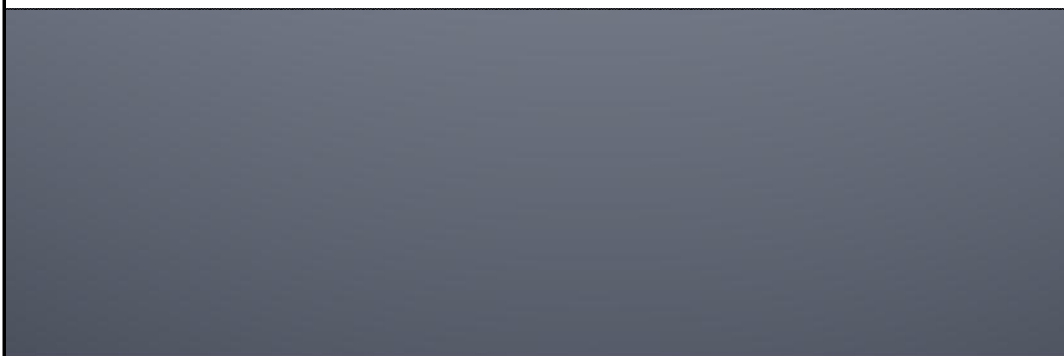




# Use of Sound for Navigation by Blind Pedestrians



# Tasks today

---

- Who am I, what do I do?
- Touch on some notable developments in the understanding of sound related to navigation without sight
- Discuss some common acoustic phenomena and sound cues related to navigation without sight

# Models of adaptation

- Compensatory versus deficit
- Compensatory: child will develop better perceptual skills in non-visual arenas to make up for vision loss
- Deficit: child will experience perceptual and therefore, performance deficits
- Truth, as always, is a little more complex

# Spatial hearing defined

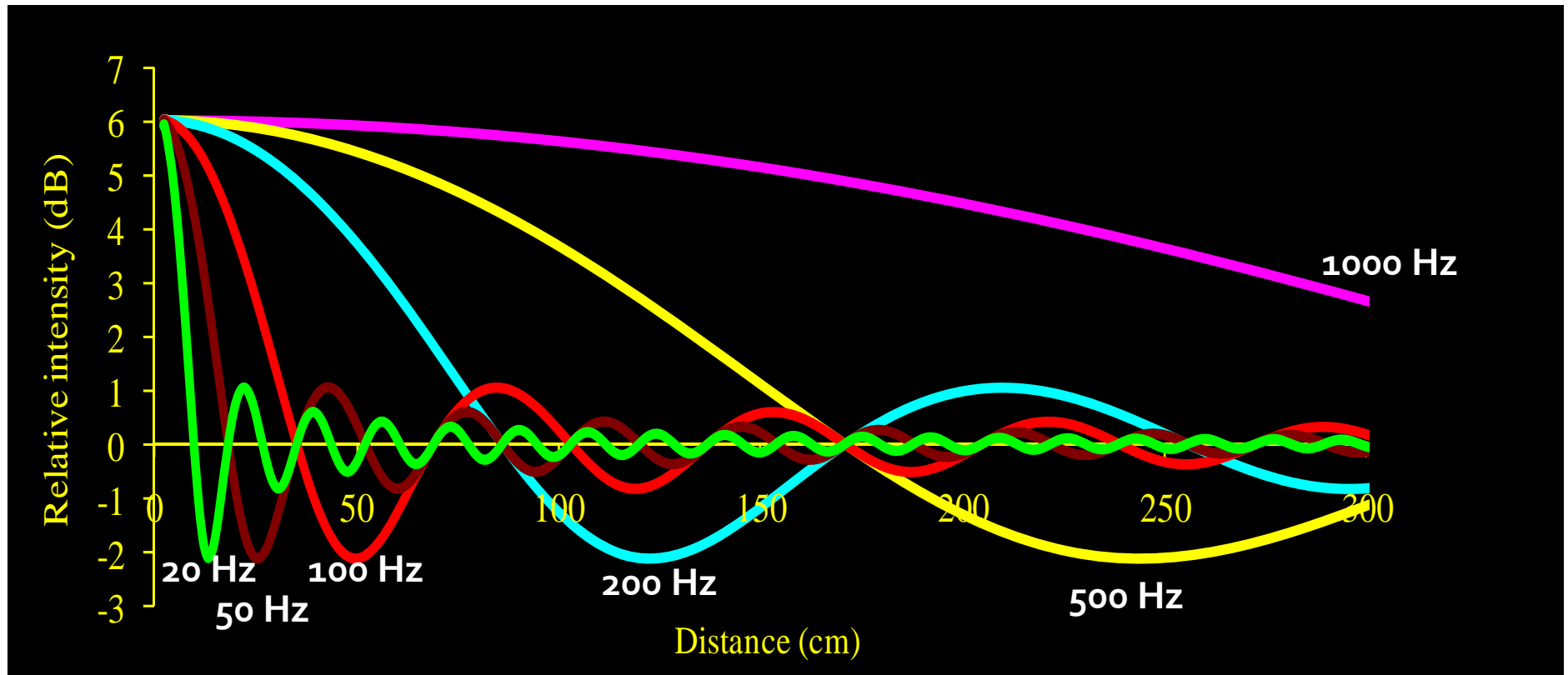
- Spatial hearing – using sound to understand the environment around you and your place in it
- Although blind people have used sound forever, sometimes with great ability, many cannot explain what they are doing (e.g., James Holman)
- Facial vision – subtle cues felt as pressure on the face
- Hyper-sensitivity to air currents, temperature, light, electromagnetism through special facial sensors or perception of the ether

# Brief history of object sensing

- Diderot (1749) – described the phenomenon
- Dallenbach (1940s) – demonstrated that facial vision was acoustic based
  - Tested blind and sighted, blind better but sighted performance was fair
  - Led to use of the term “echolocation”
  - Broadband works best, with pure tones, 10 Hz allows approximate detection
- Understanding refined by Ashmead and Wall (1990s)

# Sound cues and mobility

- Build up of low frequencies along large objects



- Blind pedestrians often experience being drawn into openings to the side of their travel path
- Caused by an unconscious perceptual need to balance binaural acoustic signal



# Juurmaa (1960s) and Rice (1970s)

- With training, people can:
  - Detect small objects 2 to 3 meters away
  - Judge the distance of an object to within inches at close range
  - Determine lateral location to within several degrees
  - Judge size differences to within fractions of an inch at close range
  - Determine shapes of objects
  - Identify texture differences



# Development of skill

---

- Appears to be unconscious
- Highly skilled individuals often rode bicycles or skated when young
- Can be trained
- People who are blind often experience the facial pressure but trained sighted blindfolded people often perceive objects in a pseudo-visual impression

# Sound cues and mobility

- Features of sounds that give information useful for mobility are:
  - Pitch – such as the low frequency build up
  - Directionality
  - Timbre
  - Intensity
  - Envelope
- We will look at some examples

# Sound cues and mobility - directionality

---

- Certain frequencies localized better than others but dependent on many variables
- Binaurality crucial
- Head movement optimizes ILDs and ITDs and reduces front/back confusion

# Sound cues and mobility – timbre and intensity

- Timbre relates to the particular signature of a sound, sound identification
  - Familiarity with a sound will make it easier to pick out of the background
  - Broadband more useful than pure tones
- Intensity – the louder a sound, the easier it is to hear (but only up to a point)
  - Ambient sound masking acoustic signals is one of the greatest hazards to blind travel
  - As the environment gets quieter, pedestrians can hear things better but important signals also get quieter

# Sound cues and mobility - envelope

- Sharp onset and offset of a sound makes it pop out of the ambient sound better
- Most localizable and detectable signals tend to be repetitive “click train” type sounds
- If signal is too long, the perceptual system compensates and becomes less sensitive
- United States APS locator tones are square waves of 880 Hz played every second
  - Advent of APS may parallel current issue

# Room acoustics

- Precedence effect and reverberation decay play important roles
  - Allow perception of room size, clutteredness
- Certain room geometries and object shapes intensify different frequencies
- Objects in room further disrupt the acoustic field (i.e., sound shadows)
- Combination of object perception and room acoustic perception can be translated to outdoor object perception

# Pedestrian as active agent

- Head movement optimizes localization
- Whole body movement allows a more robust perceptual flow (analogous to Gibson's optical flow)
- Self produced sounds make subtle acoustic cues more robust (e.g., Daniel Kish)
- For example, recent data showed detection of an idling hybrid at 30 feet

# Impact of quieter vehicles

---

- Harder to detect, reduces efficiency of certain O&M tasks
- Addressing the change may not lie in recreating past acoustic environments
- Determination of what critical acoustic cues are necessary for the performance of key O&M tasks might point the way to addressing the issue



# Thank you

---

Robert Wall Emerson  
Western Michigan University  
Department of Blindness and Low Vision  
Studies

[robert.wall@wmich.edu](mailto:robert.wall@wmich.edu)