# Using Sound to Help Visually Impaired Children Play Independently

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## Abstract
Play is important in the early development of young children, as it encourages them to explore the world, develop skills and learn to socialise with their peers. Blind and visually impaired children face challenges that can stop them becoming involved in play activities at nursery and school, leading to dependence on adults and reducing the benefit of playtime. We are exploring the use of an audio bracelet for young children, which uses sound to help them overcome these challenges through better awareness of their surroundings. We describe the design and prototyping of our system and present scenarios which demonstrate its use.

## Author Keywords
Visual impairment; children; play; sound; wearables.

## ACM Classification Keywords
K.4.2. Computers and Society: *Social Issues* – Assistive technologies for persons with disabilities

## Introduction
Play is important for the early development of children. Through play, they learn more about the world, the things and people within it, and the interactions between them. This contributes to the development of motor, language and social skills, which are important for further development. Blind and visually impaired

children engage in less complex and less social types of play than their sighted classmates do [10], however, meaning they do not get as much out of playtime.

Instead, they spend more time alone, withdrawing [3] and engaging in simpler play [10]. In discussions with experts on visually impaired education, we have found that these behaviours often arise because the children lack the confidence in their ability to engage in more varied and social play when at nursery (kindergarten) or school. For example, a visually impaired child may not know what activities are available, where those activities are in the play room, and where his or her friends are. This can lead to dependence on adults (teachers, classroom assistants, etc.), who are often unable to attend to the child during busy playtime, as the other children also need help and supervision.

We are investigating a solution to these challenges, which will use sensory information from a wearable device to encourage visually impaired children to engage in more varied play, without depending on adults for help. We will do this by using audio to give children a greater awareness of what activities and people are around them, also helping them to move between activities and find their friends. While other work has investigated auditory assistive systems for older user groups, these typically focus on larger scale environments (e.g. navigation along city streets) rather than within smaller spaces, like nursery playrooms and school classrooms. We look at the unique challenges of this setting and we describe the discussions that informed our ideas. Based on these discussions and initial prototyping, we identify initial design requirements for our system and our plan for future work.

IBEACONS

iBeacons are Bluetooth-enabled objects or devices which transmit structured meta-data that other devices can read, with the signal strength being used to estimate proximity. This ability to estimate proximity makes iBeacons a popular choice for indoor localisation, which cannot be done accurately or reliably using GPS.

## Related Work

In this paper we consider wearable assistive technology which uses audio to help blind and visually impaired children gain greater awareness of nearby people and activities, specifically within playrooms. The intended outcome of using such a system is to improve the child’s awareness of what is happening around them and to help them find people or places. Such auditory systems have been developed for adults before (for example [1, 2, 6, 7, 8]), though their audio designs may not be useful for young children indoors. They also tend to focus on wayfinding over larger spaces, like city streets or shopping malls, so their audio designs may not necessarily work within small and chaotic spaces like playrooms and classrooms.

iBeacons (see left) are often used with smartphones and/or headsets for the delivery of audio cues to help blind people navigate or find points of interest. This approach has been used in shopping malls [8], with buses [6] and the London Underground [7]. Saarela [8] used iBeacons to create auditory “landmarks” in a shopping mall in Finland, which visually impaired users could then use to help orient themselves and find their way. They tested this over six months with three users and found it successful, with users reporting that it gave improved freedom of movement, allowing them to navigate indoors without assistance. Our system aims to provide similar benefits to children when in school.

*Onyx Beacon* [6] used iBeacons on the bus network in Bucharest, to help visually impaired users find the right bus at crowded stations. Users found a bus on the smartphone app, which waited for the bus to arrive. When it arrived (detected by its iBeacon signal), a notification was sent to the phone. The iBeacon on the bus also produced sound, to help the user find it if there were several at the stop. This approach is novel in that sound comes from the point of interest as well as the user's own device; we consider this later in this paper.

*Wayfindr* [7] prototyped their audio wayfinding concept by deploying iBeacons at a London Underground station. Visually impaired users could use a smartphone app to find their way through the station, with turn-by-turn directions given to guide them to the correct platform. They found that precise localisation was unnecessary and that "less is more" when it came to auditory information. We take a similar approach, although we focus on the needs of children in a nursery setting.

Blum *et al*. [1, 2] described a smartphone app for blind navigation, which presents information using spatialised audio cues. A combination of speech and auditory icons are used to provide an overview of nearby points of interest as users navigate an outdoor area. Some sounds are delivered in 3D to provide simple directional cues. A "radar" metaphor was used to give an overview of nearby landmarks, sweeping clockwise around the user's head. Users found this design overwhelming, meaning it would likely be too complex for use with young children. It also relied on headphones for 3D audio, which may be unsuitable for this setting.


Figure 1: ABBI bracelet prototype and two of the kontakt.io iBeacons used by our system. Future iterations of the bracelet will have a smaller and more appealing design for children.

## Audio Bracelet for Blind Interaction

Our work is part of the ABBI (Audio Bracelet for Blind Interaction) project [4]. This project is developing a 'smart' bracelet for visually impaired children, which can sense motion and produce sound. The bracelet is designed for use in sensory-motor rehabilitation sessions (described in [4]); however, its sensors and its output capabilities mean it could also be worn by the child throughout the day, providing other benefits, such as those discussed here.

The ABBI bracelet (shown in Figure 1) has Bluetooth communication, motion sensors, and a sound synthesis system. Planned functionality includes scanning for iBeacons, which would allow the bracelet to estimate its proximity to areas of interest. In the following sections, we discuss the design and prototyping of a system which uses these capabilities to help visually impaired children when at nursery and school. First, we describe requirement capture which led to us focus on play.

## Issues in Play for Visually Impaired Children

We had formative discussions with specialists in visual impairment education, who mainly worked with young children in nursery or early primary school. During the discussions (at a meeting of the Scottish Association for Visual Impairment Education), we demonstrated the ABBI bracelet and used prototypes to show how its functionality may be extended with other technologies, like iBeacons. We used these demonstrations to inspire ideas for how the bracelet could be used to assist visually impaired children at nursery or primary school.

Most of the following discussion and feedback focused on issues which arose during play, when children are free to engage in unstructured and independent play. Play is important for children, as it contributes to the development of many key skills, including social and language skills. However, we were told of issues which mean visually impaired children do not get the most out of these sessions. We received many ideas about how the ABBI bracelet could be used to help children during play, which we now discuss.

*Moving Independently Between Activities*

During free-play time, sighted children move between lots of activities and do so independently. Blind and visually impaired children, however, tend to stay in the one place doing the same thing. Similar behaviours have also been reported in other research, with visually impaired children engaging in less complex and less social play [10]. Teachers and classroom assistants often think that lack of movement means the child is happy to stay at a favourite activity, so they leave them be. However, we were told that lack of movement often means the child lacks confidence in their ability to find their own way to a new activity. Instead, they need adult assistance or encouragement to move, but that is often unavailable because the teacher thinks they are happy where they are. It was suggested that the ABBI bracelet could be used to make the child aware of what activities are nearby, using sound to encourage them to find new activities and to explore independently.

*Awareness of Friends and Adults*

Visually impaired children are not always aware when their friends have left to go elsewhere, as children often move around spontaneously and without announcing that they are doing so. Without knowing where their friends have gone and lacking the confidence to find them on their own (as discussed before), they are often left playing alone. The ABBI bracelet could be used to help in these situations, informing the child that his or her friends have left, then helping them find their way to their location or to a new activity. ABBI bracelets could also be worn by a child's close friends, with sounds from their bracelets helping the child find them or know when they are near.

Children often need adult assistance during play and other activities, although teachers and assistants are not always available because they have to supervise and tend to the other children as well. Sometimes visually impaired children have to rely on an adult noticing them or checking up on them, rather than them asking for help on their own. To avoid these situations, a child's ABBI bracelet could help them find their teacher; for example, it could use sound to tell the child when they are near, or the teacher may also wear a bracelet which produces sound to help the child find them.

*Discouraging Inactivity and Passive Behaviours*

Blind and visually impaired children may not move much during play time because they lack confidence to do so; however, they may also be inactive because they are engaging in self-stimulatory behaviour (like rocking back and forth, or flapping their hands in front of their eyes) [9]. Visually impaired children often show such stereotypical behaviour, which should be discouraged as it takes the child away from more meaningful activities [5]. ABBI bracelets could discourage these behaviours from taking place; for example, by informing teachers when a child has not moved for a prolonged period of time or when the bracelet detects such behaviours. Sound cues from the bracelet could also be used to encourage the child to move from time to time.

In this section, we identified three topics which were commonly brought up during formative discussions of how the ABBI bracelet could be used to help blind and visually impaired children at nursery and at school. These issues relate to play, which has an important role in child development. We received many suggestions of how the ABBI technology could be used to help with these issues and in the following section we present

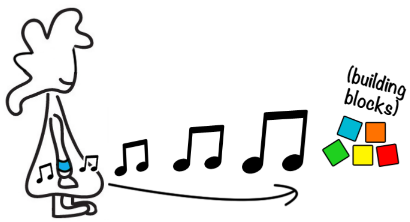


Figure 2: Amy's ABBI bracelet uses sound to tell her about the building blocks, getting louder as she gets closer.

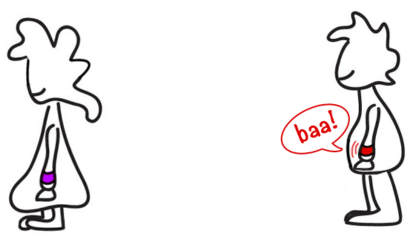


Figure 3: Jack's ABBI bracelet uses sound to help him find his friend Sally.

scenarios inspired by these ideas, showing how ABBI may be used to encourage and help visually impaired children to play independently. From these scenarios we identify key requirements for our system, which are likely to apply to other auditory assistive technologies for visually impaired children as well.

## Scenarios using the ABBI Bracelet

*Scenario 1: Finding New Activities*

Amy has been given an ABBI bracelet by her nursery teacher, to encourage her to try new activities during playtime and to give her a greater awareness of what activities and toys are nearby as she moves through the playroom. Her teachers want to encourage her to move more and experience more activities, so her bracelet is set up to vibrate gently if she stays in one place for more than fifteen minutes. After playing with the musical toys in the corner of the playroom, Amy gets up to move to another activity. As she walks through the room, a large open plan area, her ABBI bracelet creates sound to tell her what is near (as in Figure 2). She hears a sound notifying her about the building blocks and wants to play with them; the sound gets louder as she moves towards them, letting her know that she is getting closer. Once she is within a couple of metres of the right area, another sound from her bracelet tells her she has arrived.

In this scenario, sound was used to tell Amy about nearby areas of interest, with the audio design letting her know which activities she was getting closer to. An important part of our future work will be to identify the most effective sound designs for providing awareness of nearby activities and helping the child find them. Our aim is not to provide navigation instruction to a certain activity but to give an awareness of what is near as children move. This use of the bracelet could also be used in play, creating a "hot or cold" game where the child tries to find a particular sound in the room. An interesting issue which arose during our early discussions was whether or not sound should come from the environment, as well as the bracelet. For example, a sound from the area may help Amy as she gets closer, as she will be able to localise the sound more effectively than a non-directional sound from her bracelet.

*Scenario 2: Helping a Child Find His or Her Friends*

Jack is playing in the craft corner of the nursery playroom with his friend Sally, who has also been given an ABBI bracelet, and some other classmates. After a few minutes, Sally gets up and moves across the room to play with the soft animal toys. Jack's ABBI bracelet notices that Sally has moved further away and plays the sound of a sheep baa-ing. This lets him know that Sally, whose favourite animals are sheep, has moved to a new activity. He gets up and moves across the room. As he gets closer to Sally, he hears the sheep baa-ing again, letting him know he is moving towards her (as in Figure 3). When Jack reaches the soft toy area of the nursery, Sally's ABBI bracelet makes a noise. This helps Jack find her amongst the rest of his classmates.

In this scenario, Jack's bracelet informs him when one of his friends moves to a new play activity; this could be detected by a weaker Bluetooth signal strength from Sally's bracelet. Intermittent sounds were used in this scenario to help Jack find Sally's new location; this may not be optimal, however, so our future work includes investigating and evaluating sound designs to help guide children. An appropriate sound design will also have to work in noisy environments, like nursery playrooms. Another challenge highlighted by this scenario is using sound to help the child once they are near an item or person of interest. Once Jack is close to Sally, he may need further guidance to identify her amongst a larger group of children. In this scenario, Sally's ABBI bracelet used sound to help Jack find her.

A commonly raised point during our discussions was that children should not become dependent on assistive technology, in the same way that they should not have to rely on other people for help. Auditory output should aim to support, rather than replace, existing practices for orientation and mobility. Another issue raised was the potential cost to the child's family and to the school or nursery. Our scenarios are based around iBeacons, which are becoming less expensive, and computation will happen in the ABBI bracelet, meaning there is no need for expensive infrastructure. iBeacons could be added, removed and reconfigured as needed, and could be used to support many children at once.

## Current Progress and Future Work

We have adapted our initial prototypes to provide the functionality described in the scenarios, with the ABBI bracelet playing back sounds as it approaches known iBeacons. As not all of the ABBI functionality has been implemented at this stage in the project, we have used smartphones to simulate future capabilities of the bracelet. We use the ABBI bracelets for audio output, however, allowing sound from the wrist. For now, the system is programmed to know which activities are associated with which beacons, although educators will need a way of configuring and deploying the system.

When creating our scenarios and implementing of our prototypes, we identified some audio design challenges which we plan to study in future work. These include: investigating audio designs to give awareness of nearby people and activities; exploring the effectiveness of sound from bracelet vs sound from the environment; and exploring sound designs which help children locate people and places. Although the ABBI bracelet cannot synthesise speech, pre-recorded speech could also be used to guide children, which may work better than abstract audio. During this future work we will also consider the requirements identified in this paper: our audio designs need to work effectively in noisy nursery and school environments; our system should require minimal infrastructure to minimise cost; and it should support a child's development without being something they become dependent on.

## Conclusions

Visually impaired children experience many challenges at nursery and at school, especially during unstructured play time, which can have a significant role in the early development of language, motor and social skills. Many of these challenges result from their lack of confidence in their ability to move and find places independently. Through prototyping and discussions with experts on visual impairment education, we have identified ways in which a wearable assistive technology may help visually impaired children overcome some of these challenges. We presented scenarios which encapsulate these ideas and identified several audio design challenges which need to be addressed, as not enough is known about designing auditory assistive technologies for children.

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