Localizing Sounds

Pitch phenomena
Brain mechanisms of audition

**Auditory localization**

Auditory scene analysis/ perceptual organization
Auditory localization

Perceiving Azimuth
- Interaural level difference (ILD)
- Interaural time difference (ITD)

Perceiving Elevation
- Pinna

Visual-auditory interaction
- Visual capture
- Ventriloquism
Auditory Localization

Are two ears better than one?

Localization demo:
1. one ear
2. two ears
(3. two ears, no pinnae)

How can we measure auditory localization in 3D space?

The sound localization facility at Wright Patterson Air Force Base in Dayton, Ohio, is a geodesic sphere, nearly 5 m in diameter, housing an array of 277 loudspeakers.
Interaural level difference (ILD) caused by an acoustic shadow

This is why you can put the subwoofer almost anywhere.

Interaural level difference (ILD)
Interaural time difference (ITD)

The speed of sound: 343 m/sec [1125 ft/sec]
Distance between the right and the left ear: 10 cm (0.1m) [.328 ft]

\[
\frac{0.1}{343} \text{ (m/sec)} = \frac{0.000292}{0.328} \text{ sec} \quad \frac{0.328}{1125} \text{ (ft/sec)} = 0.000292
\]

= 0.292 milliseconds
= 292 microseconds

Ambiguous location information

Ambiguous location information (front/back)

Head rotation can disambiguate ILD and ITD
Ambiguous location information

Cone of confusion

Neural mechanisms involved in detection of Interaural time difference (ITD)

A: 900 – 300 = 600 microseconds

B: 800 – 450 = 350 microseconds

C: 600 – 600 = 0 microseconds

Medial Superior Olive
The underlying principle is simple. Regardless of how loud it is, sound from an indirect source -- say, a car passing alongside -- will take longer to reach the different microphones in an array than someone speaking directly into it.

The basic task of the array's microprocessors is to calculate the location of a sound by tracking its progress across each of the array's microphones. Then, using special filtering software, the electronics concentrates on the closest -- and, it is hoped, most important -- sound. The software can also focus on the array microphones receiving most of that sound while effectively shutting off the rest.


Echoes

Often not noticeable

Reverberation time (RT)
Localization is dominated by the sound that arrives first.

The precedence effect

The XR250 has a slanted front. It is done primarily to move the center of gravity back so the system does not easily fall forward. Not everyone wants to use sharp spikes on their floors to accomplish this. Some people see the slanted front as a means of adjusting the arrival time for the various drivers. It certainly doesn't hurt the arrival time, but it is already well within the acceptable limits.
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Elevation
Each pinna is unique, so the spectral shape cues to elevation must be learned.

Azimuth judgments are unaffected but elevation judgments are severely impaired.

No relearning needed.

Barn owls have specialized brain areas corresponding to interaural time difference (ITD) and interaural level difference (ILD) that vary with the azimuth and elevation of a stimulus.

Today, we will talk about

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Visual-auditory interactions

• Sound alters perceived motion

Top-Down influences on localization
• Visual capture
• Ventriloquist effect
Visual-auditory interactions

Sound alters perceived motion

Motion-bounce illusion
http://www.michaelbach.de/ot/mot_bounce


Visual-auditory interactions

- Sound alters perceived motion

Top-Down influences on localization
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Top-Down Influences on Localization

- Visual capture

https://www.youtube.com/watch?v=kFJLY6a3zy4

Top-Down Influences on Localization

- Ventriloquism

https://www.youtube.com/watch?v=kFJLY6a3zy4
Top-Down Influences on Localization

Ventriloquism Aftereffect

Analogous to prism adaptation.

Figure 11.31

Procedure for the ventriloquism effect experiment. (a) People’s sound localization is determined by having them turn toward a sound in the dark. (b) The person is trained for 3.5 hr by simultaneously presenting a sound and a light off to the right. The subject turns his or her head to where the sound is perceived, which turns out to be where the light is being flashed, off to the right of the sound. (c) After training, auditory localization is determined using the same procedure as in a, above. The light is no longer present, but subjects’ localization is now off to the right of the sound, where the light used to be. (From Reiserzeme, 1998.)

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Rapidly induced auditory plasticity: The ventriloquism aftereffect

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ABSTRACT

Cortical representational plasticity has been well documented after peripheral and central injuries or improvements in perceptual and motor abilities. This has led to inferences that changes in cortical representations parallel and account for the improvement in performance during the period of shift acquisition. There have also been several examples of rapidly induced changes in cortical neuronal response properties, for example, by intracortical microstimulation or by classical conditioning paradigms. This report describes similar rapidly induced changes in a cortically mediated perception in human subjects, the ventriloquism aftereffect, which presumably reflects a corresponding change in the cortical representation of acoustic space. The ventriloquism aftereffect describes an enduring shift in the perception of the spatial location of acoustic stimuli after a period of exposure to spatially disparate and simultaneously presented acoustic and visual stimuli. Exposure of a mismatch of 8° for 28–30 min is sufficient to shift the perception of acoustic space by approximately the same amount across subjects and acoustic frequencies. Given that the cerebral cortex is necessary for the perception of acoustic space, it is likely that the ventriloquism aftereffect reflects a change in the cortical representation of acoustic space. Comparisons between the responses of single cortical neurons in the behaving macaque monkey and the stimulus parameters that give rise to the ventriloquism aftereffect suggest that the changes in the cortical representation of acoustic space may begin as early as the primary auditory cortex.

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