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Musicality: A Game to Improve Musical Perception

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Abstract. Musicality is the concept that refers to a person's ability to perceive and reproduce music. Due to its complexity, it can be best defined by different aspects of music like pitch, harmony, etc. Scientists believe that musicality is not an inherent trait possessed only by musicians but something anyone can nurture and train in themselves. In this paper we present a new game, named *Musicality*, that aims at measuring and improving the musicality of any person with some interest in music. Our application offers users a fun, quick, interactive way to accomplish this goal at their own pace. Specifically, our game focuses on three of the most basic aspects of musicality: instrument recognition, tempo and tone. For each aspect we created different mini-games in order to make training a varied and attractive activity.

1 Introduction

From personal experience we know there are different types of people interested in improving their ability to perceive and reproduce music for a variety of reasons. There are those who would like to learn to play an instrument, to sing, or to dance, but do not know where to start. Others strive to improve their tone hearing so they will be able to tune a guitar without help, to strike the right note while singing, or maybe even find the right notes to compose their own music. As dancers they want to have a really good perception of the tempo of a piece of music as well as its tempo changes. There are those who just enjoy listening to music, but ask themselves if they could enhance their perception of music somehow. Others are just curious to see how musically inclined they really are. In addition, there are people who are already taking music lessons and studying music at a university or consortium to become musicians or music teachers, who may be frustrated by boring theory lessons that repeat the same exercises again and again. All these people interested in music comprise the target audience of our game, whose goal is to provide a fun interactive way of testing and improving their musicality.

There is no widely agreed upon definition of musicality however most people agree that it is a term describing the feeling (or perception) of music [7,9].

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Musicians are viewed as people with a high sense of musicality, but that does not necessarily mean they are born with it. While some people are musically inclined, it still requires practice and training to shape musical skills into something that can create respectable art.

The brain has a certain level of plasticity which allows this honing of skills [12]. Through exercises and training it is possible for a player to improve certain aspects of musicality, which is also the stated goal of our work. Specifically, we focus on three aspects of musicality: *instrument recognition*, *sense of tempo*, and *tone hearing*. These three aspects are usually considered among the most basic skills users need in order to start improving their musicality and, as mentioned above, they give valuable input to learn to play an instrument, to sing or to dance. For each aspect we have designed a set of mini-games that both train and assess the player's skills in that specific aspect. Our game shares the essence of several different musicality tests. However, it deviates by focusing on three general aspects instead of specific rote skills, targeting users of different skill levels. Through player testing, we confirmed our goal of creating an educational application that motivates the player to keep practicing on their musical skills.

2 Related Work

There already exist several musicality tests, most of them being used by universities as entry exams to test prospective students, e.g. the Seashore test, or PROMS (Profile of music perception skills) [8]. PROMS consists of tests for melody, tempo, accent, tone, tuning, rhythm, embedded rhythms, pitch and timbre. There was also a test conducted in the United Kingdom in 2011 [2], taken by more than 150,000 people, the largest ever investigation into the musical profile of an entire nation. It turned out there were some hidden musical talents in the population, and that many people seem to over or underestimate their musical abilities. A lot of people in the music business scored rather low at that test, so no real correlation exists between people who make money from music and their musicality. It was apparent that people who had undertaken musical training were better at remembering melodies and tapping out a beat in time, but not at detecting subtle differences in sound [1,2].

There are also commercial websites and applications that train a player's musical abilities or ear, respectively. These include Musical-u [3] and the Perfect Ear [4], which focus on music theory like interval hearing and other exercises for ear training. Pure ear training should however be differentiated from musical ear training. The website thetamusic [13] features several different, unconnected mini-games to train different aspects of musicality. In contrast, we strive to connect our created games to form a coherent product.

More developed music training applications also exists, such as Meludia [10]. Meludia is an ear training application that provides exercises in the form of simple games. Meludia covers many fundamentals aspects of music: recognition of melodies, forms, rhythm, intervals, chords, inversions, progressions. The development of the player ranges from the Discovery to the Expert modules. They also

include a practice mode and provide feedback when a player makes a mistake. In the discovery mode the tasks are formulated in a way that no musical knowledge at all is needed, e.g. they ask for stable/unstable instead of harmonics: minor/major. All in all, we can say that Meludia is in far from our vision of a musicality enhancing game. Our work is meant for a more general audience and not only (amateur) musicians and people taking music lessons. We also focus on three aspects of musicality: *instrument recognition*, *tempo*, and *tone*, with several different mini-games for each. Specifically, we developed a *missing instrument* mini-game to recognize when an instrument is removed from an ensemble by listening to the same piece of music with and without the missing instrument.

3 Game Design

As mentioned in Sect. 1, the purpose of this game is to help train and improve the player's musicality over a time period. Our game is centered around a musicality test which is used to assign a level of musicality to the player over the three previously mentioned aspects (*instrument recognition*, *tempo*, and *tone*). Although more clinical musicality tests (e.g. [8]) could also have been implemented, we decided to focus on the three mentioned aspects as they are fundamental components of musicality. For each aspect, we develop several mini-games, listed in Table 1. To ensure the overall quality of each mini-game given the time frame of development, we focused on producing three to four games for each musicality aspect. We offer five levels of difficulty, each one accompanied with a title presented to the player. Specifically, these levels are: Level 1 - Beginner, Level 2 - Amateur, Level 3 - Professional, Level 4 - Rock star and Level 5 - Maestro. We use the same mini-games in our test and in the two training modes we present later in the section.

Table 1. Overview of mini-games per aspect

Aspect	Instrument recognition	Tempo	Tone
Mini games	Instrument recognition Missing instrument Instrument counting	Tapping along Continue tapping Tempo difference	Sorting tones Tone memory Matching tones Pitch difference
Purpose	Hear instruments in a arrangement	Build skills related to rhythm and pace	Distinguish frequencies and intervals

Each of our mini-games ranges in difficulty between Beginner (Level 1) and Maestro (Level 5). For our *instrument recognition* mini-games, we increase the number of instruments played in each track. We also increase the number of instrument options that are presented to the user. We use these tactics to challenge the player to clearly hear and distinguish the different instruments in a track in order to choose the correct answer. For our *tempo* mini-games, we

reduce the acceptable threshold between the player's input and the tempo for a given composition. Specifically for the *tempo difference* mini-game, we shrink the change in tempo between the two presented tracks, making it more difficult to distinguish the difference between them. Finally we reduce the interval between the different notes or tunes the player has to distinguish in our *tonal* mini-games. By either reducing the difference between compositions or increasing the possibility in choices, each of our mini-games can become progressively more challenging and continue to assist the player in building their musicality skills.

To make our game accessible to a wide audience, we designed two training modes: "Story mode" and "Challenge Mode". Each mode leverages different player incentives in order to promote engagement. Story mode is a more traditional walk-through experience for players looking to improve their musicality through suggested games. Challenge Mode caters to a more competitive style of play, motivating players by completing achievements. Both modes contain the same mini-games and focus on the three aspects of musicality listed in Table 1.

3.1 Challenge Mode

Challenge mode allows a player to play all mini-games regardless of their musicality level. This mode exists primarily for those players who do not wish to follow a progression of levels, but rather enjoy quick, short games. The "Challenge Mode" also gives the player the opportunity to choose the specific mini-game they wish to play at any of the five levels of difficulty. Specifically, the player is presented with a list of all musicality aspects that they are able to train in and after selecting one they are shown a list with all games related to that aspect. After finishing three rounds of the mini-game, the player is presented with a score (in the form of stars) so that they can see how well they performed. The amount of stars that the player receives depends on how successfully they have completed the exercise. The game keeps track off the highest amount of stars a player has gotten for a specific mini-game at a particular level of difficulty. This presents the player with the goal to get three stars for every mini-game at every difficulty level. Additionally, the player is given the chance to take the musicality test whenever they wish to quickly determine their level without the need of collecting the required points to do a test as is required in Story Mode.

3.2 Story Mode

The player follows a minimal story to gradually increase their musicality in Story mode. A level is assigned for each musicality aspect and the overall musicality level is shown, e.g. if the player is assigned level one for all aspects then their overall level is 1.1.1 (where the first number is the level in *Instrument Recognition*, the second the level in *Tempo* and the third the level in *Tone*). In Story Mode, the player follows the character they created who is a beginner musician. This person wants to make a name for himself in the world of music. However, they lack the necessary musical skills and need training to acquire them.

The story is viewed from the perspective of the player and takes place in present day. In order to improve a particular aspect of musicality, the player must play mini-games (shown in Fig. 1) related to that aspect.

Successfully completing (part of) a mini-game earns the player notes for that aspect. Once the player has gathered enough notes they are allowed to take a quiz to increase their musicality level. This quiz is actually the musicality test with each aspect increased in difficulty by one level. We do this to check whether the player has improved their musicality. If the player fails the quiz, then they stay at the same level and are left with half of the musical notes that they had before taking the quiz. If, on the other hand, the player has improved in at least one aspect, they advance a level for that particular aspect. In addition to that, the player is shown playing at a music gig. Depending on their level, they either play a small bar gig, a large concert hall, or somewhere in between. The player's goal in Story Mode is therefore to complete the final concert for each aspect, achieving a musicality level equal to 5.5.5.

3.3 Technical Challenges

Because our game runs on mobile devices, there are a few limitations which we have to deal with. One of our goals was to ensure that our game could be accessed by as many people as possible. This goal influences how many devices we want to support. To make it possible for people with older phones to also run our game we chose to support Android devices which ran "Ice Cream Sandwich" (API 15) or higher. In practice this means that our application will run on 99.6% of all Android devices [6].

As many of our mini-games have the player compare pieces of a composition to determine differences, the mini-games require meta-data about the piece of music. For instance, the *missing instruments* mini-game requires the instruments in order to remove one instrument and display the removed instrument choices to the player, and the *tempo difference* mini-game requires timing information (such as BPM and a time signature). As we want to programmatically make these changes to the composition, we chose to use MIDI [11] instead of conventional MP3 files. MIDI files contain score information (note velocity, duration, pitch), as well as information about which instrument plays a certain note and timing information (BPM of the music and time signature). We can manipulate this information in order to play a composition at an exact BPM or pitch. However, MIDI files do not contain any information on how something should "sound". This means that we are unable to represent certain musical perception skills, such as *accent*. Usually a MIDI file is played by a MIDI sequencer which takes the timing and instrument information and plays a instrument sample at the right time. For this game, we use the Android MIDI sequencer "MediaPlayer" [5]. The overall pipeline of the MIDI System is shown in Fig. 2.

The process of analyzing a MIDI file for all of its information is the most resource intensive task in our game. Even though MIDI files are only a few kilobytes in size they usually contain at least 1000 MIDI events which all have to be processed. To reduce the amount of stutter of the game when reading

(a) Story Mode

(b) Instrument Recognition Mini-game

(c) Tempo Difference Mini-game

(d) Tone Mini-game

Fig. 1. Screen shots showing our game's story mode as well as a mini-game for each aspect of musicality we test.

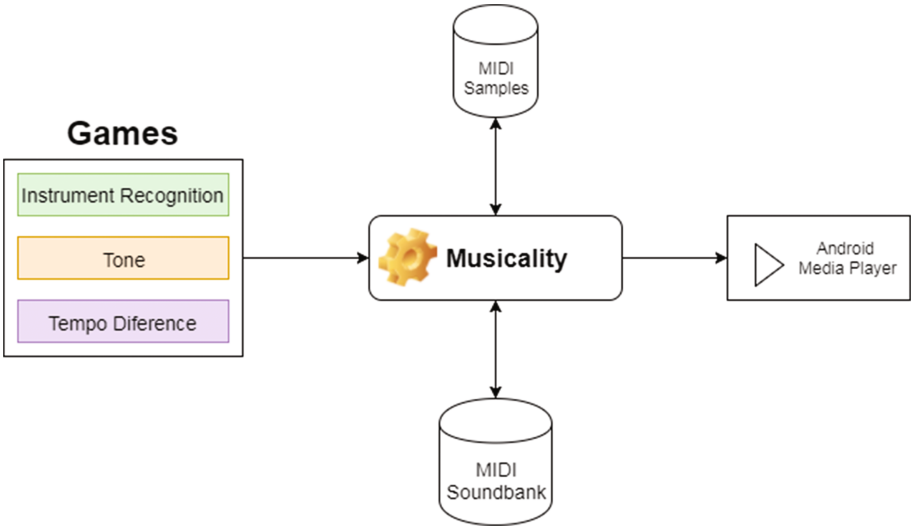

Fig. 2. MIDI System pipeline

and processing the MIDI data we decided to split the process in two parts. The MIDI file is first analyzed and all relevant information is extracted and stored. After this is done modifications can be made to (an abstract representation of) the composition without performance penalties. Then, once the player plays the music, the MIDI file is reassembled with all the updated information. The process of reassembling the MIDI file typically only happens once; if the player pauses and plays the music again and no modifications are made, the already assembled piece of music is loaded from a cache.

4 Evaluation

To evaluate the game during development, a test session was planned every week, making sure that newly implemented features worked and acted like intended. In this section we discuss our method of testing as well as some of the feedback obtained during testing.

4.1 Design of Test Sessions and Tests

We conducted weekly sessions with testers who evaluated our application. We allowed the testers to play the mini-games related to a certain musicality aspect, and we analyzed their play for: *difficulty*, *engagement*, *enjoyment*, and overall functionality of the mini-games. We used this analysis to determine direction that we would follow as the development progressed. It also allowed us to gain insight as to if the mini-games were meeting the expectations of the testers as well as if the testers felt the mini-games were improving their musicality.

We had a diverse testing group (56% male and 44% female), where a majority of our participants were young individuals (86% were between 21–30 years old). Moreover, one of the test players was a professional musician whose feedback played a vital role during the development phase of the prototype. Many of the test players also actively played the mini-games on a daily basis. We hoped that by looking at the two ends of the targeted group we would be able to get a good picture of what the needs and preferences related to our game are.

4.2 Result and Discussion

For our game, feedback from both the musician (people who have experience in playing at least one instrument) and non-musician group were indispensable as the "alignment" of such feedback from both groups depicts the extent of the success of the implementation. We received positive feedback from both groups concerning the design and the originality of some aspects of the game, especially *Missing Instruments*. The latter group also commented that they believe that it might help them improve their musical perception. Furthermore, players seemed to enjoy playing and most of them were motivated to continue playing in order to achieve better results themselves.

Since we were especially curious to know how the audio quality affected gameplay, we explicitly asked the participants during observations. Most of the testers said it is sufficient, but we also got some complaints that some of the instruments sounded too similar which made it unnecessarily difficult to recognize them. Moreover, testers suggested that they would like better audio quality instead of MIDI audio which is the motivation to incorporate better quality audio files in the game as a future step.

Some suggestions from the tester group provided insight into possible future additions to the existing prototype. For example, the players would like to be able to play the mini-games intuitively, without studying the instructions. Also, the aspect rated with the most disliked mini-games was *tempo*, as the tapping mini-games seemed to not always work properly or giving not the right guidance to follow the beat.

Furthermore, there is still room for improvement in terms of audio quality and responsiveness. The difficulty scaling of some of the mini-games still need tunning, which will require more player and test data. Additionally, there is also the possibility of adding new mini-games for the existing aspects and adding new aspects to further expand on the musicality topic.

While the implemented game is only a prototype we can conclude from the feedback that we have received that the overall design and functionality are at an acceptable stage. Based on the feedback received, we were able to achieve the creation of a fun and aesthetically pleasing educational game. Also, even though some additional tweaking is required, all the implemented mini-games work well and contribute to the learning process of the player.

5 Conclusion

We presented the design, development, challenges and evaluation of a game prototype aimed at improving a players' musicality. The game consists of mini-games to improve three aspects of musicality: *instrument recognition*, *tempo*, and *tone recognition*. These mini-games can be accessed through two different modes: A story mode, where the players are presented with games at a difficulty that is appropriate for them, and a challenge mode, where the player can pick an aspect, choose specific mini-games and difficulties in order to obtain maximum score in all of them. We used MIDI files, allowing us to quickly create and manipulate complex musical compositions with a slight decrease in audio quality when compared to acoustical or studio recordings. This is definitively a potential area for improvement to incorporate high quality audio files as audio is on the forefront of the game. Doing so will require solving new technical challenges, as we cannot remove instruments from an audio file. Keeping file size in check will be one of the bigger problems when increasing the number of compositions and games. Furthermore there are still some more possibilities to apply gamification techniques to, for example, encourage recurrent practice. Finally, since a person's musicality improves with practice over time and due to the short time frame this prototype has been in development we were not able to test how successful the game really was concerning the improvement of musicality. For further insights, thorough user studies must be conducted separately for different player groups. This should be one of the main concerns when moving forward with the further development of this musicality game. We hope that carrying out this more robust user study (by possibly examining different approaches for our two testing groups) will provide insight into the "alignment" of feedback by two groups. After such a study, we hope to determine if **(i)** the less musical group agrees that by playing the game it is possible to gain musical intuition, and **(ii)** the more musical group agrees that the game keeps them motivated to achieve better results.

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