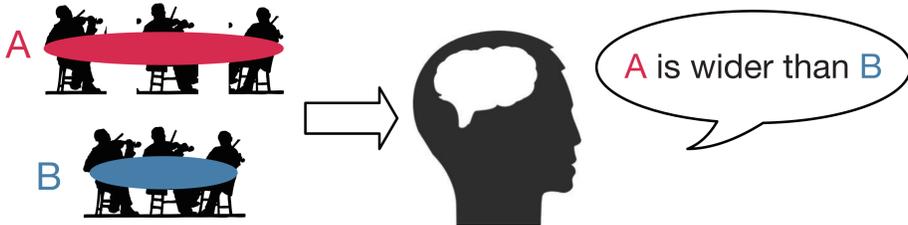




## Objective

To allow sound engineers to develop their sensitivity and memory to one of the spatial perception of sound, Auditory Source Width (ASW) using isomorphic mapping to a visual cue.



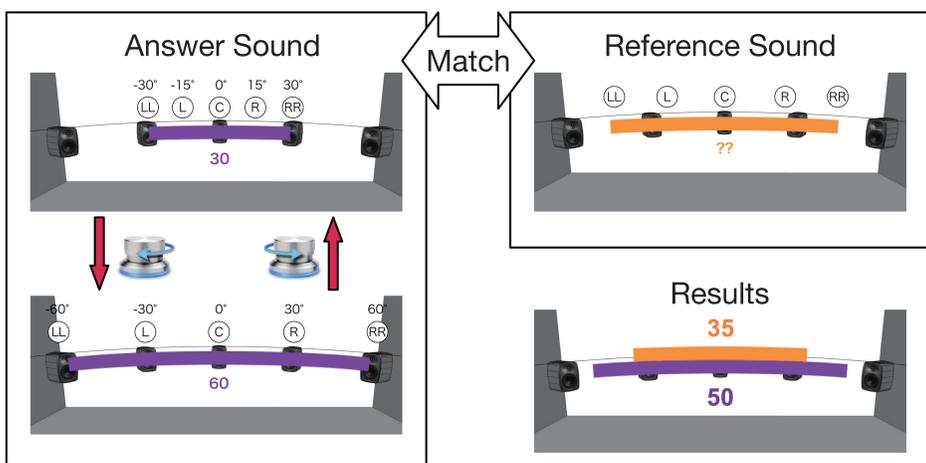
## Background

As multichannel reproduction system is becoming general, audio contents with more extensive spatial impressions has increased.

Therefore, having **internal reference of ASW** is important for future sound engineers. This internal reference indicates an ability with which one can discriminate ASW consistently regardless of changes in external factors such as listening environment and time.

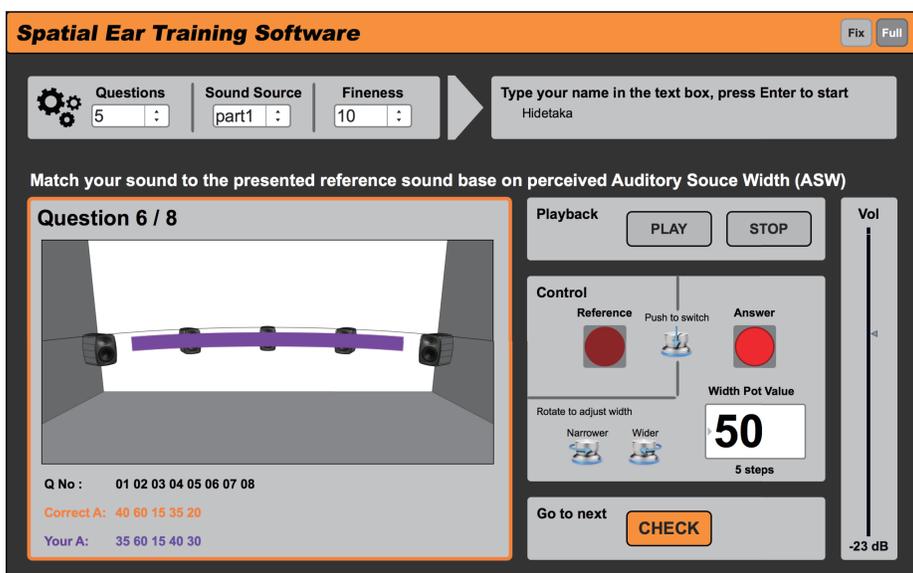
## Software Overview

Trainees are asked to adjust the **Width Pot Value** and control five channel sound sources reproduced from front five loudspeakers until it matches the ASW of reference sound.



Purple colored bar indicates virtual image of ASW corresponding to **Width Pot Value** of controlling "Answer Sound". After answering, trainees will get a feedback with orange colored bar which indicates the width of "Reference Sound".

The software automatically generates result text data that includes information of question numbers, answered **Width Pot Values**, and reference **Width Pot Values**.



## Required Settings

- Five matched loudspeakers located at azimuth of 0°, -30°, +30°, -60°, +60° for "Loudspeaker version".
- Headphones or earphones for "Headphone version".
- Five channel sound sources which consists of LL, L, C, R, RR.

## System Overview

### Width Pot Value

The **Width Pot Value** in this software is a **parameter that controls ASW of reproduced sound**. It corresponds to the panning position of five-channel sound sources. The range of it is set from 1 to 60, which extends maximum width controlled by a conventional two-channel stereo system. If  $N$  is given **Width Pot Value**, the position of the sound source  $P_{(LL, RR)}$ ,  $P_{(L, R)}$ ,  $P_{(C)}$  are expressed in the numerical formula on the right which means panning intervals among five sound sources are always equal.

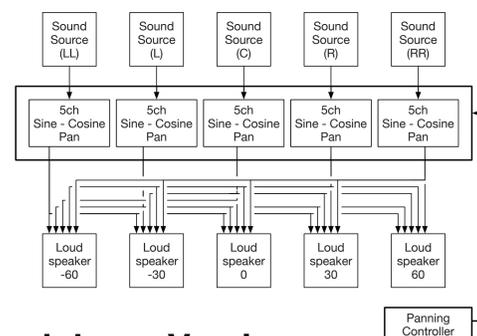
$$\begin{aligned} P_{(LL, RR)} &= \pm N \\ P_{(L, R)} &= \pm N/2 \\ P_{(C)} &= 0 \end{aligned}$$

### 5 channel panning method

When given the panning positions of each sound source among five loudspeakers, **the sound source is distributed according to a simple "sine-cosine" pan law**.

If  $P$  is given panning position, distribute energy to every five channel loudspeakers are expressed in the right numerical formula.

Figure below shows block diagram of signal flow of sound sources



$$G_{SP-60^\circ} = \begin{cases} \cos \frac{3 \times (P+60) \times \pi}{180} & (-60 \leq P < -30) \\ 0 & (-30 \leq P < 0) \\ 0 & (0 < P \leq 30) \\ 0 & (-30 < P \leq 60) \end{cases}$$

$$G_{SP-30^\circ} = \begin{cases} \sin \frac{3 \times (P+60) \times \pi}{180} & (-60 \leq P < -30) \\ \cos \frac{3 \times (P+30) \times \pi}{180} & (-30 \leq P < 0) \\ 0 & (0 < P \leq 30) \\ 0 & (-30 < P \leq 60) \end{cases}$$

$$G_{SP0^\circ} = \begin{cases} 0 & (-60 \leq P < -30) \\ \sin \frac{3 \times (P+30) \times \pi}{180} & (-30 \leq P < 0) \\ \cos \frac{3 \times P \times \pi}{180} & (0 < P \leq 30) \\ 0 & (-30 < P \leq 60) \end{cases}$$

$$G_{SP30^\circ} = \begin{cases} 0 & (-60 \leq P < -30) \\ 0 & (-30 \leq P < 0) \\ \sin \frac{3 \times P \times \pi}{180} & (0 < P \leq 30) \\ \cos \frac{3 \times (P-30) \times \pi}{180} & (-30 < P \leq 60) \end{cases}$$

$$G_{SP60^\circ} = \begin{cases} 0 & (-60 \leq P < -30) \\ 0 & (-30 \leq P < 0) \\ 0 & (0 < P \leq 30) \\ \sin \frac{3 \times (P-30) \times \pi}{180} & (-30 < P \leq 60) \end{cases}$$

### Headphone Version

By recording total 60 binaural sounds of every one **Width Pot Value** at listening position, headphone version has been implemented. Binaural recording was simulated virtually using CATT-Acoustic v8 with The Universal Cone Tracer(TUCT).

## Future Work

- To implement the function of realtime convolution of binaural signals and sound sources for the headphone version, so that trainees can use their original sound sources for training.
- To improve the **Width Pot Value** compatibility with perceived ASW using a psychophysical scaling.
- To develop an add-on model for the software, which will automatically analyze trainee's results data and show their progress.