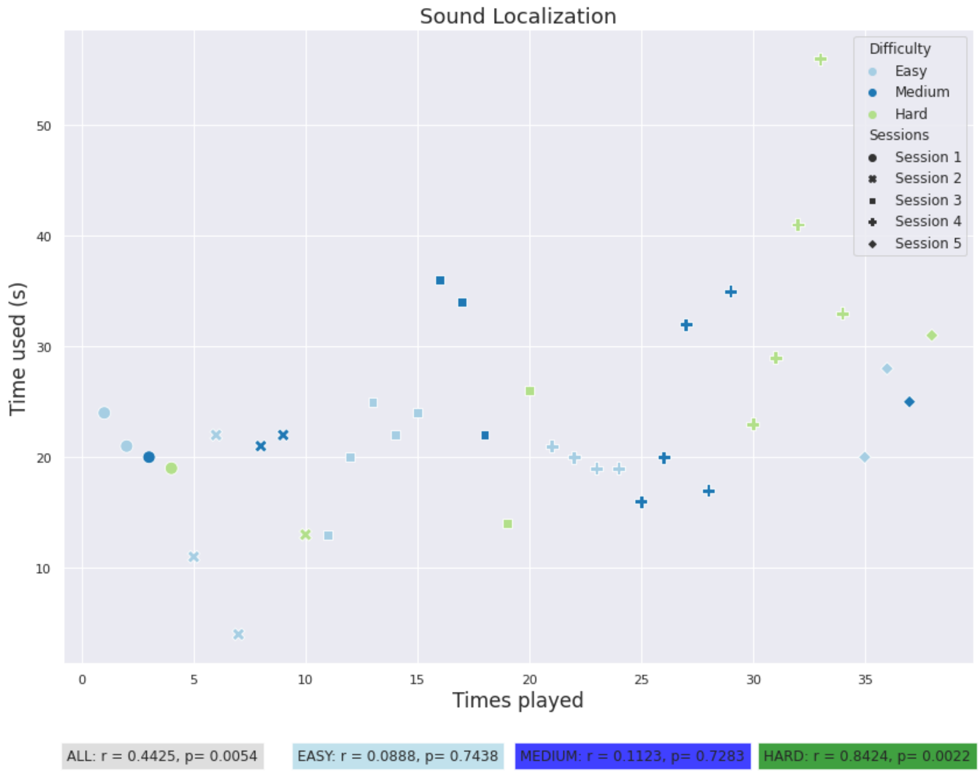

Figure 8: Scatter plot showing correlation between time used in seconds and number of times played when playing the instrument identification level.

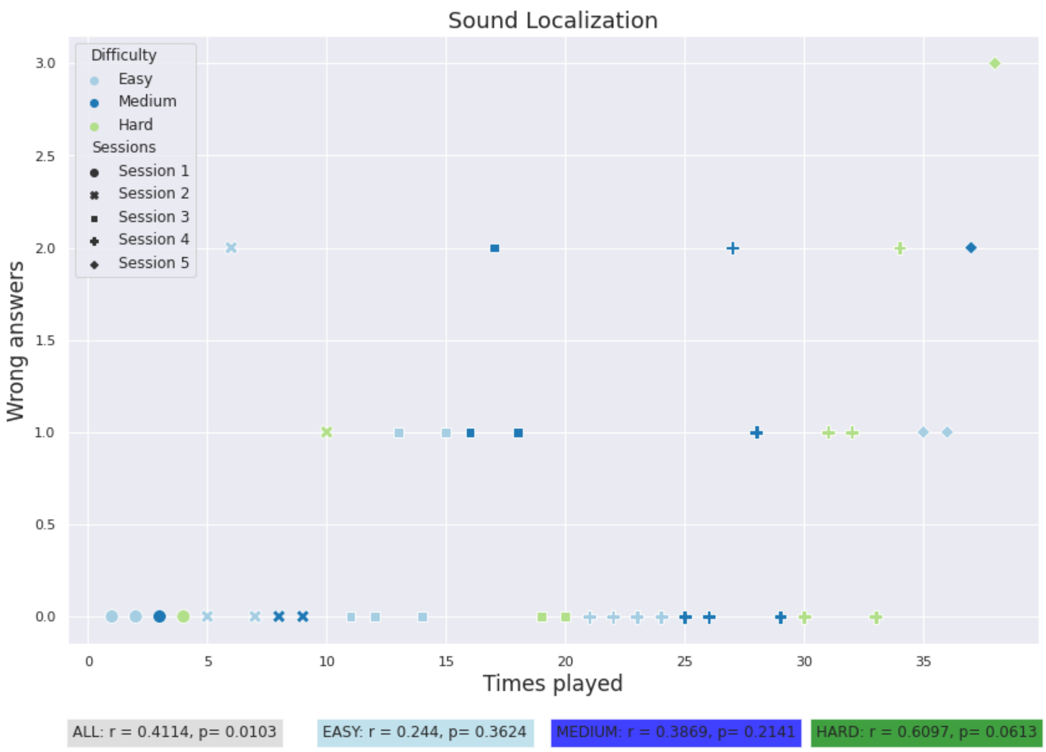

Figure 9: Scatter plot showing correlation between time used in seconds and number of times played when playing the instrument identification level.

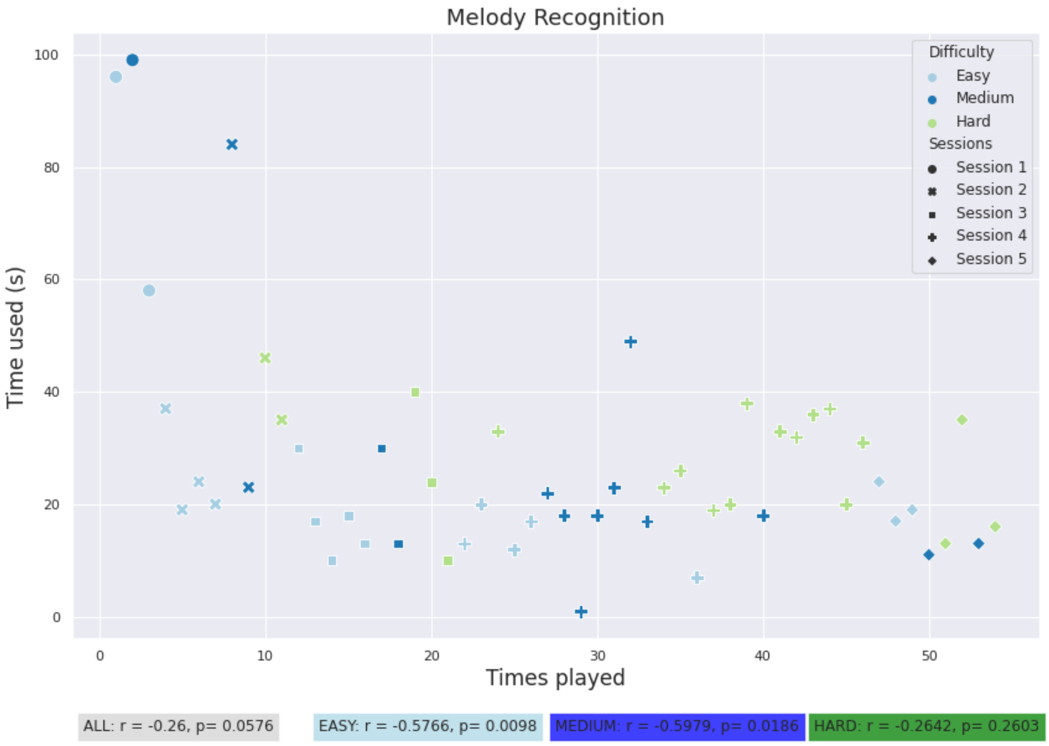

Figure 10: Scatter plot showing correlation between time used in seconds and number of times played when playing the instrument identification level.

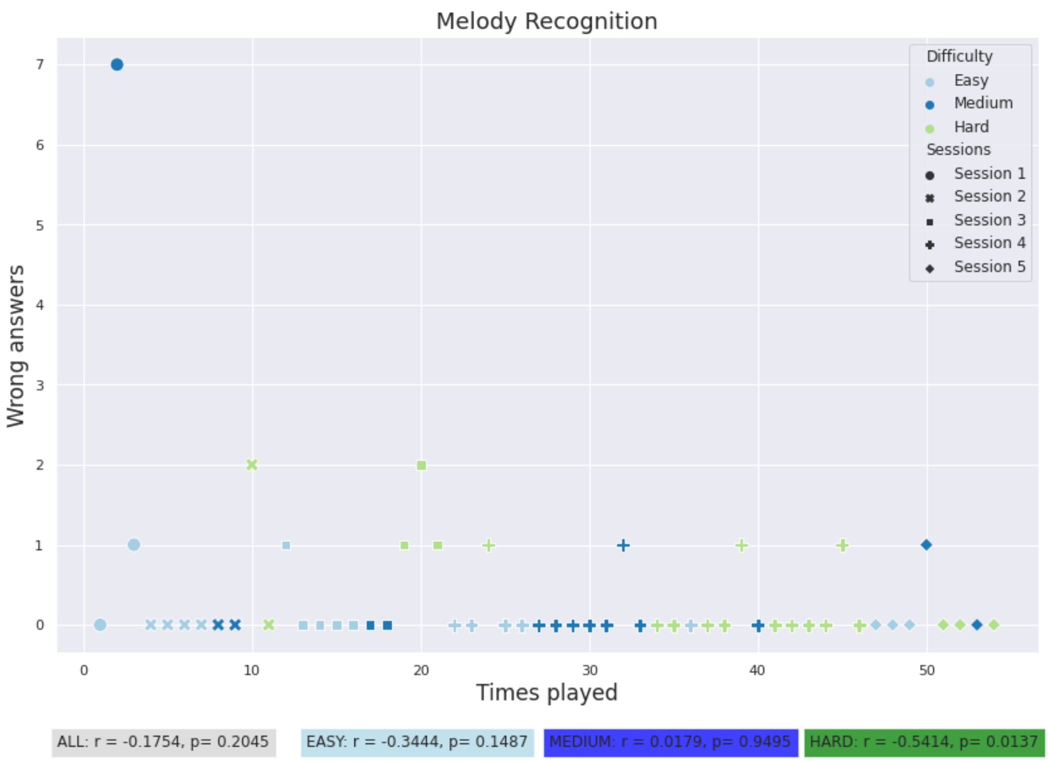

Figure 11: Scatter plot showing correlation between time used in seconds and number of times played when playing the instrument identification level.