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Berge, Drew; Bettencourt, Danilo ; Lageweg, Stanley; Overman, Willie ; Zaidi, Amir; Bidarra, Rafael

DOI
10.1145/3383668.3419919

Publication date
2020

Document Version
Final published version

Published in
CHI PLAY 2020

Pinball for the Visually Impaired – an Audio Spatialization and Sonification Mobile Game

Drew Berge
Danilo Bettencourt
Stanley Lageweg
Willie Overman
Amir Zaidi
Rafael Bidarra*
Delft University of Technology
The Netherlands

ABSTRACT

We present *Pingball*, an audio-based mobile game that makes the classic experience of a physical pinball machine accessible to everyone, including those with visual impairments or complete blindness. Pingball keeps the essential game mechanics of traditional pinball, but both the game design and the level design were totally overhauled, to be playable without any visuals. This was accomplished by building every feature from the ground up using only sonification techniques, such as shifting pitches and varying volumes, and spatialization techniques, such as moving audio sources through three-dimensional space. The level design makes use of a broad stereo-field by having a widened playing area featuring gameplay objectives spread over different locations. Evaluation has shown the game was considered quite playable and enjoyable by players both with and without a visual impairment.

CCS CONCEPTS

• **Human-centered computing** → **Accessibility**; **Auditory feedback**; *Interaction paradigms*; • **Social and professional topics** → *People with disabilities.*

KEYWORDS

audio spatialization; sonification; audio games; blindness; inclusive games; mobile games; pinball

ACM Reference Format:
Drew Berge, Danilo Bettencourt, Stanley Lageweg, Willie Overman, Amir Zaidi, and Rafael Bidarra. 2020. Pinball for the Visually Impaired – an Audio Spatialization and Sonification Mobile Game. In *Extended Abstracts of the 2020 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '20 EA), November 2–4, 2020, Virtual Event, Canada.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3383668.3419919

*Corresponding author: r.bidarra@tudelft.nl

CHI PLAY '20 EA, November 2–4, 2020, Virtual Event

ACM ISBN 978-1-4503-7587-0/20/11…$15.00
https://doi.org/10.1145/3383668.3419919

1 INTRODUCTION

Almost all video games that are currently available in the market use visuals as the predominant channel of engaging the player and conveying information. However, this leaves very little playing choices to people with significant visual impairments, and things get only worse for those with complete blindness [4, 5, 8]. While many games try to accommodate people with various disabilities, visuals still play a central role: playing those games with only sound is infeasible. Some games are playable with only their audio, but there are far fewer games that have audio-only design as a central principle [1, 2, 7]; Pingball comes in this last category. Designing a game to be played without any visuals is a task with quite unique challenges, including identifying the most suitable areas to take advantage of the audio space, as well as the inherent limitations of not having any visuals to rely on. We describe the main design decisions of Pingball, briefly summarize its technical implementation, and discuss the player testing performed and its results.

We developed Pingball in cooperation with muZIEum[1], a unique museum in Nijmegen, The Netherlands, where visitors experience in a variety of immersive ways what it is to have visual impairments. At the moment, muZIEum is taking the necessary steps to provide its visitors with the opportunity to play Pingball.

2 DESIGN

At its core, Pingball aims at conveying the game mechanics of traditional pinball within an audio-only player experience, with the goal of making pinball entirely playable by people with any level of sight, from fully sighted to completely blind. Among other aspects, this means having various elements typical of pinball, like (active) *bumpers* that bounce the ball back, *flippers* to keep the ball from rolling into the drain, as well as trying to keep the elements of fun provided by traditional pinball, including the sometimes *frantic bouncing* of the ball when it lands in the right spot. Pingball is also designed to be a *pick-up-and-play* game: just as one who tries pinball for the first time can almost immediately start playing it, Pingball is conceived as a low-threshold, instantly accessible game. The best example of this regards how the player interacts with the game: when launching the game, the option is (orally) given to either hear a tutorial or start a game. This choice is made by simply tapping the left or right side of the screen, and this tapping

[1] https://muzieum.nl/

mechanics already represents the entire control scheme of the game, driving both the flippers and the minigames.

Various options for spatializing and sonifying game elements were considered and implemented. The most immediately noticeable difference from traditional pinball is the shape of the playing field: normally, pinball machines are rectangular, their length larger than their width. Instead, Pingball uses a wide field, 'stretching around' the sink, to make better use of spatialization, and thus getting the most out of lateral directional audio.

Still, even perfectly spatialized audio would not be enough, on its own, to make Pingball a playable and enjoyable game. Various aspects of the game rely on sonification to give the player essential feedback on the state of the game. For example, crucial features like the position of the ball sliding on the flippers, or the distance from the ball to the drain, have their own specific sounds. The methods used to sonify this information include but are not limited to pitch shifting, playback frequency and volume, and are partly inspired by the Audio Game Hub [3].

Most concessions that had to be made revolved around the level of feedback specificity possible without any visuals. For example, with traditional pinball, a player may be able to see the ball rolling quickly towards the drain and respond accordingly; without a visual aid, however, it becomes significantly harder to tell if the ball is heading straight towards the drain or if it will just roll past that direction. A similar limitation holds for choosing how (and when) to shoot the ball with the flipper: in pinball, there are often narrow corridors to shoot the ball into; that level of accuracy when aiming for targets cannot be demanded without specific spatial audio cues, somehow indicating what is happening. For this reason, the field is split into three sections, each with their own theme, as well as characteristic and identifiable sounds. This helps make it clear to the player where the ball is, while simultaneously providing more opportunity for diversified mechanics. In addition, these sections also enable the player to intentionally aim for a specific target, without the layer of confusion that would be introduced when attempting trial and error in the dark.

To give the player an increased sense of achievement, the game includes the possibility of unlocking a pair of minigames, after meeting the appropriate conditions. This brings variety to the gameplay experience, while also giving the player an overall goal to work towards to increase their score.

The main challenges in designing Pingball arise from the various trade-offs that had to be made when making an audio-only game. One example of a concession that had to be made to balance overall playability with ease of access was a short voiced tutorial to explain a few key sounds and mechanics. This supposedly goes against the desired pick-up-and-play feature, but our experience confirmed that even a short tutorial strongly helps overcome the significant hurdle of learning what the sound cues mean: it allows the player to get into action much faster after the tutorial than they would by starting with zero knowledge. However, if too many different sound cues were to be implemented, this could overwhelm the player with overlapping sounds, all conveying potentially important information. We believe that the choices made in designing Pingball achieved a good balance within all tradeoffs and constraints, while still being true to what it principally was designed to be: a very accessible and enjoyable audio-only pinball game.

3 IMPLEMENTATION

Pingball was implemented in Unity 2019.3.7f1 using C#, Probuilder and Oculus Audio SDK 1.48. Builds were cross-compiled for both Windows and Android, with only minor changes to the code between these two versions to account for the different control schemes. Unfortunately, the latest version of the Oculus Audio SDK at the time of writing (mid 2020) has no iOS support, so even though many amongst the target audience use iOS devices, an iOS build of Pingball is not yet available.

As an intended installment for the muZIEum, it is important for Pingball to be able to tune the audio to specific headphones. For this, parametric equalization using measurements of those headphones helps in improving the tonal accuracy of all audio sources in the game. This equalization occurs at the end of the audio pipeline. It compensates for imperfections in the frequency response caused by the headphones. This also improves the overall quality of audio spatialization, as the accuracy in the higher frequencies is important for binaural audio to sound realistic [6].

The first versions of Pingball used Unity's physics engine to simulate everything, including the flippers with physics from a real pinball machine, similar to most other pinball games. This, however, resulted in a somewhat frustrating experience when visuals were disabled, as physics are hard to predict when there are multiple bodies with inertia interacting with each other. Therefore, to improve the feeling of the game, we ended up revamping Pingball's flippers, dropping Unity's physics simulation and replacing it with unmovable flippers, featuring a simplified gradient of forces from the hinge to the tip. According to multiple play-testers, these static flippers have indeed dramatically improved the feeling of the game.

4 EVALUATION

To evaluate how playable and enjoyable Pingball is, an online questionnaire was sent to 29 people, some with and some without a visual impairment. Included in the questionnaire was a link to download the Android version of the game, as well as a Windows build for people not owning an Android phone. Naturally, the game version the participants played did not provide any visuals, so all participants were forced to play with their headphones, using only their hearing.

After the participant finished playing the game, a few questions were asked regarding three aspects of the game: *gameplay*, *sound design* and *map design*. The gameplay section evaluates game playability, in particular how difficult it is to play. The sound design section aimed at determining the usefulness of different sounds and the difficulty of estimating the roll direction of the ball. The map design section tries to ascertain how accurate the players are able to guess the map layout of the game and checks whether the participants manage to reach any of the minigames.

In general, play-testers were quite satisfied with Pingball. Regarding the gameplay, 83% of players found the game "fun to play", with 35% of players even indicating they find the game "very fun to play". There were two main points of improvements used for further development. First, 45% of players wanted to hear their score more often, so milestones were added: for every 100 points scored, the player is notified. Second, 83% of players did not notice the sections,

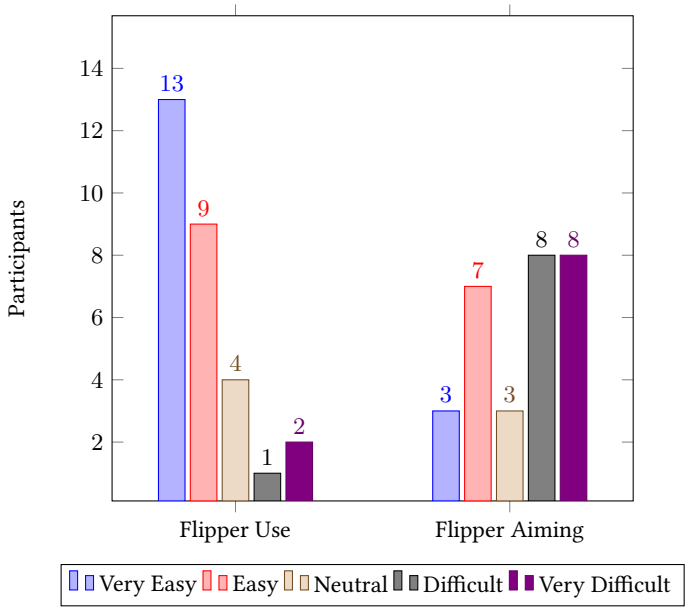

Figure 1: Evaluation results regarding flipper control

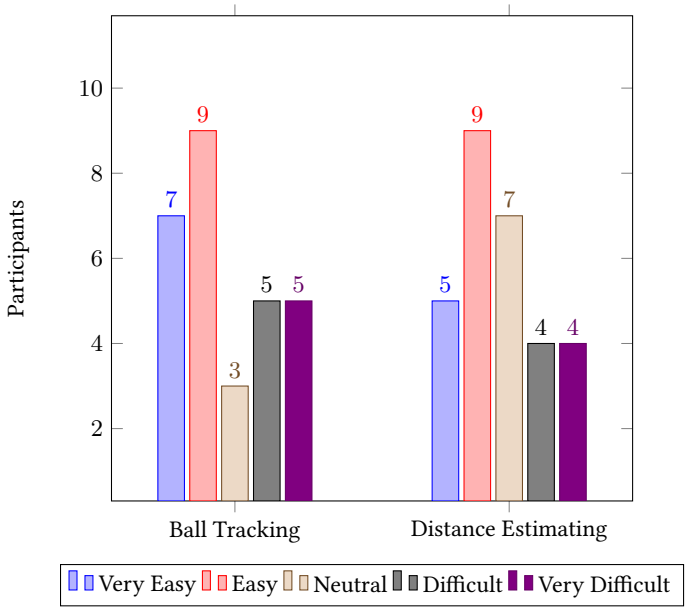

Figure 2: Evaluation results regarding ball tracking

nor that they were expected to visit all of them. This aspect is now explained in the introductory tutorial. Most players had an easy time using the flippers but had some trouble aiming with them; see Figure 1. Tracking the ball and estimating its distance from the flippers also did not impose much of a challenge to most of the participants; see Figure 2.

The map design section gave mixed results: only a small percentage of the participants were able to form a mental map layout of the field similar to what it actually is. However, even though they did not know the exact map layout nor where the minigames were located, most participants did manage to get into at least one of the minigames.

The sound design section collected the best results. Most participants had a very easy time determining the direction the ball was rolling towards, and the majority ranked the sonification techniques implemented, including the sound when the ball is approaching the flippers, to be a useful feature.

5 CONCLUSION

Pingball gives an answer to the question 'How can we design and implement a very accessible and fun audio-only pinball game?' Designing an audio-only game requires a rather different approach and process compared to most other games. Implementing spatialized audio did not relay as much information to the player as initially expected, which lead to more creative solutions to further improve playability, including various sonification features. Ultimately, the results of our game evaluation lead us to conclude that Pingball achieved the proposed goal.

In this paper we intentionally omitted images of the actual game and, particularly, left out numerous concrete details, e.g. on the actual shape and layout of the map, on the types of sounds used, on the themes of the sections, or on the minigames. We believe that providing them would constitute a sort of spoiler, and that it is much better that every player starts playing the game in equality of circumstances, regardless of any visual impairment.

The field of audio-only games is certainly limited at the moment, but has an enormous design potential for a wider range of really inclusive games. We hope that Pingball stimulates others to pursue this goal.

The Pingball game and its trailer are available at https://forms.gle/S5h5a5hsjBochenm9, where players are also encouraged to fill in a brief playtest questionnaire after having played the game.

ACKNOWLEDGMENTS

We thank Lars Lommers and Heleen Vermeulen, from the muZIEum, for their support and enthusiasm in this project.

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