Soundoku: A sound puzzle game

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***Abstract*—We present *Soundoku*, a sound-based puzzle game designed for sighted people. The goal of this game is to determine if it is possible to transform a popular puzzle game like *Blendoku* into a sound-based puzzle, without making it a musical game, and to obtain a fun, interesting and eventually instructive game. Initial evaluations of our game by players between the ages of 17 and 26 indicate that the game is considered fun if not addictive. These results pave the way for the creation of a game using procedural generation of sound puzzles.**

***Index Terms*—Audio game, Sound Puzzle Game, Soundoku, Education**

I. Introduction

In video games, sound and music rarely have the lead role outside musical games like *Just Dance*, *Guitar Hero* or *Beat Saber*. But even in these games, visual information is essential to play.

Non-visual games or games where the visual is secondary are usually designed with blind people in mind. Attempts to make games accessible to both blind and sighted people and allow them to play together are increasing [1]. Some games are specifically designed for the blind: *Blind Hero* [2] replaces the visual information of *Guitar Hero* by the use of a haptic glove. *Pingball* [3] makes the classic experience of a physical pinball machine accessible without visuals by sound spatialization. And some games are designed specifically for educational purposes: to train navigation skills of blind children [4] or to give sighted people a sense of the experience of being blind [5].

Sound-based puzzle games for sighted people like *DarkEcho* [6] or *MazeSounds* [7] do not really require listening to the sound. The first one proposes a visualization of the sound waves emitted to make the limits of a labyrinth appear; in the second one, the sound is emitted by the walls of the labyrinth and can be used only to locate them. Sound-based puzzles where the sound has to be listened to in order to solve them are also aimed at a partly blind audience, and are often focused on reordering pieces of a musical track [8], [9]. An exception is the game *Phonopath* [10]: it requires careful listening and sometimes manipulation of the sound spectrogram. It is finally neither accessible to the blind nor to beginners because it requires a serious sound background.

We therefore set ourselves the goal of creating a puzzle game for sighted people in which sound is the main element of the gameplay: Can we convert a popular puzzle game into a sound-based game for sighted people without turning it into a musical game or make the sound a simple position signal? Can the sound and visual roles be reversed? That is, can sound be the main element of the game instead of the visual and the visual reduced to a supporting role outside of a game specifically related to music (dance game, or playing music) and will this game be fun for sighted people, interesting and possibly educational?

To answer these questions we have designed *Soundoku*. *Soundoku* is directly inspired by *Blendoku2* [11], a game in which the player must reconstruct scales of colors varying in hue, value and saturation by aligning tiles of different colors along several axes.

The larger goal of *Soundoku* is to lay the groundwork for procedural generation of sound puzzles for a wide audience including sighted people and people who do not necessarily have musical knowledge. This prototype should allow us to check if it is possible to create a sound game as popular as *Blendoku2*. How to adapt the gameplay? Which sounds to use? Can we create puzzles simple enough to be accessible to a large audience, but still interesting and fun?

In what follows, we present *Soundoku*, its game design and content design. We then report on the first tests we did on players and discuss the adaptations we had to make to transform a visual-based game into a sound-based game.

II. Soundoku game design

Our project is inspired by the game *Blendoku2*, a free mobile puzzle game for Android and iOS mobile devices. In *Blendoku2*, players must fill a grid with squares of different colors, some of which are already placed. The goal is to obtain a smooth sequence of colors, both vertically and horizontally.

The transposition of color scales into sound scales seems quite straightforward, which guided our choice. We developed *Soundoku* with Unity [12] and created 5 chapters of 10 levels each.

In the following we present game design decisions and content design.

A. Game design

Tiles are initially in disorder, like in *Blendoku2*. These tiles are aligned in a secondary grid placed above the grid to be completed. Each round tile is a button; you can click on it to listen to the sound and click on a location in the destination grid to place it there. When the destination grid is filled, a

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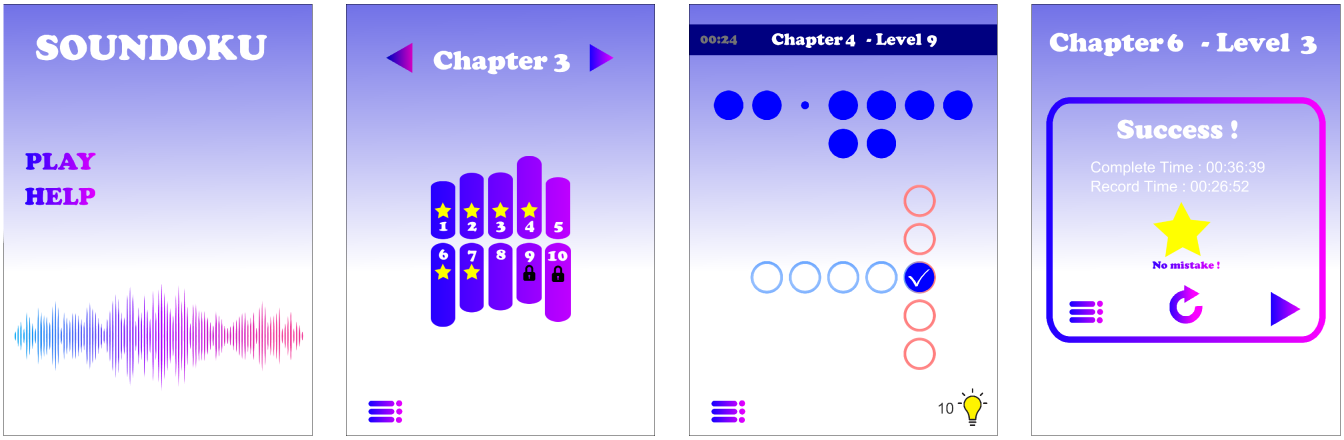

(a) Main menu. (b) Level selection menu. (c) In-game interface. (d) Victory menu.

Fig. 1: Screenshot of *Soundoku*.

harsh sound indicates if the proposed solution is incorrect; otherwise each sound is played in order before going to the victory screen (fig. 1d).

We opted for simple graphics. There are no visual clues to guide the placement of the round tiles. The game is divided into 4 screens: main menu, level selection menu, in-game interface and victory menu (fig. 1).

We created 5 chapters whose difficulty is comparable to that of the first level of *Blendoku2*. The rarity of sound puzzles explains this choice. Players are not used to depending only on sound clues: the difficulty of the game is therefore quite high even for a grid limited to a maximum of two sound scales placed vertically and horizontally.

B. Content design

The four main characteristics of a sound are pitch (frequency), loudness (amplitude), timbre (wave shape), and length (duration). Each chapter focuses on the variation of one or two sound characteristics. In levels that vary two different characteristics of sound, the player must complete two scales of sound placed along two different axes. The sound scales were created using REAPER [13]; they are synthesized sounds such as piano, guitar or simple sine waves.

Chapter 1 proposes pitch scales (piano, guitar) with increasingly reduced intervals ranging from 2 to 0.5 tones. Chapter 2 varies the duration of the sounds (from a piano or a simple synthesizer) with a finer and finer difference from 312.5 to 62.5 ms. Chapter 3 varies the wave shape of a synthesized sound from sine waves to triangular or square waves. Chapter 4 proposes two scales varying the duration and pitch (from 2 to 0.5 tones and from 250 to 62.5 ms). Chapter 5 proposes sound scales (piano, guitar) with a low pass filtering varying by bands from 1000 to 250 Hz.

All these sound scales were made by hand. However, the generation of these sounds can easily be done procedurally off-line, and, we believe, even on-line.

III. Play Test and Game Improvements

We conduct preliminary tests on 14 players, which are Saint-Cyr cadets and members of their family, to evaluate the *Soundoku* game. All players were between the ages of 17 and 26 and none of them were visually impaired. Some play a musical instrument but there are no true musicians. After finishing the game, the players filled out a survey with 5 questions evaluated with a 5-point Likert scale [14].

In what follows, we present the results of these tests, the information we have gained from them, and the improvements we have made to the game as a result.

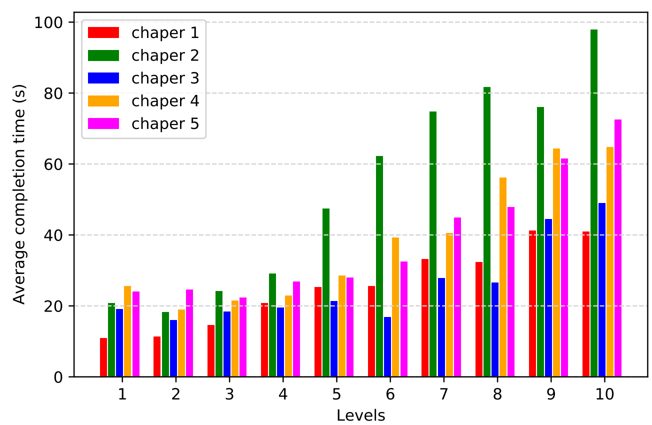

Fig. 2: Average time to complete each level of each chapter of the game.

A. Play test results

We evaluated the difficulty of the different levels according to the time needed to solve them. Figure 2 shows the average time required by the different players to solve each level in each chapter. We can see that the desired progression of difficulty is well present in the succession of levels and chapters. However, it appears that the difficulty of chapter 2

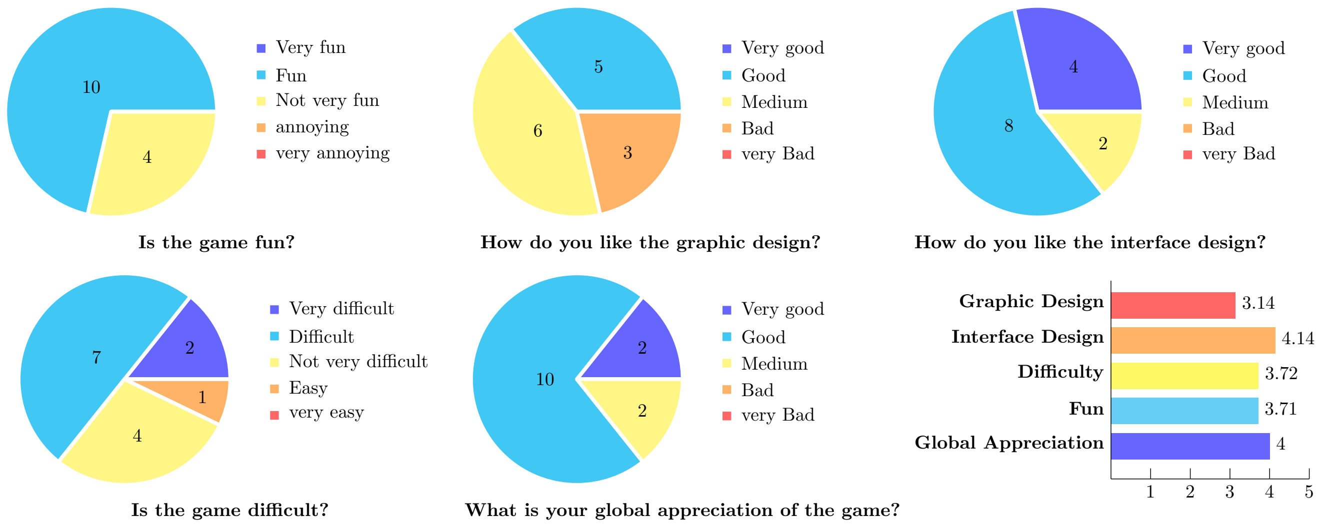

Fig. 3: Question answers for the 14 tested players.

is too high. Puzzle solving time increases too quickly from level 4 and is well over 1 minute after level 6.

Figure 3 presents the results of the survey. It appears that the graphic design is what players like least, while the interface is what got the highest score. We did not linger on the graphic design improvement, because it was not the main goal of this work.

The difficulty score is between “Not very difficult” and “Difficult”, which is close to the desired difficulty of the game: it should challenge players without being laborious. However, it appeared that difficulty is perceived differently by different players. Indeed, players who are musicians or have a “better ear” may find some levels easy especially when it comes to classifying sounds according to their pitch. The fun level score correspond to “Quite fun”, but it could still be improved as some players found that the game can be repetitive.

Some players have spontaneously gave us their impressions of the game with recurrent remarks:

- Chapter 2 (which varies the duration of the sound) is not very fun and is repetitive, and is too difficult at the end.
- Chapter 3 (which varies the wave shape) is the most fun.
- Chapter 4 (which varies duration and pitch) is hard to understand, as there is two different varying parameters.
- The game is not that fun sometimes, but it is addictive.

B. Interface and game play improvement

In chapter four, some players have found it hard to understand that the parameter that varies is different between the horizontal and vertical axis, and were a bit confused. To make this more clear, we use different slot colors when there are different varying parameters (fig. 1c). This way, players should be more able to understand there is a different varying parameter for each axis.

To avoid re-introducing a visual clue, we also thought of using preliminary levels varying only one of the parameters at a time on one of the two axes before joining the two. Additional playtesting will be required to identify the best of the two solutions.

When a sequence is correctly reconstructed, we added an illumination of the corresponding round tile to improve the perception of each sound played.

To avoid the player getting bored if he is blocked, we added a hint system. It gives him the possibility to place a chosen pawn automatically by clicking on a hint button.

C. Content improvement

The players feedback shows that variation of sound length in chapter 2 can be boring, we then change the varying parameter at the middle of the chapter, and replace length by volume. This way, the player will have to understand that there is a change in the varying parameter, and it will revive its interest.

A constant increase in duration is less noticeable for long sounds: the longer the sound becomes, the smaller the ratio of difference between two sounds is. Acoustics teaches that an octave interval corresponds to a division by two of the length of the vibrating element that produces the sound. This division by two corresponds to a multiplication of the fundamental frequency by two. Thus, the frequencies of two sounds separated by the same interval are distant by the same ratio. As for the frequency variation, it seems that the ratio of the length variation between two sounds must be constant for an equivalent increase in duration to be perceived.

To make the sound scales more balanced we have modified the way of varying the different sounds that compose them. Let n be the order of a sound, and T_n its length. Then, for any n: $T_{n+1} = T_n \times c$. Where c is a constant to be adjusted according to the desired difficulty.

Furthermore, using a sound with a shorter decay make it easier to distinguish its end, so we also reduced the decay of the sounds that we use in chapter 2.

One of our concerns was whether it was possible to make a fun game without making it a musical game. However, some of the players who tested our game expressed the desire for an additional chapter consisting of reordering the pieces of a melody. We then added a 6^{th} chapter with 6 levels corresponding to 6 melodies (Mozart's Trout, Beethoven's Ode to Joy, Rossini's William Tell Overture, etc.).

IV. Discussion and Conclusion

We have created a sound puzzle game inspired by *Blendoku2*. The color scales are replaced by sound scales varying according to different parameters: pitch, duration, volume, timbre (wave shape variation or low pass filtering).

Our goal was to clear the creation a sound-based puzzle game for sighted people, that requires careful listening of the sounds to solve the puzzles, while being fun and interesting without being a "musical game". Our goal was also to evaluate this prototype to lay the foundation for procedural generation of sound puzzles.

The tests carried out on a first version of *Soundoku* show that the game is considered rather fun or at least addictive by the players. Although the difficulty of the 5 chapters of the game corresponds to the simplest level of *Blendoku2*, the puzzles were evaluated as rather difficult by the players. We assume that a greater use of sound as a gameplay element in games could train players, and would allow to increase the difficulty level.

The demand of the players for an additional chapter based on the reconstruction of melodies shows an attachment of the players to the "musical game" genre, however. This seems to reflect the habits of players who tend to ask for what they know and like. However, the fact that the players rated the game as rather fun gives hope that it will be possible to open them up to new types of sound game.

Concerning the gameplay aspect, several avenues of future work are to be explored for the evolution of the gameplay and to make the game more interesting, fun and pleasant: for instance, we could make sure that the final reading of the reconstituted sound scales results in an aesthetically pleasing phrase. A chapter based on melody reconstitution could have several horizontal axes allowing to superimpose several instruments – a melodic voice and accompaniment or, much more difficult, two melodic voices of the same tessitura – thus educating the player to polyphonic listening.

It will be interesting to measure the influence of *Soundoku* on listening to see if the game improves sound recognition, increases sensitivity to sound, and educates the ear. The game could then be used as a means of testing hearing avoiding the bias of classical tests where the patient can consciously or unconsciously cheat by claiming that he "hears" a sound. It would also be interesting to know if such a game could provide a means of rehabilitation in the case of sound trauma, for example.

A last question is also raised: is a sound game more difficult only because of the lack of education of the ear or is it an inherent difference in our senses? It would be interesting to compare the difficulty and learning curve in *Blendoku* and *Soundoku* games, and identify the criteria of the sound that makes a puzzle more difficult. This difficulty can also depend on the age (and the auditory capacities) of the players: tests on different age groups would be desirable for a study of the difficulty.

The work done on *Soundoku* and presented here was a first step in creating a game with procedurally generated sound puzzles. We are going to make *Soundoku* evolve to generate the different levels procedurally. For this we plan to use *Gradrigo* [15], an audio synthesis programming language developed by one of the authors of this paper. It aims at procedural generation of the classic arcade cabinet-sounding audio effects.

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