On the use of "Smart Tones" to Aid the Perception and Location of a Moving Ball by the Visually Impaired

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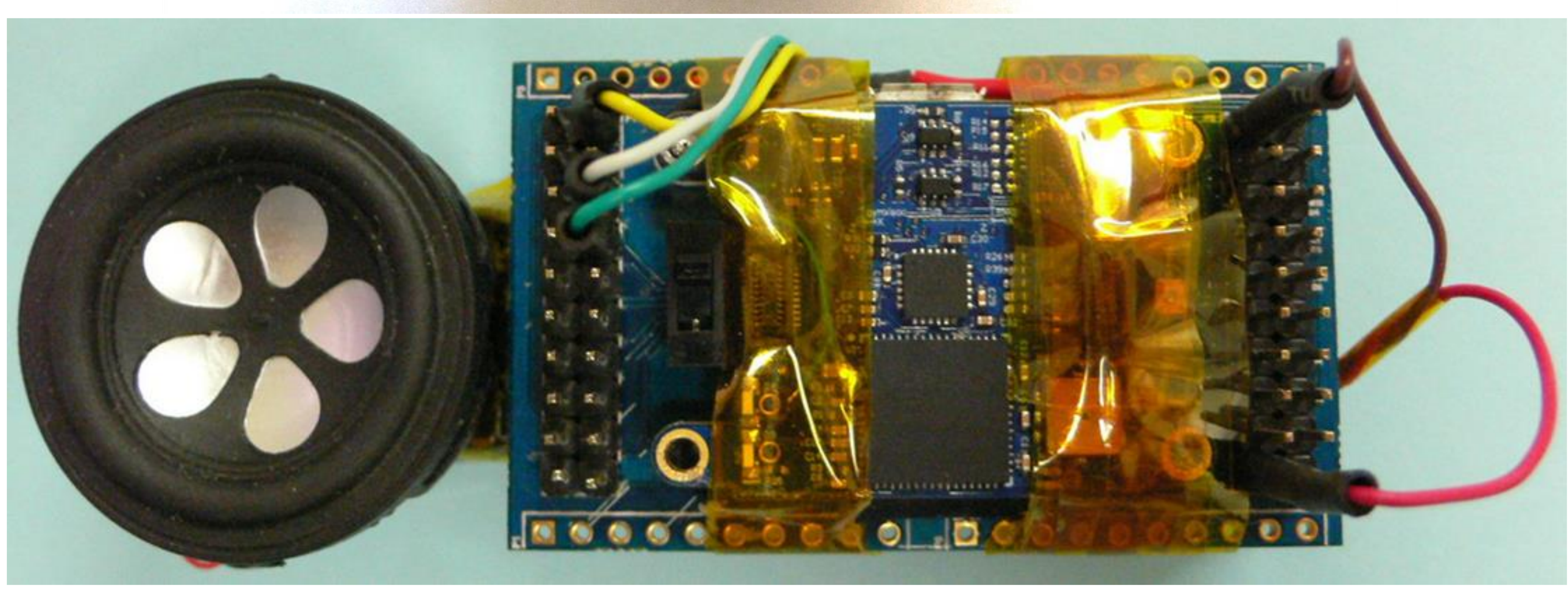
BACKGROUND

Existing soccer balls for players who are blind or visually impaired are limited by the use of conspicuous noise makers that provide sparse feedback to the players involved. Examples include buzzers that produce a fixed tone regardless of the ball's motion,[1] and embedded bells or bags that produce no sound when the ball is stationary and inconsistent sound when the ball is in motion.[2] To address these limitations, researchers at The Robotic Design Laboratory at The University of Queensland have developed a soccer ball for players with visual impairment, the I-Ball.[3]

The I-Ball consists of a hollow foam ball containing a microcontroller that varies the tones emitted by a miniature buzzer based on input from a motion sensor (Fig. 1).[3] The I-Ball can produce any sound, but was initially set to produce a continuous base tone for locating when stationary, that increases in frequency and intensity with increases in the ball's roll-rate (as measured using the on-board MEMS gyroscope) for locating when in motion.[3]

Figure 1. The I-ball features a smart embedded circuit, a rechargeable battery, a



Initial Field Testing

Initial field tests on the I-Ball on volunteer soccer players who are blind or visually impaired suggested these players were better able to locate the I-Ball when:[3]

- They were closer to the ball.
- They were playing indoors rather than outdoors
- When the continuous base tone was replaced with an intermittent base tone that increased in rate as the ball got closer to the player and decreased in rate as the ball got further away from the player.

These initial field tests also suggested these players were better able to judge the rate of rotation of the I-Ball (its speed when rolling) when they were further away from the ball.[3]

Both the volunteer soccer players s who are blind or visually impaired and their sighted teammates reported that after they became familiar with the I-Ball, and overcame its novelty, they found it to be less distracting than a standard beeper ball and their playtimes increased.[3]

DO PERSONS WHO ARE BLIND "HEAR BETTER"?

Two views on this question have been advanced:[4]

- Persons who are blind should be severely impaired, given that vision is essential to develop many auditory concepts.
- Persons who are blind compensate for their blindness through the remaining senses, allowing them to develop accurate auditory concepts.

Adults who are blind or visually impaired have been shown to perform better than sighted persons in tasks related to attention focusing, speech perception, word memorization, and pitch discrimination (although not all studies agree), but not pitch-timbre categorization.[4] Congenitally blind or early-blind adults have also been shown to perform better on these tasks compared to late-blind persons.[5] Children who are blind or visually impaired have been shown to have pitch discrimination and pitch-timbre categorization abilities that were similar to matched, sighted controls but worse than adults who are blind or visually impaired.[5]

When compared to sighted adults, adults who are blind or visually impaired have shown sound localization abilities that are:

- Better for azimuth.[4]
- Equal for single target localization in azimuth and elevation,[6] relative elevation and absolute and relative azimuth,[7] and minimal audible angle and simple pointing.[8]
- Worse for elevation-related spectral cues in more complex acoustic environments,[6] absolute elevation,[7] and bisection tasks (requiring a representation of auditory space in memory).[8]

Possible reasons for any improved auditory function in persons who are blind or visually impaired centre on changes in brain function induced by blindness . These include neuronal reorganization and compensation via recruitment of brain structures left unused by the lack of visual input. The latter includes possible unmasking of latent, pre-existing auditory connections to the visual cortex.[4]

THE PROPOSED STUDY

Put simply, the proposed study aims to:

1. Find the best sound/s to play through the I-Ball so that persons who are blind or visually impaired can most easily locate it.
2. Determine if auditory training improves the ability of persons who are blind or visually impaired to locate the I-Ball.

In more detail, the proposed study aims to bring together the robotics of the I-Ball and the psychoacoustics of auditory processing to compare persons who are blind or visually impaired to persons who are sighted on psychoacoustic tasks of most relevance to locating the I-Ball. These include the ability to:

1. Locate continuous tones of differing frequencies and intensities.
2. Locate intermittent tones of differing frequencies, intensities and pulse rates.
3. Use changes in frequency, intensity and pulse rate to track changes in location and ball roll rate.

The proposed study also aims to compare the ability of persons who are blind or visually impaired to those who are sighted on their ability to improve their performance on the above psychoacoustic tasks following auditory training.

These studies will be conducted in co-operation with Vision Australia and Sporting Wheelies.

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