Legend of Iris

Game Design

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Games are a great medium to teach people all sorts of skills. The serious game Legend of Iris, developed at the Technical University of Delft, utilizes this fact to help blind children. Legend of Iris aims to help children develop their hearing and teach them how other blind people have learnt to navigate in new environments. The skills are thought by having the player solve various puzzles. Parts of the story explain techniques such as echolocation. The game world is rendered so that people with eyesight can help the player. Legend of Iris accepts a variety of controllers next to the keyboard such as Game Controllers and the Oculus Rift which make playing the game feel very natural. The design of such a game brings challenges not present in ordinary games such as realistic sound simulation, audio accessible menus, finding and working with blind game testers and not being able to use a mouse.

The challenge

This chapter explains the assignment and how it came to be, as well as how we decided to approach it.

Purpose

Teaching blind people to navigate by themselves through new environments can be a dangerous endeavour. It usually requires a mentor to be present as well. This lead to our assignment which was to create a serious game for blind children, that helps them with learning how to navigate through new environments on their own.

Approach

Our first step was to visit our commissioners, Richard Hendriks and Nikolay Gaubitch, and ask for clarification of the assignment. We learned why the project was important to them and what they intended to do with the result.

After having a better idea of the assignment, we came up with a lot of ideas for games and game elements. We created proof-of-concept games, researched existing games and got into the field and

interviewed Rudjer Glavurtic, a music composer who became blind at the age of 14. The interview gave us a better idea of what skills are actually important and of ways to train these skills.

TIP It would have been beneficial to have met someone from the field we were designing a game for earlier. Not only did we have a really good time, talking to Rudjer was inspiring and allowed us to confirm or refute many of our assumptions. To realize this, make someone on your team responsible for finding and creating an appointment with people who can help immensely.

Also, we emailed for several weeks without any results. Calling set us up for a testing session in 15 minutes. Use that mobile phone of yours.

With the experiences from playing the proof-of-concept games and the new insights gained from the interview, we started to write the definite requirements. All this data allowed us to create and select game elements that would have to be in the final game.

The first prototype and beta versions of our game were situated mostly in the real world, at least the parts that were actually playable. By playing the game ourselves and through feedback from our commissioners and project coordinators we quickly noted there were a lot of things missing, such as ambient sounds, having the sound of your footsteps change for different surfaces, proper explanation of the controls and so on. Also, there were some things that didn't fit in a game for children, such as getting hit by cars and fireballs. Another problem was that the majority of coders had never worked with Unity before, which resulted in a low code quality.

As with any type of software, the design and coding is an iterative process. After noting the problems and good elements of our prototype we started over. We did a complete rehaul of the story and, while we could copy some parts of our code and assets, rewrote the game using better core systems for dialogues and managing player progress.

For this final prototype we held a testing session at a school for blind people. We strived to make the most of this opportunity and worked hard to design a proper testing method and player survey. The details can be found in our Testing Report document.

TIP It would have been beneficial to have this test session earlier. If you are responsible for something on your team and it is not clear to you how to achieve your goals, the correct response is to ask your team to help you out. Don't look for other things to work on as this will hurt the project in the end.

Using the results from our last big testing session we were able to improve Legend of Iris here and there by tweaking some values and for example adding more ambient sound.

Results

The key information from the results obtained after each step in the game design approach appear in order in this chapter.

Assignment

The assignment was pretty clear. We had to develop a serious game that helped children develop auditory orientation skills. The motivation behind this project consisted of at least the following points:

- We want to continue with the project from a signal processing perspective.
- Audio-only games is an interesting field.
- Get to know how and what blind children learn.
- Architects and designers can learn what its like to be blind and create better accessible products.

The precise target group was kids between 6 and 12 years old. This mostly affected the story, not so much the game elements. So the game is useful for older people but just not as attractive.

The in game language should be English so that our commissioners would understand what was going on as well as making it easier to internationally distribute the game for demonstration. This was in direct contrast with the target audience since it would be significantly harder to find you children who speak English.

Another important point was that they would rather have something small that works really well than something large that doesn't work that well. This held for the number of skills to be thought as well as the quality of in-game sound.

> **TIP** Assume the assignment is incomplete and not everything in it has to be well thought out. It very demoralizing when your idea is rejected based on the assignment document, only to later on discover that the reason it was rejected for is not actually that important to the commissioners.
>
> If your team does not support you, take it upon yourself to contact your commissioners and ask for clarification.

Initial ideas

When we had a better idea of the assignment, we went totally ham on the ideas. Two branches emerged: the funfair side and the 3D exploration side.

The funfair consisted of a lot of mini-games that could be played individually and focussed on different skills. Overnight we already came up with 4 mini-games: Simon Says, Whack-a-Mole, B.O.M.B.O.T.S.

and Lock-Picker. These ideas can be found in the Brainstorm Document which was not added as an appendix since it is a bit of a mess, instead it should be available as a separate attachment for anyone who is interested in our other ideas.

The exploration side was what we went with eventually, a sound based role playing game where you progress through a story and have to complete certain objectives.

Existing games

We were surprised by the amount of games that were seemingly available. However, many of them don't work once you try to download and play them. Not one of us has seen an audio game that has even become remotely popular.

> **TIP** Stop with your studies, learn Unity and submit a project on Kickstarter. We are sure that when you put in enough effort, it is possible to bring an audio game to a big non-blind audience. Especially when it is playable on mobile.

Field research

We interviewed Rudjer Glavurtic, a blind music composer of around 40 years old. He is originally from Croatia and came to the Netherlands to study Composition and Organ in Utrecht.

Rudjer said he is not really interested in computer games. He played some when he was little but he lost his eyesight when he was 14. There is a big difference between people who have been blind since birth and those who have been able to see for some part of their lives. Rudjer often thinks of things visually, by imagining colors and shapes. Sound echos also allow him to get an idea of the shape of objects.

To train his visualization and memory, he wanted to learn to play chess. Tried to download an app but the controls were not properly explained so he stopped. Rudjer uses an iPhone with some apps that read information from the screen and allow him to explore button locations.

When Rudjer became blind he had a lot of trouble accepting it, later on he learned to see it as a challenge. He takes his white cane and reconstructs the world around me using other senses. The most important thing to him is having freedom in movement and because of that in living.

Typical obstacles blind people come across include:

- Walking the sidewalk.
- Taking the bus.
- Doing groceries.
- Finding things in your house.

Adding vibrations could be a good way to provide feedback to collisions.

It is important to know where a sound is coming from and to be able to assess how fast the object is moving. Those are the two skills Rudjer thinks we should focus on.

Echolocation is especially useful in larger environments. It allows Rudjer to get an impression of the space around him.

Another exercise Rudjer proposed is to have a sound that you need to follow through space. But it gets more and more silent making it more difficult to follow. Add a bit of ambient sound and people can practice focussing on important sounds.

Rudjer did some workshops for blind children where he taught them a Russian martial art called Systema. It helped children gain confidence when moving around because he learnt them to fall and to find a way release the energy obtained when you experience pain. Reducing the fear of hitting something helped the kids a lot. “Sometimes it would happen for me to hit my head against a sign. Once you get hit, you become more tense and you don’t want to go outside anymore. “

Another exercise Rudjer did with the kids was one of disturbance. The children would have to do something like sitting straight up while they were being pushed or disturbed in another way. This teaches them to focus and deal with the experience of being disturbed.

There were big differences between the skill levels of the children. Some were amazing and some were very bad and couldn't even discern between left and right. This is a matter of personality and environment. If a child has to or wants to explore the environment around him they will become a lot better than children who don’t get this sort of exercise.

Requirements

After the assignment was clear we started to maintain a sorted list of requirements. The first four, the must- and should haves, are essential. The project should be considered a failure If the final prototype does not satisfy these. Here is the list:

1. The game must be entertaining to (blind) children.
2. The game must increase the confidence of blind people when navigating new environments.
3. The game must train players in estimating the origin location of a sound they hear.
4. The game must teach the controls to the player.
5. The game should train people in focusing on sounds important to a certain situation.
6. The game should teach the player to look at other people when they talk, people who were born blind often do not do this because they have no reason to.
7. It would be nice if the game teaches the player to grab or avoid an object that emits sound.
8. It would be nice if the game teaches the player to move to a location by listening to cues in the environment.

9. It would be nice if the game teaches the player about sound echolocation, sound propagation, the doppler effect, transformation of sound when bouncing of objects and other interesting concepts and terms to spark their interest.
10. It would be nice if the game trains people in echolocation.
11. It would be nice if the game encourages people to challenge their friends.
12. It would be nice if the game decreases people's reaction time.
13. It would be nice if the game trains people in stress management.
14. It would be nice if the game trains a user's spatial memory.
15. It would be nice if the game trains a user's overall memory capabilities.

TIP When looking at the requirements now it seems that we have been a bit sloppy. We should have described a measurable test that tells us whether or not we fulfilled a requirement. With the definitions above we can adjust the test so that the game fulfills the requirement.

A test for the first requirement could be: "We let n blind children play the game and measure s: the number of players who would encourage their friends to play it too. If the proportion s/n is more than 25% the game has to be entertaining". Another test would be: "Let n blind children play the game for 15 minutes, then let them choose to between continuing or doing something else they like. If the proportion of players that want to continue over the total number of players is more than 50%, the game has to be entertaining". In other words, there are many options and we recommend spending a substantial amount of time on this so that you know what you should focus on. Knowing that you should focus is one thing, finding out what to focus on is another.

One might argue against training any of the skills mentioned in the requirements because you can better train them in real life. However the beauty of a serious game is that you can make the exercises more interesting than they are in real life allowing people to focus longer. Another benefit is being able to do it whenever you want and not needing a teacher.

Beta release

Our previous game design document has detailed info on the beta release. In short it featured a first person 3D exploration game where you would have to follow a fairy through a building and then outside. You would have to watch out for cars when crossing the street. After finding a teleport location you would go to an imaginary land, escape a prison by finding the right person by comparing sounds. Then you had to avoid angry moles before the final level where you would have to catch magicballs and avoid fireballs to use the magic of the end boss against himself.

Legend of Iris

In Greek mythology, Iris is a messenger of the gods. She is essentially the links between men and the gods. Legend of Iris is a game where the player is contacted by Lucy, a fairy from the spirit world. The player then uses his computer to run Iris, a program that allows you to connect with the spirit realm. When you successfully connect you take control over a creature from the spirit world which in our

case is Beorn, a clumsy fluffy bear. Lucy guides you through the world while you have to complete a number of challenges.

Story

We completely rewrote the story to allow for a good explanation of the controls and difficulty progression as well as being a better fit for the audience. It is now almost completely set in an imaginary world, a welcome change from the beta according to our user tests. The most positive point that we kept from the beta was the fairy Lucy who assists the player. It was a good thing that the player is never alone. The complete script for the story can be found in Appendix 1.

Challenges and level rationale

The principle of the gameplay did not go through major evolutions from the beta to the final version. Major differences are that the controls are now interactively explained and that there are more levels with their own theme and overall challenges. Legend of Iris currently features the following in-game challenges:

Short description of challenge	**Strongly connected requirements**
Follow Lucy by listening to her bell.	3, 5, 7
Avoiding Spirits flying across a bridge you are walking on.	3, 5, 7, 12, 13
Following a path by listening to a chain of machines.	3, 8
Following a path while avoiding frogs.	3, 7, 8, 13
Listening carefully to find the right bird.	3, 5, 7
Catching the right bird while different birds are flying around. Birds explain something related to sound such as echolocation.	3, 5, 7, 9, 12, 13

TIP Focus on the most important requirements when designing mechanics, puzzles or content for your game.

The first level brings some interesting modifications. The player now has to walk over a fenceless bridge, meaning the player can fall into the water beneath. Lucy can teleport the player back to a checkpoint in case the player does fall off. What did not change is the concept of avoiding cars. This time around however the cars are spirits flying across the bridge. Another part of the bridge is suspended by noisy machines. This part is interesting because the player has to remember in which direction he or she is going or the player will go the wrong way.

The second level requires the players to memorize the location of an object. The principle is simple: We follow Boris, an owl, but only makes a sound occasionally. Therefore when the player hears Boris, he will have to estimate where Boris is an move towards him. If you only move while you hear Boris it will take a very long time to reach him.

The third level is a copy of the minefield from the beta but made a little bit longer. This time the player has to avoid frogs in a swamp. Frogs take the player back to a checkpoint and then disappear when the player comes to close. Just before this happens the frogs emit a warning sound.

The fourth level consists in finding a bird that makes particular noises. This is not that easy because there are several types of birds as well as ambient forest sounds.

The objective in the fifth and last level is to catch the right bird several times while all kinds of birds are flying around the player. The player has to try and find the right bird to then estimate where it is going and intercept it to catch it. The difficulty of this is probably very high.

Controls

The first prototype required used a mouse which was a shameful thing, because your mouse has absolute point of reference. Fortunately this mistake was more than made up for by introducing support for the Oculus Rift and game controllers.

An issue that still existed in the beta was that the left stick of the game controller controlled both movement and rotation. Rotation should have been put on the right thumbstick instead.

Sound

We required a sound simulation system that performed in real time and was easy to use in Unity projects. Being able to discern between front and back was, according to our interview with Rudjer and to our commissioners, more important than getting a more advanced audio simulation to run properly.

We offer support for both AstoundSound and Phonon 3D. Both systems provide a head-related transfer function. A complete discussion on the tradeoffs between different possibilities can be found in Appendix 2.

Graphics

The biggest additions with respect to the beta are the visual “sound waves” emitted from characters in game who are talking or making an important sound and the subtitles. These changes make coaching without also having access to the audio a lot easier.

Evaluation

We set out to satisfy at least 4 requirements. Requirement 1 and 2 however are too vague to mark as fulfilled or unfulfilled. Going by the last usertest we will however claim that our game is very likely to

be entertaining to blind children which satisfies requirement 1. Requirement 2 is not immediately apparent, training a skill costs time and effort. We did not manage to have blind people play our game regularly and measure changes in their confidence in real world situations.

The game focuses a lot on requirement 3. With AstoundSound or Phonon 3D enabled we are convinced that it is possible to improve your sound origin locating skills by playing a lot. The same goes for requirement 5.

Requirement 4, stating that the game should teach its controls to the player, is satisfied with the creation of the final prototype of Legend of Iris.

We failed to satisfy requirement 6: making the game reward the player for turning their head towards people who speak to him/her. We simply did not find the time to implement this.

In conclusion, we should have been more careful with specifying the requirements. In the end the only ones who can call the project a success or a failure are the commissioners but we could have had a better idea.

Future work

The research done for this project offer a solid base to continue from. Most of the information gathered and results obtained has been carefully archived and available per request. The source code for the game is also publicly available at https://github.com/audio-game-crew/legend-of-iris.

Some areas of improvement and new ideas:

- Developing and/or integrating a better sound simulation engine.
- Allowing the use of a mobile phone as a controller.
- Keeping the puzzles but slightly changing the story and audio to fit the game to a different audience.
- Building and optimizing Legend of Iris for mobile platforms.
- Finding and experimenting with head-tracking headphones.
- Exposing the game to architects and designers.
- Add more environmental sounds and background music.
- Implement a difficulty setting, where environmental sounds may be softer etc. Way points closer, less obstacles on the way.
- Creating a demonstration mode where only the essentials are present: instructions but no story.
- Adding haptic feedback when using a controller.
- Designing new, more effective or fun challenges.

Appendix 1: Story Script

START:

Getting ready

T0.1	*Iris*	Welcome to Iris, the most immersive all-in-one software for remote control of spirit bears. We offer the best online connection to the spirit world. You can modify many settings, by pressing escape at any point. When you are ready to continue, press forward. *wait 10s* When you are ready to continue, press forward. *wait 10s* *repeat all* { repeat with 5 second interval } When you are ready to continue, press forward.

CONTROLS #1:

Connection

T1.1	*Iris*	*tuuuut*tuuuut* You have 1 incoming call from *“Lucy”*. Connecting you through now.
	Lucy	*phone effect* Hello? Human? I need your help!! Are you there? Please press up/down/left/right in that order, to confirm you can hear me and that the connection is properly working.
T1.2	*Lucy*	Human, please press up/down/left/right in that order. You can do it! If you are not sure about how your controls work, you can press escape to check the settings of Iris.
T1.3	*Iris*	Checking response from spirit world… Connection in perfectly stable condition. You are now ready to connect to a spirit bear. Disconnecting because of reason, in… 5… 4…
	Lucy	What?! NO stop!
	Iris	*monotone* Ha. ha. ha. just kidding.
	Lucy	Ah phew! haha! Iris is a bit silly sometimes. Anyway, we will start the connection in a moment. But first, let me explain what is going on. I am Lucy, a fairy from the spirit world. We have a huge giant roaming the streets of my spirit village. We have no idea how he got there, and why, but all the spirits of the village are scared and have been hiding in their little houses. No one dares to talk to the giant because we are all so scared! We need an intelligent human who is a good listener. We will connect you with a fluffy spirit bear. You will be able to control his movements, and you will hear everything that he hears. It is quite the experience, really! So, will you help us, human?
	Iris	Turn off your computer to confirm

	Lucy	No, human, don’t! Iris is kidding... again.
	Iris	Ha.ha.ha.
	Lucy	Just press forward to confirm. Will you help us, human?
T1.4	*Lucy*	Oh... you don't.. want to help us? If you make up your mind, please press forward to confirm that you want to help us. We can really use the help of a talented human like you! Press forward to confirm!
T1.5	*Lucy*	Human, would you like to help us? We can really use the help of a talented human like you! Press forward to confirm!
T1.6	*Iris*	Question confirmed.
	Lucy	Yaaay! That is so great to hear. We are going on an adventure together. It is going to be awesome! Let’s start connecting you to a spirit bear now. Amazing what technology can do nowadays.
	Iris	Neh, it is okay. Whoever said technology would replace all paper obviously hasn't tried wiping their butt with an IPad…ha. ha. ha…. Starting connection in 3… 2… 1…
	Other	*connection sounds*
	Lucy	*during connection sounds* Here we go!

CONTROLS #2:

Try controls

T2.1	*Iris*	Connection established. Good luck.
	Lucy	Alright, human. You are now in connection with a fluffy spirit bear, called Grumble. Right now he is waking up.
	Grumble	muhehue *sleepy*
	Lucy	Alright, he got up.
	Iris	Forward and backward movement enabled.
	Lucy	Let’s see if you can move him. Press forward and backward to move Grumble.
T2.2	*Grumble*	*impatiently* muuuuuuu
	Lucy	Human, press forward and backward to move Grumble. If you don’t understand your controls, you can press escape to check or change the controls settings of Iris.
T2.3	*Grumble*	*falling* mumUmUUU *thud*

	Lucy	Haha, aww poor Grumble. He fell down, but that is okay. He is quite strong and has a lot of fur to break his fall. He is a bit clumsy sometimes though. At least he is fully awake now!
	Iris	Rotations enabled.
	Lucy	Let's try and see if you can turn Grumble around in order to look at a different direction. First do a full rotation to the left. [if using keyboard] Press the left or right keys to turn left or right. [if using mouse] Move your mouse to the right, to turn right and visa versa. [if using OR] Just turn your head into the direction that you want Grumble to look at.
T2.4	*Grumble*	*impatiently* muuuuuuu
	Lucy	[if using keyboard] Human, just press the left or right keys to turn left or right. [if using mouse] Human, move your mouse to the right, to turn right and visa versa. [if using OR] Human, just turn your head into the direction that you want Grumble to look at.
T2.5	*Grumble*	*disapprovingly* muuuuuuu
	Lucy	Human, you are turning into the wrong direction. [if player should turn right] You have to turn right! [if player should turn left] You have to turn left!
T2.6	*Grumble*	*happy* muuuuuuu
	Lucy	Well done!! Now let's turn back around. Do a full rotation to the left!
T2.7	*Grumble*	*happy* muumumuuuu!!
	Lucy	Well done, human!! Notice how the sound changes when you turn? You should pay close attention attention to the changes of audio in order to orient yourself.

CONTROLS #3:

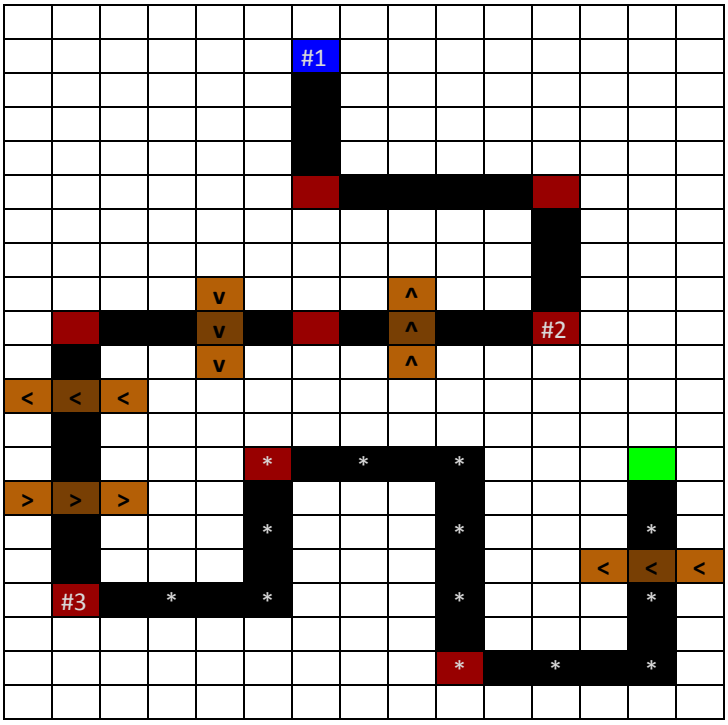
Walk around

T3.1	*Lucy*	Alright, you are ready to try walking around! Before we can get to the spirit village, we should get Grumble ready to move out. First he needs his shoes, and second… well… he needs to unplug his belly rubbing machine. He doesn't like it when devices are on stand-by when he leaves the house. It may start a fire, you know? Let's first move Grumble to his shoes. I'll fly over to their location, so you may follow the sound of my wings.

T3.2	*Grumble*	*impatiently* muuuuuuu
	Lucy	Human! Try to focus on the sound of my wings and walk towards me! Listen carefully to where my sound comes from, turn towards it and walk into my direction. You can do it, I believe in you.
T3.3	*Grumble*	*making effort, putting on shoes* muuuuuuumumuu
	Lucy	Good job, human!... haha, Grumble! Your shoes are even bigger than your belly is.
	Grumble	*yea so?* muumuu?
	Lucy	Okay, human. Let's now head towards his belly rubbing machine. Follow me!
T3.4	*Grumble*	*impatiently* muuuuuuu
	Lucy	Human! Try to focus on the sound of my wings and walk towards me! Listen carefully to where my sound comes from, turn towards it and walk into my direction. You can do it, I believe in you.
T3.5	*Other*	*belly rubbing machine turns on*
	Grumble	*very satisfied, being rubbed* mu! mu! mu! mu! *burp* mu! mu! mu! mu!
	Lucy	Grumble!! No! Get out and turn it off!
	Other	*belly rubbing machine turns off*
	Grumble	*disappointed* muhhh.
	Lucy	Good, Grumble! You can get a belly rub later, when you come back home.. Alright, human! Let's head to the door so we can get out of this place. It smell funky in here. You should be glad you are not connected to Grumble by smell! It smells like my grandma's feet, when she doesn't shower for a month. Quickly, follow me!
T3.6	*Grumble*	*impatiently* muuuuuuu
	Lucy	Human! Try to focus on the sound of my wings and walk towards me! Listen carefully to where my sound comes from, turn towards it and walk into my direction. You can do it, I believe in you.
T3.7	*Grumble*	*happy* muuuuu!
	Lucy	Yes!! You made it! You now know how to control Grumble and how to follow the sound of my wings. This will come in handy!
	Other	*door opens*

LEVEL #1:

Cross Bridge



T4.1	*Lucy*	Ahhhh fresh air
	Grumble	*very much liking the air too* muuuuuuu
	Lucy	We are now on a very lengthy bridge that goes to my village. The bridge is a bit narrow, and has a lot of turns. That's because the bridge is built over a river that runs through a few high mountains. However, I...
	Grumble	*running, panting* hu hu hu hu hu hu
	Lucy	*while grumble is running* Grumble!!!
	Grumble	huuuuUU *falls*
	Other	*teleportation sounds*
	Grumble	*relieved* muu!!
	Lucy	Grumble!! Wh... why..?? Oh wait... I see. Below us is not just a regular river, it is a river of... honey! I actually have some for you, Grumble! Here! Just save some f...
	Grumble	*drinking like crazy*
	Lucy	WOW! He drank it all in one go!! Oh Grumble...

	Grumble	*happy* muuu!
	Lucy	Haha! By the way, human, as you noticed I have magical powers! If something significant happens, I get my spirit juices flowing through my magnificent body! The spirit world then opens up highly concentrated Wibbly Wobbly Timey Wimey spirit magic locations where I can teleport Grumble to. Whenever he falls off, I will teleport him back to the beginning of the bridge section he fell off from. Alright! Let's cross this bridge! Follow me!
T4.2 *	*Grumble*	huuuuUU *falls*
	Lucy	Woops!
	Other	*teleportation sounds*
	Lucy	Okay! You are safe. Let's try again. Follow me!
T4.3	*Grumble*	*silly* muu
	Lucy	Hey come back! You are going the wrong direction!
T4.4 *	*Grumble*	*scared* uhoh uhoh uhoh!
	Lucy	Human! Watch out, Grumble is standing really close to the edge.
T4.5 *	*Grumble*	*glad* muu!
	Lucy	Well done! / You are doing great! Now the next segment. Follow me!
T4.6	*Lucy*	Hmmm, human, you have to watch out now. Some spirits are crossing the bridge sideways. They appear very scared because of the giant in our village. I am afriad they might push Grumble off the bridge if he touches them… So you have to listen carefully in order to avoid them. But I believe you can do it. Follow me, human! :)
T4.7 *	*Spirit*	Out of the way!! There is a giant in the village!!
	Grumble	huuuuUU *falls*
	Lucy	Woops!
	Other	*teleportation sounds*
	Lucy	Okay! You are safe. Let's try again. Follow me!
T4.8	*Grumble*	*scared* MU!
	Lucy	Phew! Close call, Grumble almost touched a spirit.
T4.9 *	*Grumble*	*happy* mu muuu

	Lucy	Awesome how you avoided those spirits! Well done. Let's continue over the next section.
T4.10	*Lucy*	Alright, the next few sections are a bit more difficult. I can't fly over them, because the bridge is kept in the air by machines. The energy they send off damages my wings so I can't guide you over of these parts. You are going to have to orient using the sound of these machines. Good luck, human! You can do it!!
T4.11	*Grumble*	huuuuUU *falls*
	Lucy	Woops! Watch out, the bridge turns here.
	Other	*teleportation sounds*
	Lucy	Okay! You are safe. Let's try again. Follow the sound of the machines.
T4.12	*Grumble*	*relief* muuu!
	Lucy	Well done! That was tough, wasn'it it? You did great though. You are a great listener! Let's continue over the next section with machines.
T4.13	*Grumble*	*very happy* muu muu muuuuuu!
	Lucy	Very goood!! We reached the end of the bridge. Here is a portal to my village. Grumble, don't be scared, you might feel some dizziness and lightheadedness, but that is normal. Here we go!! woooop!
	Other	*more special teleportation sounds*

* few variations

LEVEL #2:

Catch Boris

T5.1	*Other*	*teleportation sounds end*
	Lucy	*whispers* uhoh…. we arrived at my village but we are standing right next to the giant... Let's hope he doesn't see us. Stay still!
	Grumble	*GIANT!?* MUHUH?! muuuuu!!
	Lucy	*whispers* GRUMBLE! SSSST!
	Giant	*slow low voice* Huuuhhh? Who is there? A fairy!! Wait! I don't mean any harm. I am only here because I am hiding from the science birds in the forest! I just want shelter. I am scared! Can you help me please?
	Lucy	Uh… uhm… OH!! Of course! Giants hate science!! But, why are there science birds in our forest?

	Giant	They are studying and copying the sounds of the animals in the forest… Fairy, what if they will start copying my voice as well? Can you imagine a bird, saying things like “my butt itches”, or “mom!! I don’t like vegetables”?? That would be embarrassing.
	Lucy	Haha it would. We will help you, but if we get the science birds out of the forest, will you go back there and leave us alone?
	Giant	I promise. This is no place for me!
	Other	*Approaching flapping wings*
	Lucy	Oh here comes Boris the 77th, the great owl of Gahoot, the king of our village, and protector of all that is spirit. He is not THAT great though, he has a depressing Candy Crush highscore... I am guessing he wants to speak to you, human!
	Boris	Hi there, *hooot* I couldn’t help but overhearing the conversation. Lucy, are you sure you picked the right human for the task at hand?
	Lucy	Yes, 100% sure.
	Boris	Well, to be sure, human, I am going to test you. *hooot* I will fly towards some location closeby and you have to remember where that was so that you can come and find me.
	Lucy	OK human, stand still when he takes off, and listen closely to the sounds he makes. Use the sounds of the village around you to orient yourself and to remember Boris’ location!
	Other	*flapping wings of boris flying to some random location*
	Boris	*hoot at location*
	Lucy	OK, go find him!
T5.2 *	*Boris*	*hooot*
T5.3	*Grumble*	*annoyed* muuuu
	Lucy	Try to focus on the sounds of the environment in comparison to Boris. If you forget where he is, he might make some noises once in a while.
	Boris	*hooot*
T5.4	*Boris*	Hmmm.. You got me! *hooot* But you got lucky human! Let's tr... AAAH
	Grumble	MUHH HAWHAW
	Lucy	GRUMBLE!! Don't bite our king you idiot!
	Grumble	*disappointed* muhhhh
	Boris	*hOOOt* Oh fudge, now my feathers are all messy. Ah, well. I needed a haircut anyway. Right, where was I. *hooot* Oh yes: let's try again and see if you got lucky!!
	Other	*flapping wings of boris flying to some random location*

	Boris	*hoot at location*
	Lucy	OK, let's go find him again!
T5.5	*Boris*	Great! *hooot* You are doing well. Perhaps you are indeed as talented as lucy said. *hooot* One more to be sure!
	Other	*flapping wings of boris flying to some random location*
	Boris	*hoot at location*
	Lucy	OK, let's go find him again, one last time!
T5.6	*Boris*	Awesome! *hooot* I see you are indeed very talented!
	Grumble	*happy* muhhhhh
	Lucy	Yaay! I told you!
	Boris	Yes! *hooot* Very well. *hooot* I'll fly you to the forest where you can find the science birds. I think I know where they are. Here we go! hold on tight, Grumble! *hooot*
	Other	*wings start flapping around player*
	Grumble	*scared* muh? muhh! MUHHHHHHH HEHHUHUEHE
	Lucy	*happy* Wiiiiiii

LEVEL #3:

Cross Swamp

T6.1	*Other*	*wings stop flapping, landed*
	Grumble	*relief* muhhhhhh
	Lucy	It smells here, IEEUW. Even worse than Grumble's house. Where ARE we??
	Boris	Well, we arrived at the swamp! *hooot* I was only able to land *here*. The birds are further ahead, beyond the swamp, *hooot* so you are going to have to cross it. However, there are frogs that really like biting fluffy spirit bears. *hooot*
	Lucy	Hmm, alright. Human, I will fly to the end of the swamp. Again, follow the sound of my wings, but avoid the frogs!
T6.2	*Other*	*frog bite*
	Grumble	*pain* MUU!
	Lucy	Woops!
	Other	*teleportation sounds*

	Lucy	Okay! You are safe. Let’s try again.
T6.3	*Grumble*	*impatiently* Muuuu
	Lucy	Try to focus on the sound of my wings and avoid those slimy frogs on the way! You can do it, human!
T6.4	*Lucy*	Hooray! You made it! Well done! Those frogs were sooo smelly, and slimey. Ughhh!! I am super glad we passed the swamp.
	Grumble	*agrees* muu!! mu muu
	Lucy	Let's continue quickly
	Boris	Perhaps I will install a frog shower at the swamp one day. *hooot* For now, let’s move on! We'll move to the clearing where I heard the birds are located. Follow me and Lucy, Human! *hooot*
T6.5	*Grumble*	*impatiently* muhhhh
	Boris	Focus on the sound of lucy's wings or my hooting! You can do it. *hooot*
T6.6	*Grumble*	*silly* muu
	Lucy	Hey come back! You are going the wrong direction!
T6.7	*Grumble*	*playing with flies* muhhh muhuheuhe muhe HUH huheu
	Lucy	Grumble! Leave those poor flies alone!
	Boris	Human, What is the difference between a fly and a bird? A bird can fly but a fly can't bird! *hoot* HUAHUAHUAH
	Grumble	huehuehue
	Lucy	hihihi
T6.8	*Boris*	Oh oh oh! Another one! *hooot!* What do you call a fly without wings? A walk. HUAHUAHUAH
	Grumble	huehuehue
	Lucy	hihihi
T6.9	*Boris*	Lucy *hoot* someone said you sound like an owl.
	Lucy	Who??
	Boris	haha! *hoot*
	Lucy	OH! hihi, fooled me!
	Grumble	*mimics the joke in mumbles, laughs* muu?? huehuehue

T6.10	*Boris*	Ahhh! yes! here we are. The science bird must be around here!
	Grumble	*glad* muuuu!
	Lucy	OK! What's next, Boris?

LEVEL #4:

Find science bird

T7.1	*Boris*	Well, if you listen carefully, you may hear many bird callings. However, there is one that mimics all the others. That is the science bird! Humans call them Lyre Birds!
	Lucy	Ok, human, you are a great listener! Why don't you go find him. Good luck!
	Boris	*hooot*
T7.2	*Grumble*	*impatiently* muhhhh
	Lucy	Human, the bird you are looking for mimics the sounds of the forest, including those of other birds. Listen carefully!
T7.3	*Boris*	I don't think that is the bird we are looking for! That is just a regular bird.
	Grumble	*disappointed* muhhhh
T7.4	*Boris*	YESSS!! *hoothoot* That's the one! But to be sure, let's test him. Bird, what is "sound"?
	Bird #1	*whistle* Sound is a vibration, or wave, that can be heard as it reaches our ears by traveling through matter, such as air, wood or water. *whistles*
	Boris	*hoot* yes! I am convinced. How many more of you are there?
	Bird #1	*whistle* there are still 3 others! I can call them out with our secret emergency question, but then one of you has to catch them.
	Boris	OK, do it!

LEVEL #5:

More science birds

T8.1	*Bird #1*	*whistle* Why do seagulls fly over the sea? *whistle*
	Bird #2	*from a distance* Because if the flew over the bay
	Bird #3	*from another distance* they would be called
	Bird #4	*from another distance* baygulls!

	Bird #1	*from another distance* ooooooh!!
	Boris	Oh oh *hoot*, I can see spirit crows approaching
	Bird #1	*whistle* Oh did I forget to mention, that crows also respond our emergency calls? It is a problem we still haven't figured out how to avoid.
	Boris	Ok, human, birds will be flying passed you. Only grab the science birds *hoot*, so listen carefully to their calls. Whenever you do catch a crow, you have to bring it to Lucy. She will then keep it in a cage for now. Good luck! *hoot*
T8.2 *	*Grumble*	*disappointed* muuuu
	Lucy	Oops! That was a crow. Bring it to me!
	Crow	*kaaaa*
T8.3 *	*Lucy*	OK! I have got the crow. Now go get that science bird!
T8.4	*Boris*	Yes! You have one! *hoot* Let's test it. Bird, if I make noise a kilometer away from you, how long does it take for you to hear it?
	Bird #2	Well, 1 kilometer is a 1000 meters and sound travels roughly 335 meters per second through air. 1000 divided by 335 is about 3. Therefore, 3 seconds after the mentioned disgusting event, you will hear it.
	Boris	Let's test this!! Luckily, I have a friend who is currently 1 kilometer away from us. Let's call him and ask if he can make some noise. *dial tones, ringing* yooo bro! I am conducting an experiment and I need you to do the thing!
	Lucy	1… 2… 3…
	Other	*distant fart sound*
	Lucy	IEEEUW, seriously??
	Boris	Thanks! Smell ya later! *hangs up* Well, that worked! Now let's get the next science bird!
T8.5	*Boris*	YAY! Another one! Let's test him too. Bird, when something passes by quickly, why does the tone change?
	Bird #3	That is called the Doppler effect. Whenever an object comes *towards* you, the sound waves coming from that object, are more compressed! Therefore, the sound sounds *higher* pitched. If the object would move *away* from you, the sound waves are stretched so it sounds... can you guess it?.... yes! *lower*!!
	Boris	Okay.. Let me fly by you a few times. Tell me if he is right. *flies by player* wiiiiiiiiiiiiiiiiii *again* wiiiiiiiiiiiiiiiiii *again* wiiiiiiiiii *CRASH* uhhhhhgggggg, im okay! im okay...
	Lucy	Be careful, boris!! But, the bird is right!
	Boris	Perfect, *hoot* let's get the final science bird.

~~T8.6~~	~~*Boris*~~	~~Ah. Well done! Another one. Let's test that one too. Bird, Can I fart in space?~~
	~~*Bird #4*~~	~~You can, but no one could hear you, because there is no air in space. Therefore, the sound can't travel any further and stays in your astronaut suit. Also, you might choke on the smell of your own fart, as it can't leave your suit.~~
	~~*Boris*~~	~~I don't believe it! Lucy, teleport us into space!!~~
	~~*Lucy*~~	~~Hold on! *teleportation sounds*~~
	~~*Boris*~~	~~*walky talky*: *hooot* SPAACEEE!! Wiiiiii... ok ok, listen closely! *pffft*~~
	~~*Lucy*~~	~~You need to turn off your radio.~~
	~~*Boris*~~	~~oh haha *hoot* let me try again *click*...~~ ~~… *click* AAAH THAT SMELL~~
	~~*Grumble*~~	~~huehuehue~~
	~~*Lucy*~~	~~Idiot… but ok, it worked. Let's head back. *teleportation sounds*~~
	~~*Boris*~~	~~Human, let's get the final bird!~~
T8.6	*Boris*	Aha! The final one. Let's test it to be sure. Bird, if I make noise in a big empty hall, why do I hear it repeated?
	Bird #5	Easy! That is called an echo! Sound waves are partially absorbed by objects in your environment, and partially bounced back. So some sound waves might have bounced on other objects before reaching your ears, while some other waves reach you directly. Since it takes time for sound to travel from the source to your ear, it takes even longer for bounced sound waves to reach your ears, so that you hear the sound a bit later too.
	Boris	Lucy! *hoot* Teleport us into a big empty hall!!
	Lucy	Okidoki!! Here we go *teleport sounds*
	Boris	Awesome!! Ok, *grumbles of stomach* here goes nothing.... *difficult hoot* *pfffff*...fff*..ff*..f*
	Lucy	OK! ENOUGH! Ugh, who gives our king beans for dinner??
	Boris	The royal cook, Beany Jean Beany. If it wasn't clear from his name, his speciality is: beans.
	Lucy	Sounds like he is the the master of gasses himself. Let's get back to the village. *teleport sounds*

ENDING:

The end

T9.1	*Boris*	Ahhh *hoooot* home sweet home. Thank you human, for your exceptional help. You are very talented, and will achieve a great many things!! I'll soon bring back these science birds back to science land.
	Bird #3	NO!! *whistle* Wait! You can take my friends, but let me stay here!! Our study hasn't been completed, I'd like to finish it. Plus, I like it here. It smells so good, and the air feels so nice and soft. Everyone here seems so friendly too.
	Boris	Yes, *hoot* you are welcome to live here! As long as you pay your taxes!
	Bird #3	But, *whistle* I scare away the giant! Isn't that enough?
	Boris	I was kidding, *hoot* we don't have taxes in the spirit world!
	Bird #3	Haha ah! *whistle* Thank you, Boris! Human, you seem very talented! I see you are motivated to learn how to orient even better by the use of sound. So, let me tell you a secret. *whistle* If you listen well and practise enough, you could roughly determine the dimensions and type of environment you are in, just by the use of sound. You could possibly even learn to hear if there is a wall in front of you. The key here, is the effect that sound has in an environment. Sound waves travel and bounce around, and since each environment is different, the bounced sound waves are also different. Let's call this the response of an environment. *whistle* Some hearing impaired humans can distinguish these responses, just by making clicking sounds. They listen to the response in the environment just like bats do. *whistle* I hope this helps! Be safe in your human world, human! *whistle* Farewell!
	Lucy	It is time to disconnect you. Thank you sooo much for your help!! The village is now happy again. All because of you. You are awesome! Perhaps see you soon again! *kisses human*
	Boris	Hopefully we'll see you again. *hoot* It was nice working with you! Byeeee!
	Lucy	byeeee
	Grumble	byeehhhh byehhhh muhh!!
	Computer	Disconnected. Iris shutting down. Goodbye!

CREDITS:

	Computer	Credits: - Names & roles - Thanks - Sources - AstoundSound - Thanks for playing Iris shutting down. Goodbye!

Appendix 2: Sound System

GSound

Uses *many* ray casts to determine environment and reverb, relative to listener.

Homepage
http://www.carlschissler.com/gsound/index.php?page=home

Demo
http://www.carlschissler.com/gsound/index.php?page=demos
https://www.youtube.com/watch?v=buU8gPG2cHI

Realistic sound occlusion Realistic reverb by sound propagation Free Support for 7.1 surround which can then be transformed to stereo using razor's surround (but no real spatial audio) http://www.razerzone.com/surround	No realistic spatial audio (HRTF/BRTF) Low performance We need to write a plugin Windows/Mac(?) only

3DCeption

Homepage
http://twobigears.com/

Demo:
https://www.youtube.com/watch?v=eYt7wfASYG0
https://play.google.com/store/apps/details?id=com.twobigears.tbe3dceptiondemo

Realistic spatial audio Room modelling (for reverb/reflections) Unity plugin	No occlusion Free version only supports 10 active sources Pro version (with unlimited sources = 19 pounds/month for up to 6 users)

Spatial Audio
"Unity currently simulates 3D sound by using volume to simulate distance, panning to simulate left and right, and the doppler effect to simulate relative velocity. However it does not provide

any audio cues for front and back, or when sounds are occluded. The Spatial Audio package improves this by adding left/right phase adjustment, and frequency filtering to simulate sound from the rear.

The package also simulates sound damping as a result of being occluded. These subtle adjustments in sound give a significant improvement in spatial awareness to the player."

Homepage?
http://entitycrisis.blogspot.nl/2014/09/surround-binaural-or-spatial-sound-in.html

Plugin
https://www.assetstore.unity3d.com/en/#!/content/21994

Demo
http://www.differentmethods.com/packages/SpatialAudioSourceDemo.html

Simple spatial audio: Phase shifting for left-right distance, frequency filtering for front/back. Simple audio occlusion Unity plugin Might be good enough?	25$ Simple spatial audio/not binaural, too simple? Audio occlusion, too simple?

AstoundGaming

Real spatial audio, based on years of research. They call it BRTF, Brain-Related Transfer Functions, as they take into account how the brain perceives the audio. Is able to simulate audio behind, in-front, below, above and next to you.

Homepage
http://www.astoundgaming.com/

Unity plugin:
https://www.assetstore.unity3d.com/en/#!/content/24064

Demo
https://www.youtube.com/watch?v=nKnhcsRTNME
https://www.youtube.com/watch?v=GeokLJGaco4

WE HAVE ACCESS! FREE OF CHARGE!! YAY

Super realistic, all directions detectable Unity plugin	~~150$~~ No audio occlusion No reverb simulation

Not sure if can be easily combined with an algorithm that does reverb sim and audio occlusion

Phonon 3D + Phonon Reverb

“Deliver immersive 3D audio experiences across all platforms, with zero effort.”
“Author high-quality convolution reverb for an entire game level with a single click.”

Homepage
http://phonon.impulsonic.com/

Demo
https://www.youtube.com/watch?v=9g4n185vqS0 (phonon reverb)
https://www.youtube.com/watch?v=hmMHMVFAfso (phonon 3d)

Realistic spatial simulation Scene based-reverb Unity Plugin Free beta	No audio occlusion (SoundFlow not released yet…) Not that realistic? Not sure

SoundFlow

Not yet released :(

Combining stuff

Use Astoundgaming for hyper-realistic surround when the sound is in the same room (and for outside scenes), and GSound for occlusion and reverb calculations if the sound is in the next room.

Custom Occlusion

cast 1 ray from sound source to player. If wall is hit before the player is reached:
Compare length to length of shortest path according to navmesh. Then change the sound based the the difference of this path with the distance between the sound source and the player (more difference => more occlusion. Occlusion = filtering some higher frequencies, since they are usually destroyed when the sound is reflected)

Simple/cheap occlusion Native Unity code (no plugin) Possible nice occlusion approximation	Not realistic enough? Probably hard to find a realistic model for the occlusion

NavMesh propagation

Use a navmesh to do propagation for reverb and occlusion, and find an X amount of shortest paths from source to listener. For each path, make sure path can't be made anymore (give penalty points to that path, and bonus points for others?). For each node in a path, check if occluded by an object: check if nodes in path each can reach the listener without occlusion. Then do occlusion for that path.

Also, nodes/edges can have effect on audio: low/high cut filter, or lower volume, based on "material" that you can define. Perhaps define per edge, but nodes do averaging on effects of connected edges.

Furthermore, nodes can reach other nodes that aren't connected by a room, but by a wall (sound can travel through walls), but this gives heave occlusion.

As a result we have sound coming from many directions, with different occlusions and reverb effects. Now use HRTF ~~(maybe something as simple as SpatialAudio plugin)~~ (we have access to the awesome AstoundGaming plugin) to make audio 3D.

For extra realism, maybe for sources and listeners in the same room, add single reflection nodes in navmesh.

Native unity code (no plugin) Possible nice approximation for reverb, occlusion Allows us to write a paper; publication yay	Probably hard to find a realistic model for the occlusion Not realistic enough? Have to implement ourselves