Echolocation in People – Definitions and Applications

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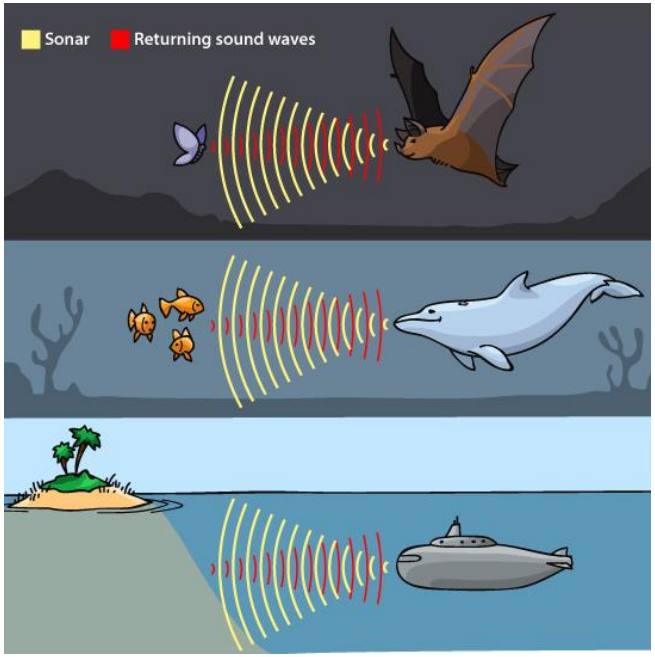
Echolocation – Bats, Dolphins

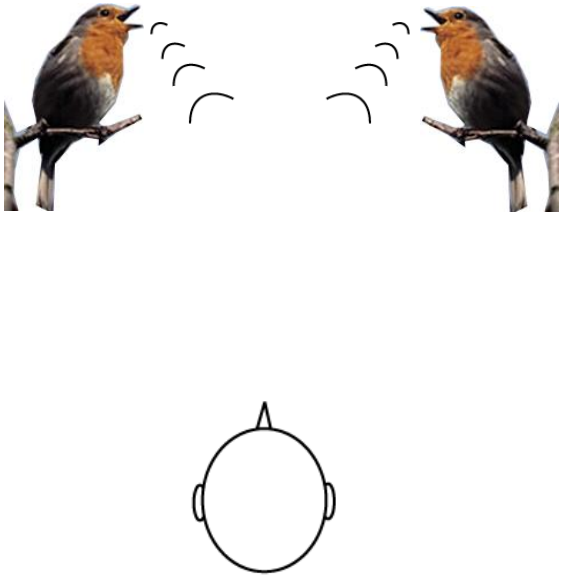


Echolocation – Bats, Dolphins … People

Daniel Kish

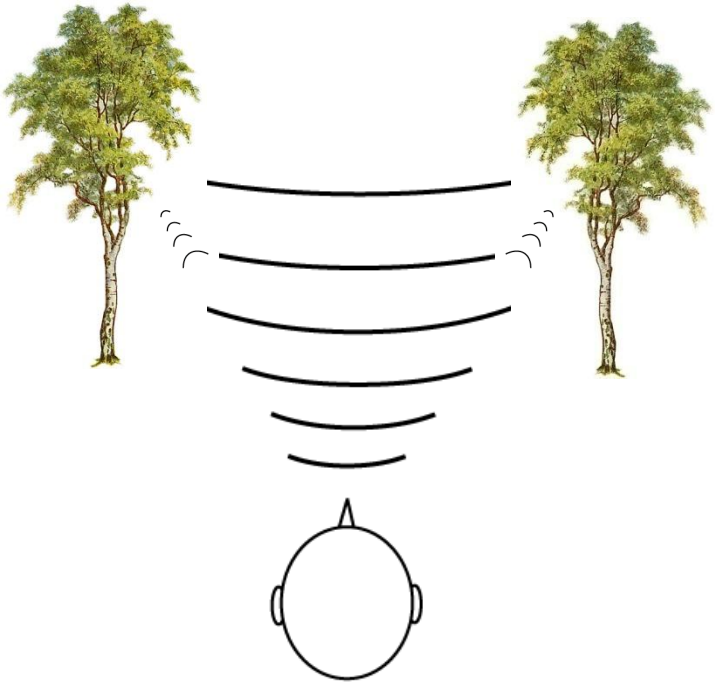
Source Localization

requires sound source, e.g. cars, voices

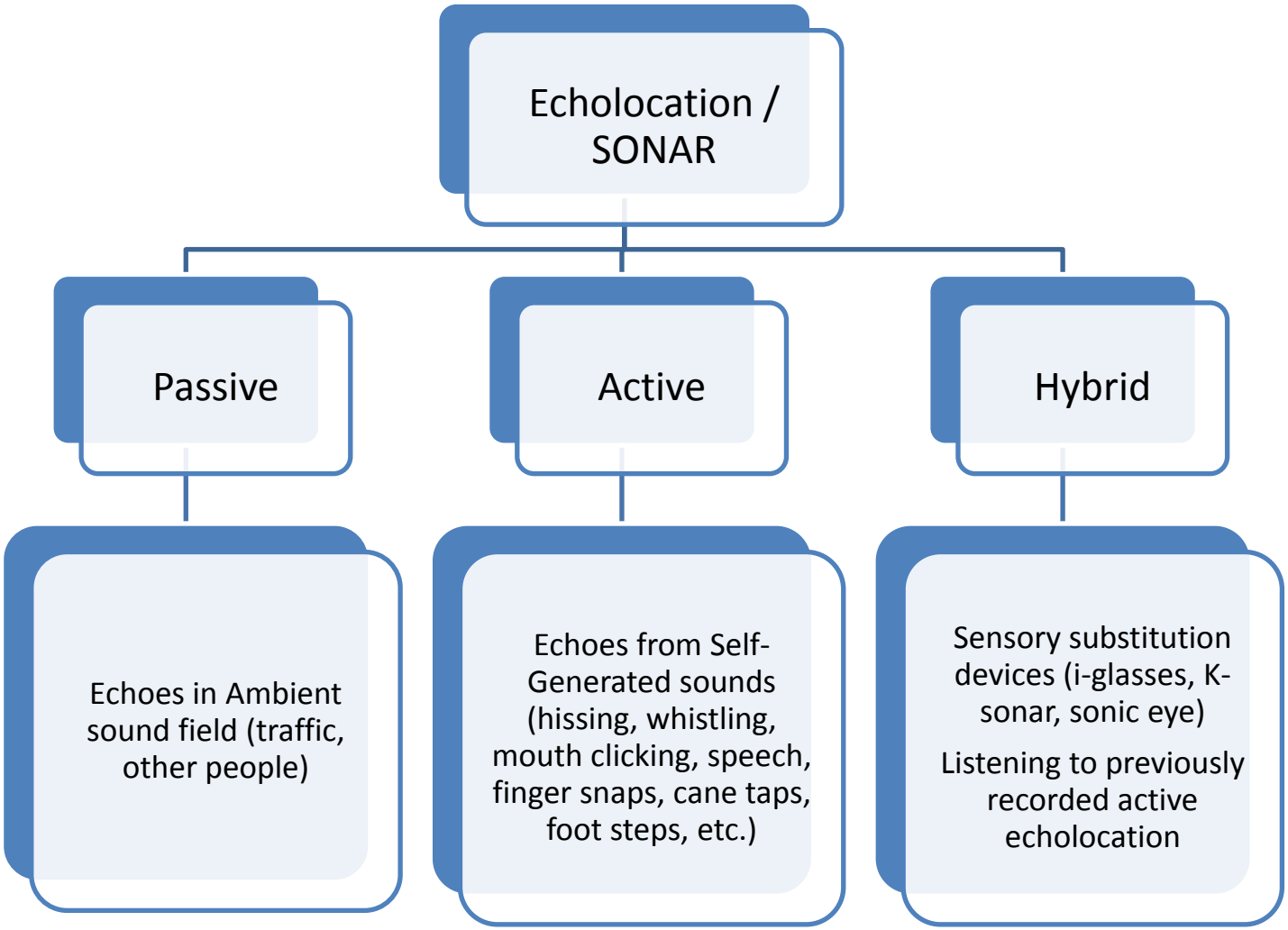


Echolocation

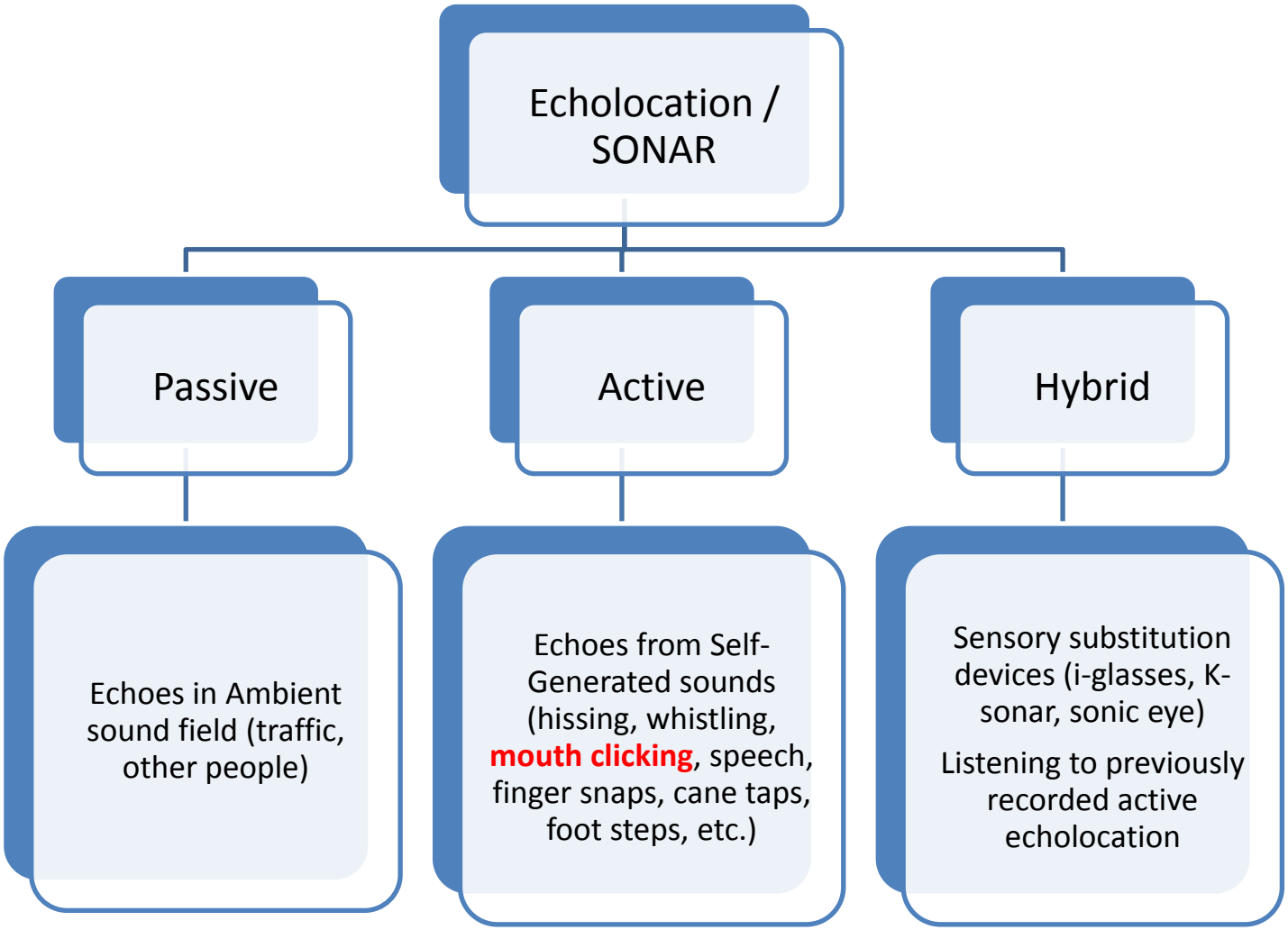
requires sound reflecting surface



Echolocation in People



Echolocation in People



Echolocation

Video - Daniel Kish – Detection and Distance

Echolocation

Video - Juan Ruiz – Navigation

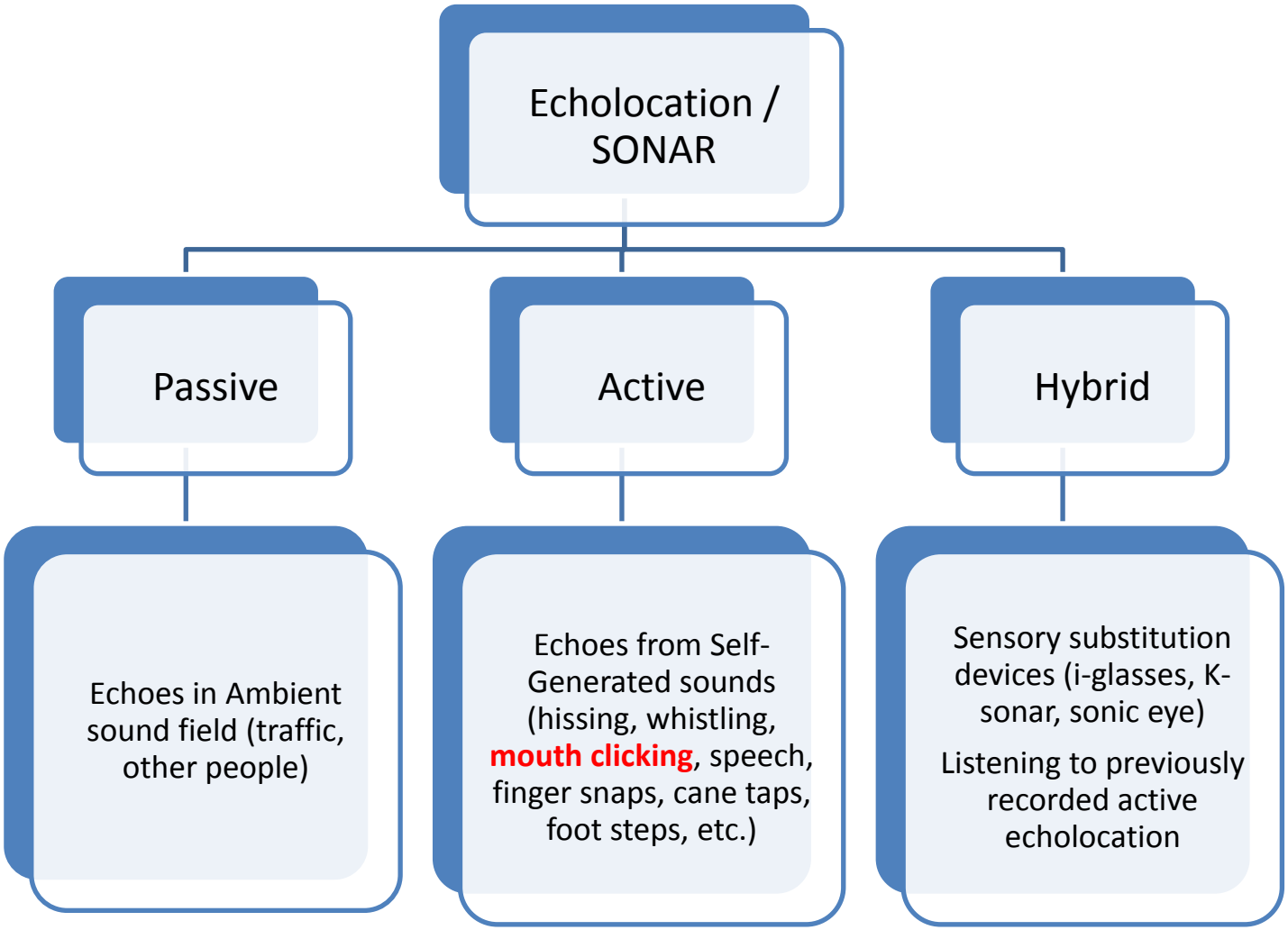
Echolocation

Video - Daniel Kish – Complex Spatial Structure

Echolocation

Video - Juan Ruiz – Shape Identification

Echolocation in People

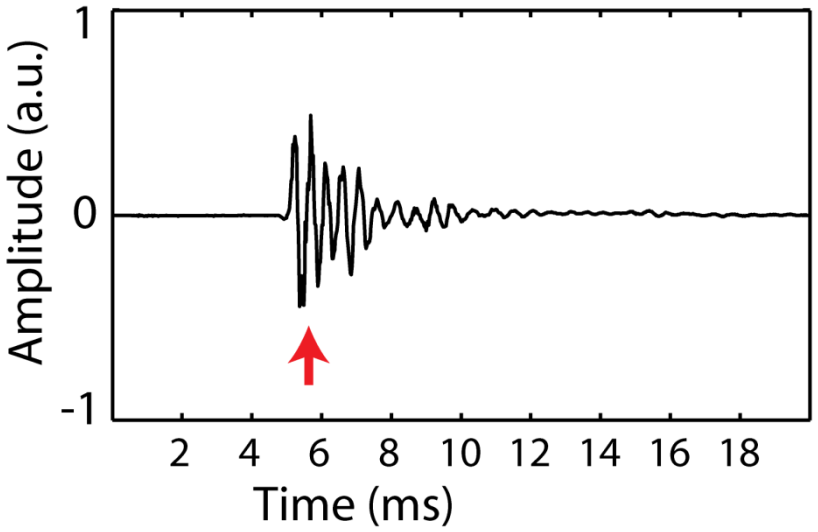


Mouth-Click based Echolocation

- Expert use
  - Many people who use active echolocation on a daily basis use mouth clicks as primary sonar emission
  - self taught and taught by others
- Has been argued that it is most beneficial for echolocation (Rojas et al., 2009)
- Provides a useful way to standardize emissions for scientific investigations

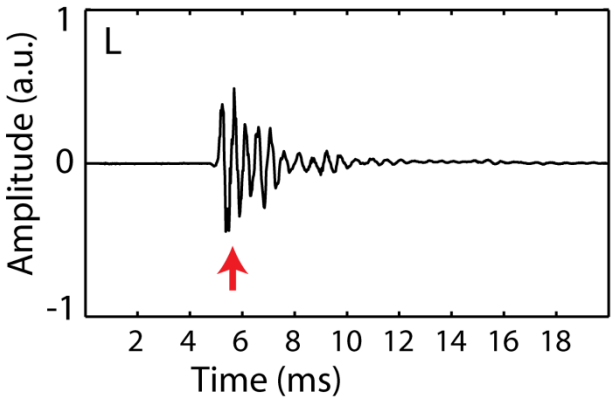
Mouth Clicks

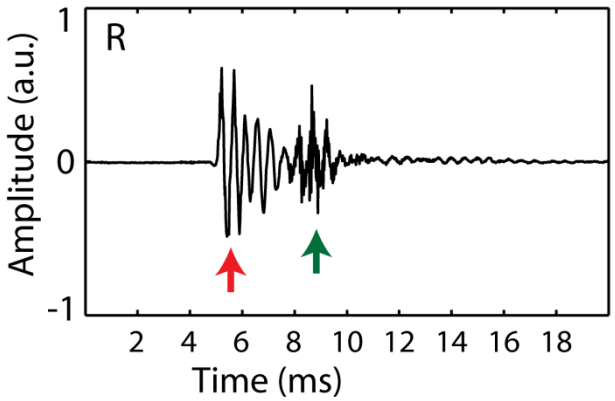
Recording of a Mouth Click



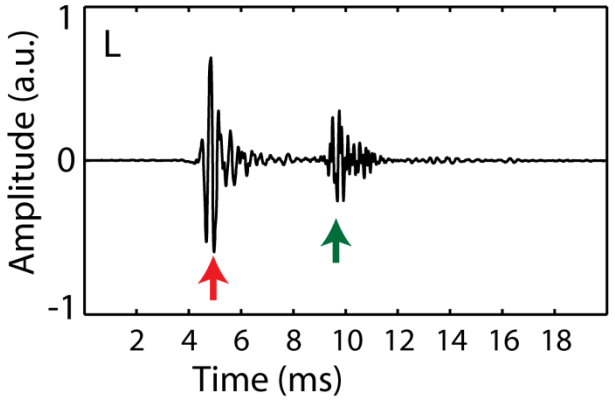
Mouth Clicks & Echoes

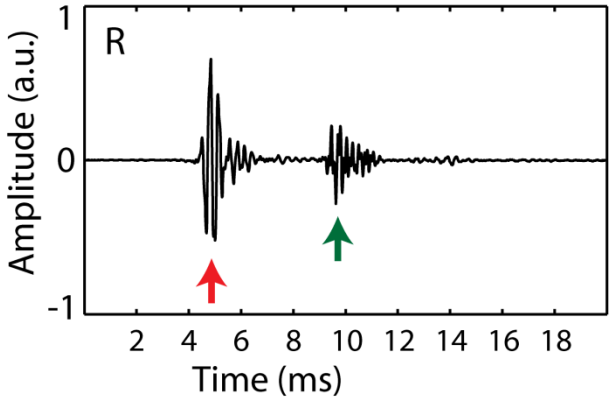
Object on the right side





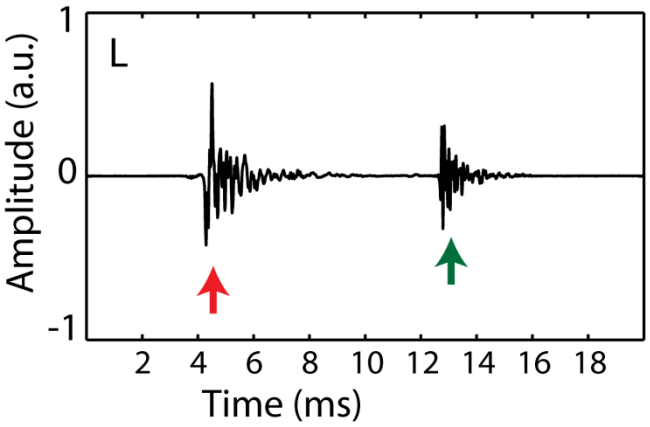
Object Straight Ahead

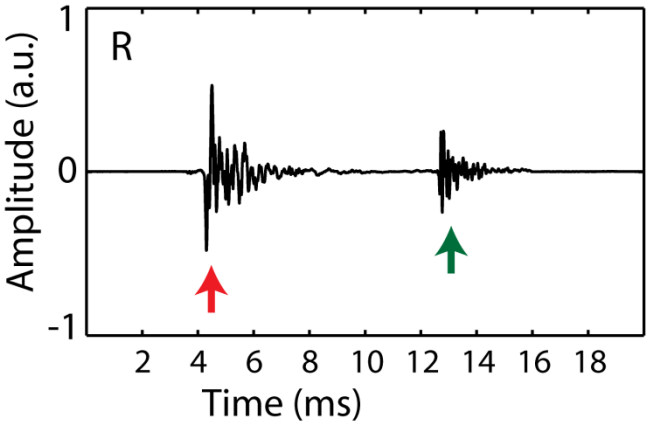




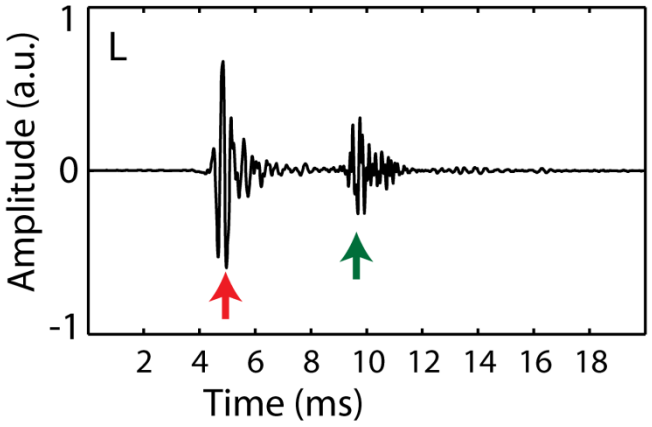
Mouth Clicks

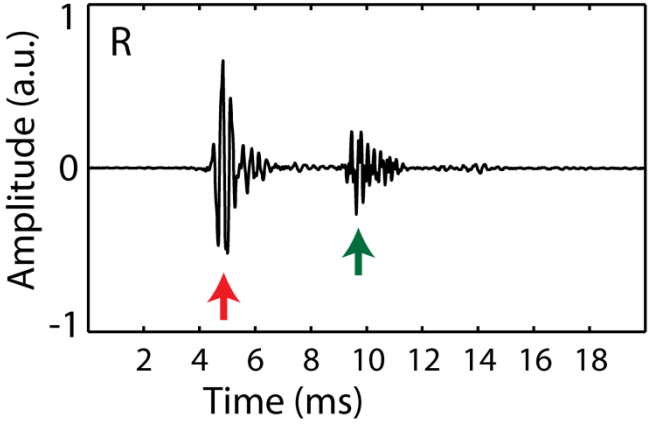
Object 150cm away



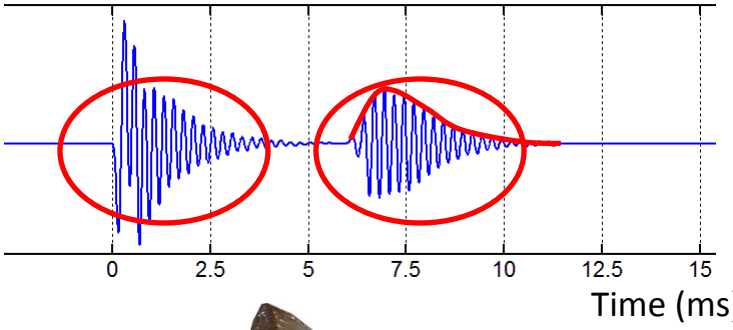


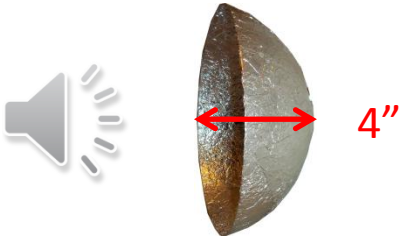
Object 85 cm away

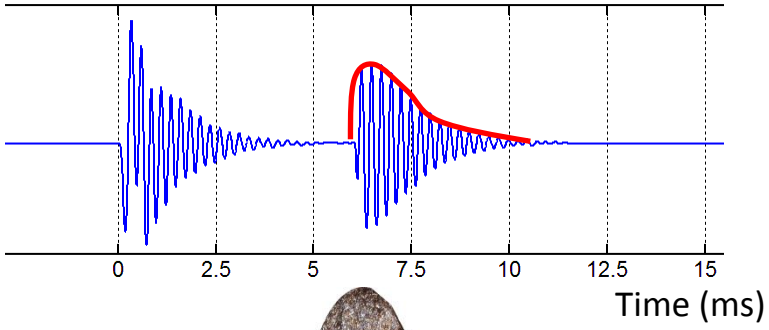


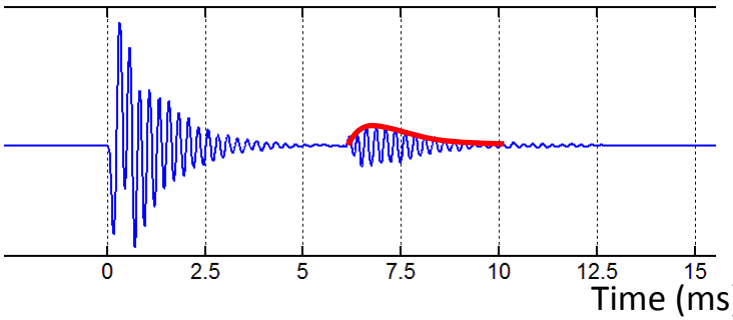


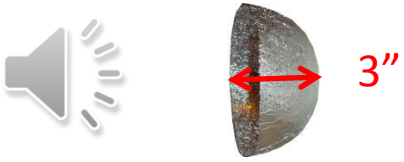
Signals for Human Echolocation

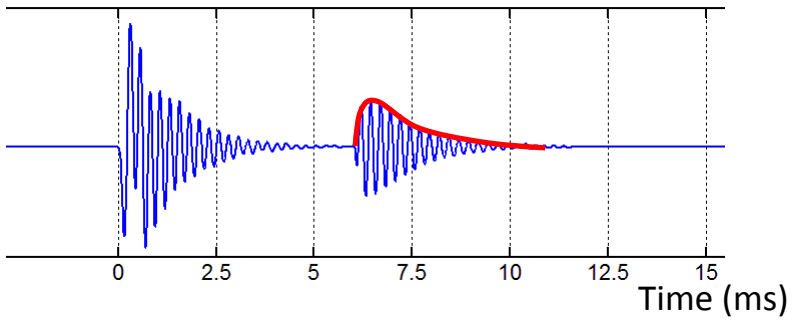












Echolocation and Spatial sensing

- Distance ☺
- Azimuth ☺
- Shape ☺
- Material ☺
- Size ☺
- Motion ☺

Echolocation and Mobility

- Survey Study *(Thaler, 2013, Frontiers in Physiology; Link to free article: http://journal.frontiersin.org/article/10.3389/fphys.2013.00098/full*
- 37 respondents (legally blind, 22 total blindness)
- People who used mouth click based echolocation reported to be more confident moving in unfamiliar place compared to people who did not use echolocation. This difference was significant.
- Everyone also reported to use a long cane

Mobility

- How effective is the use of echolocation together with the long cane?
- How good is echolocation to detect and avoid obstacles at head height as compared to obstacles at ground level?

Dr Dorothy Cowie

Ben Kirk

Durham County Council

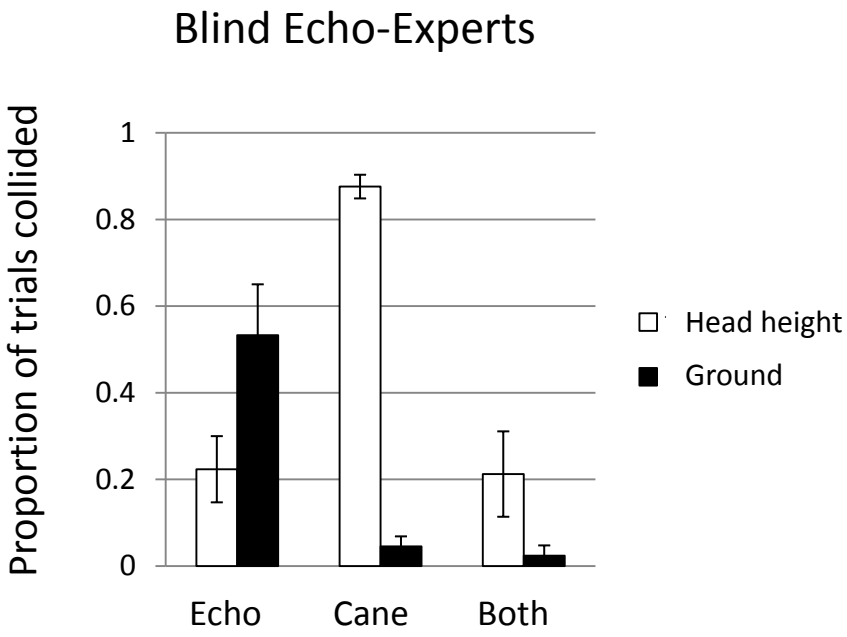
Adult sensory support team

Research Design

- obstacle (60 x 60cm) at head height or on ground
- Use of the long cane, click-echo, or both
- Blind echo-experts (7); blind echo-naïve (3), and sighted echo-naïve (7) (everyone with blindfold)
- Tracking the movements with motion capture
  - Number of collisions
  - Walking speed
  - Impact speed

videos

Results - Collisions



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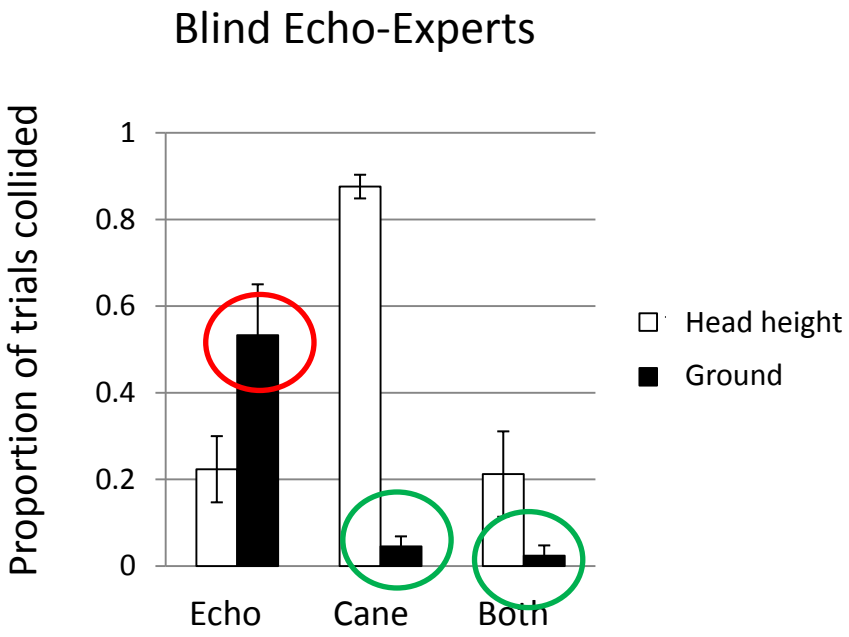

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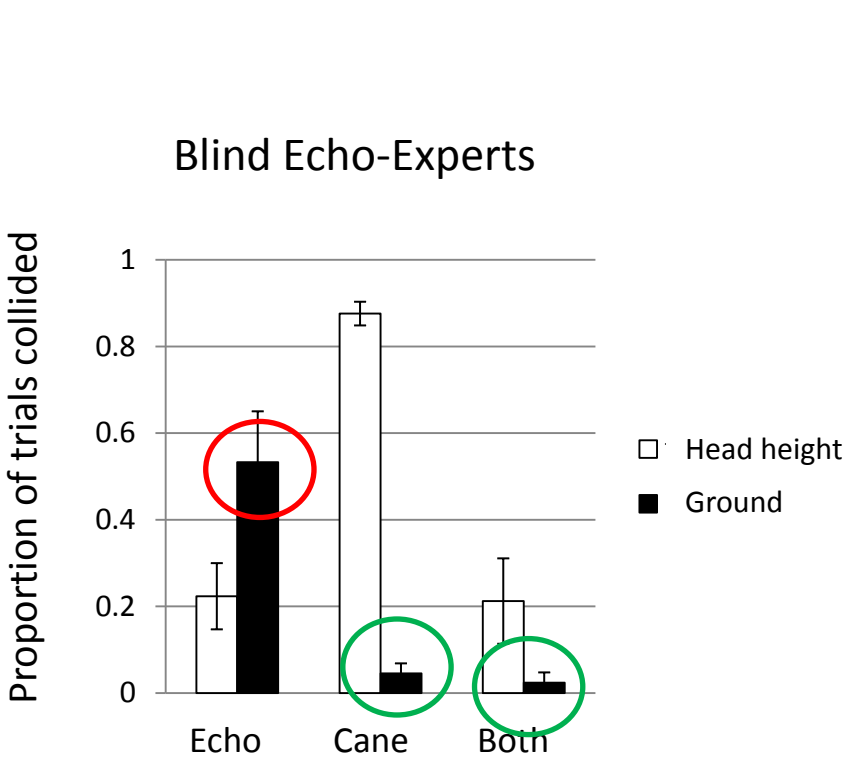

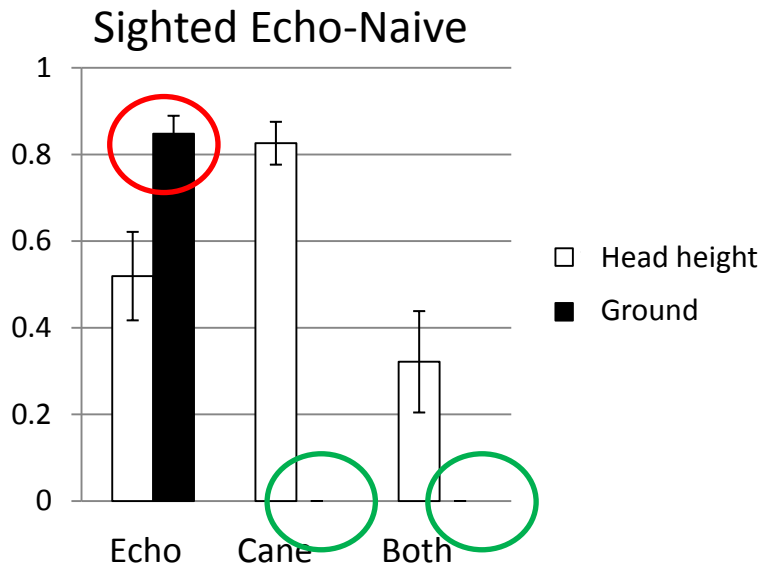

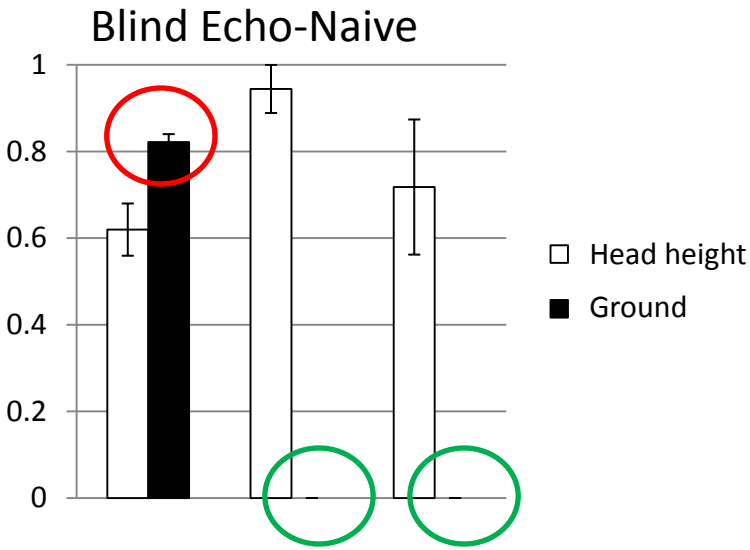

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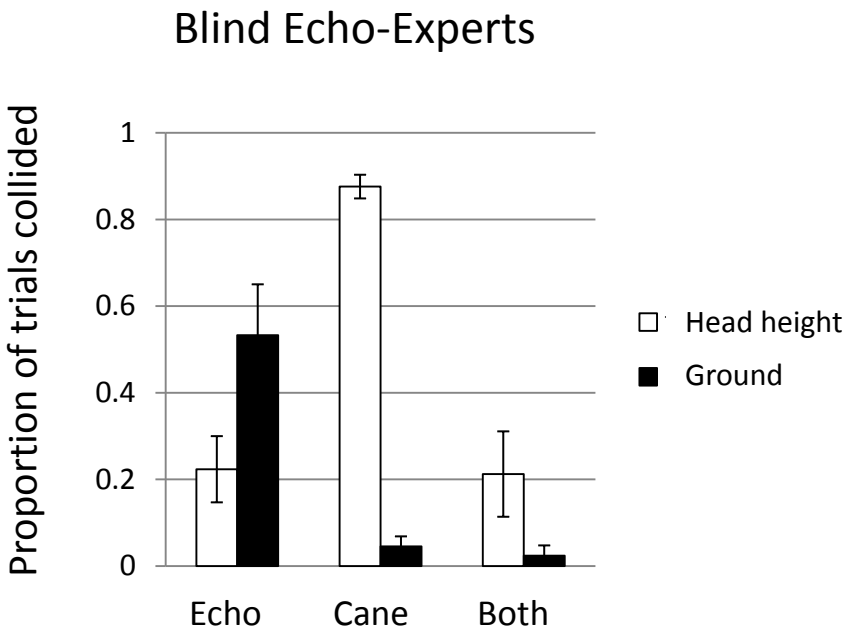

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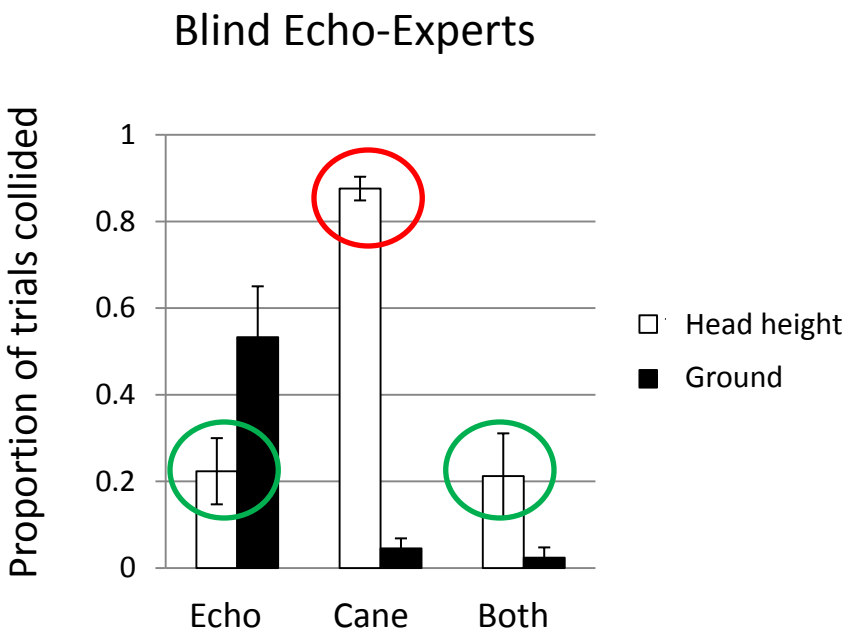

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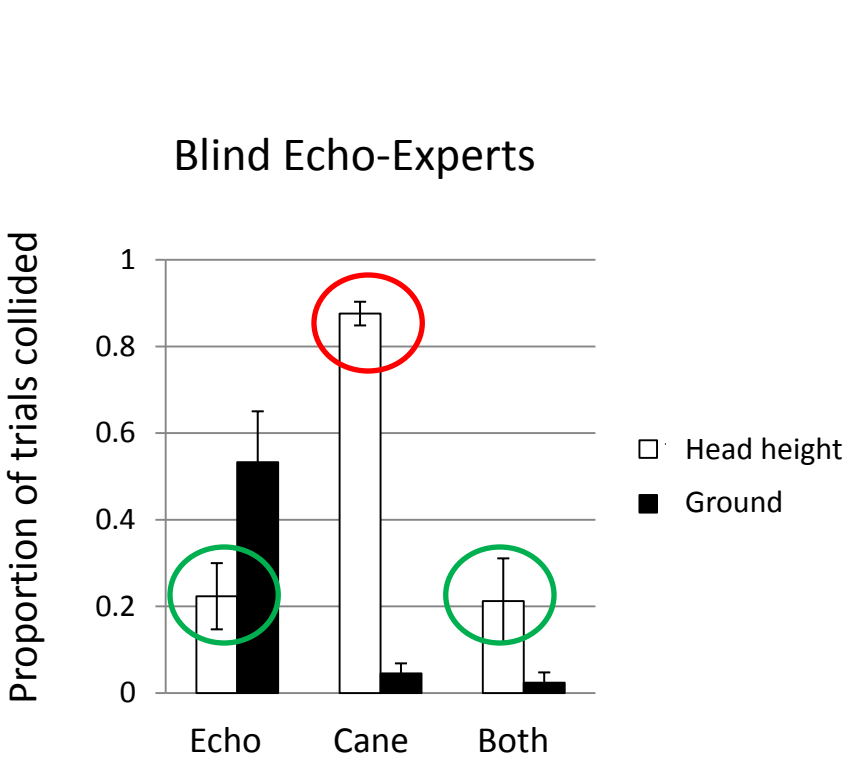
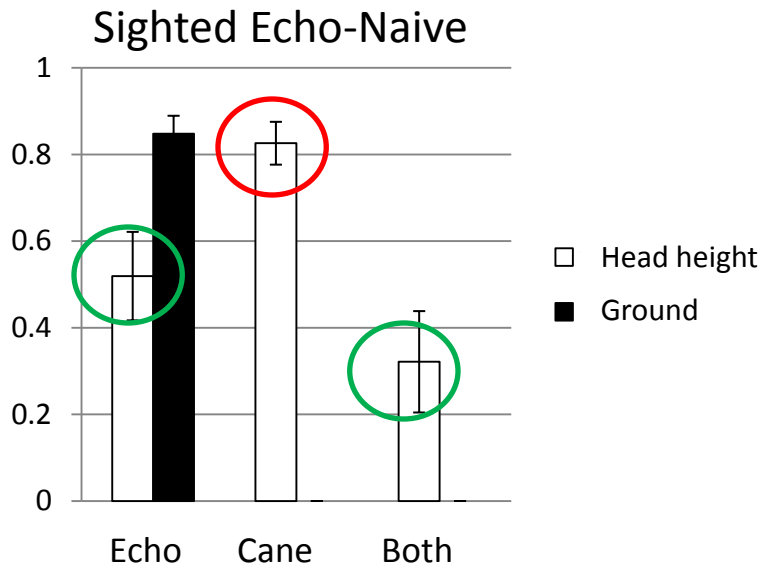
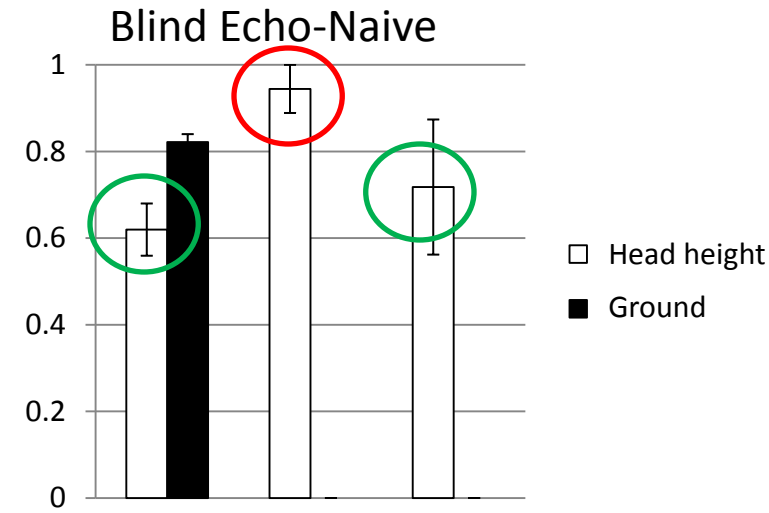
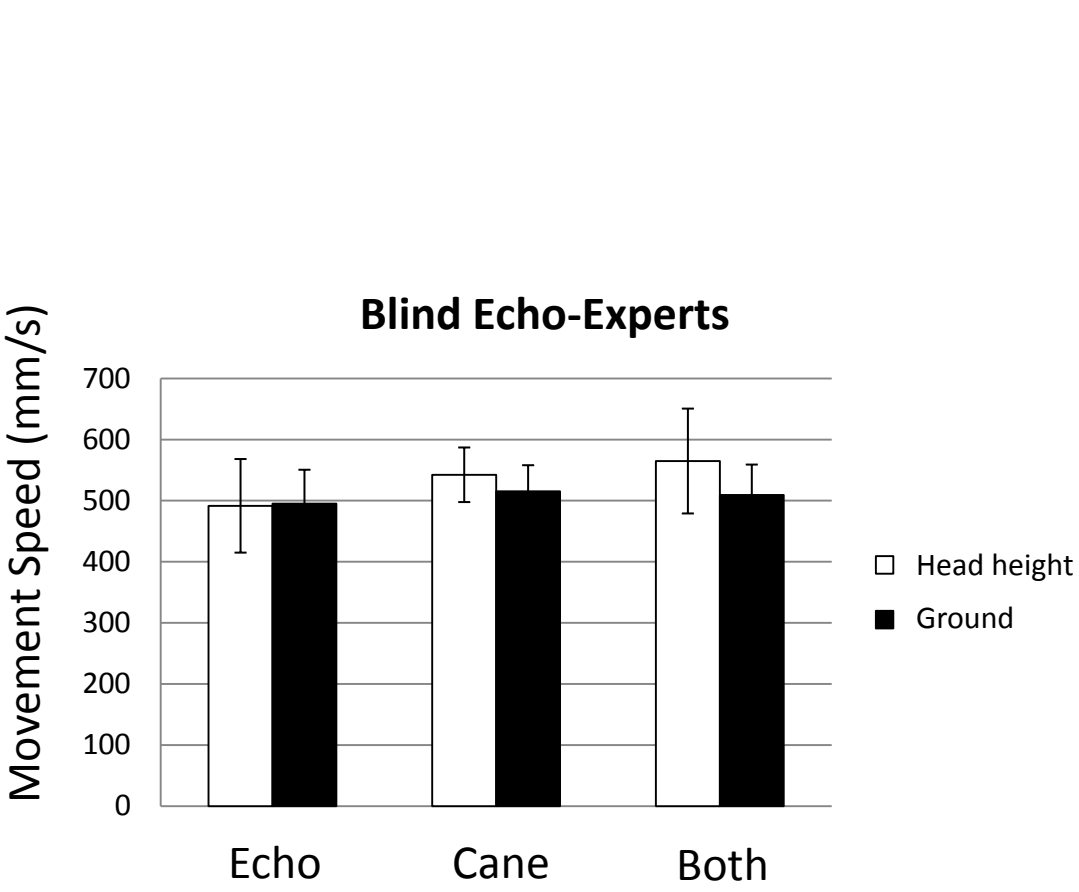
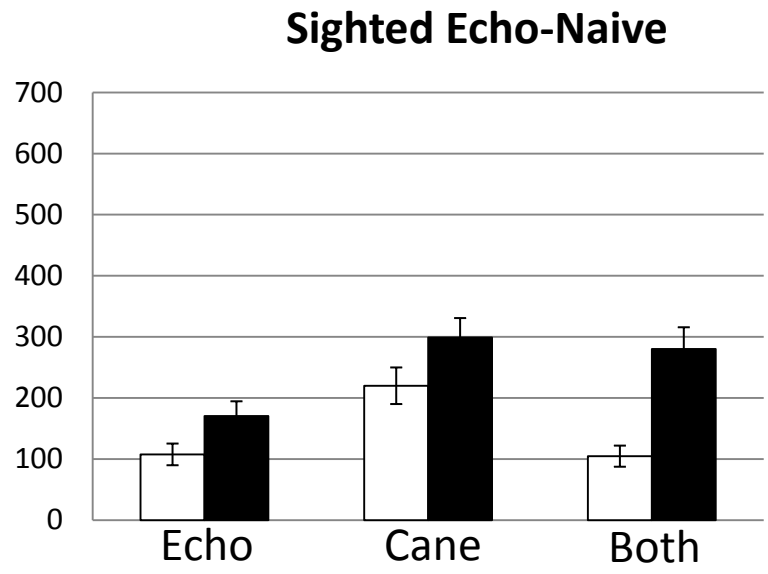


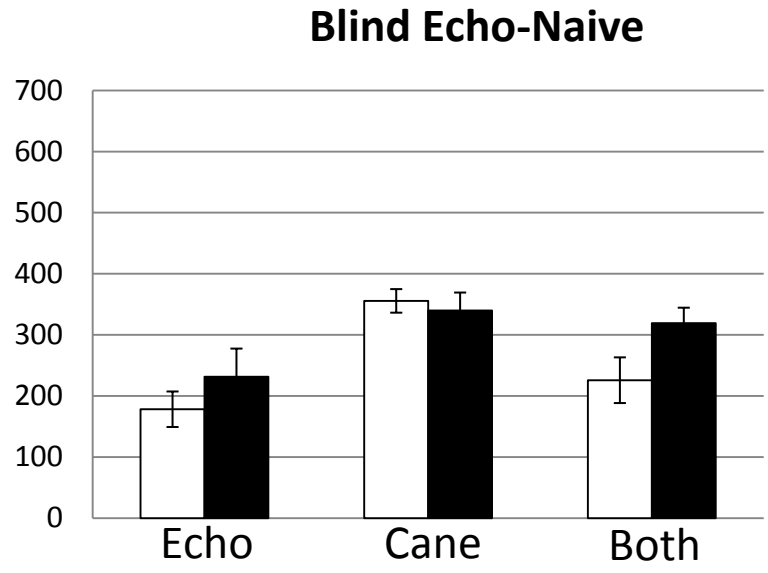




Results – Walking Speed







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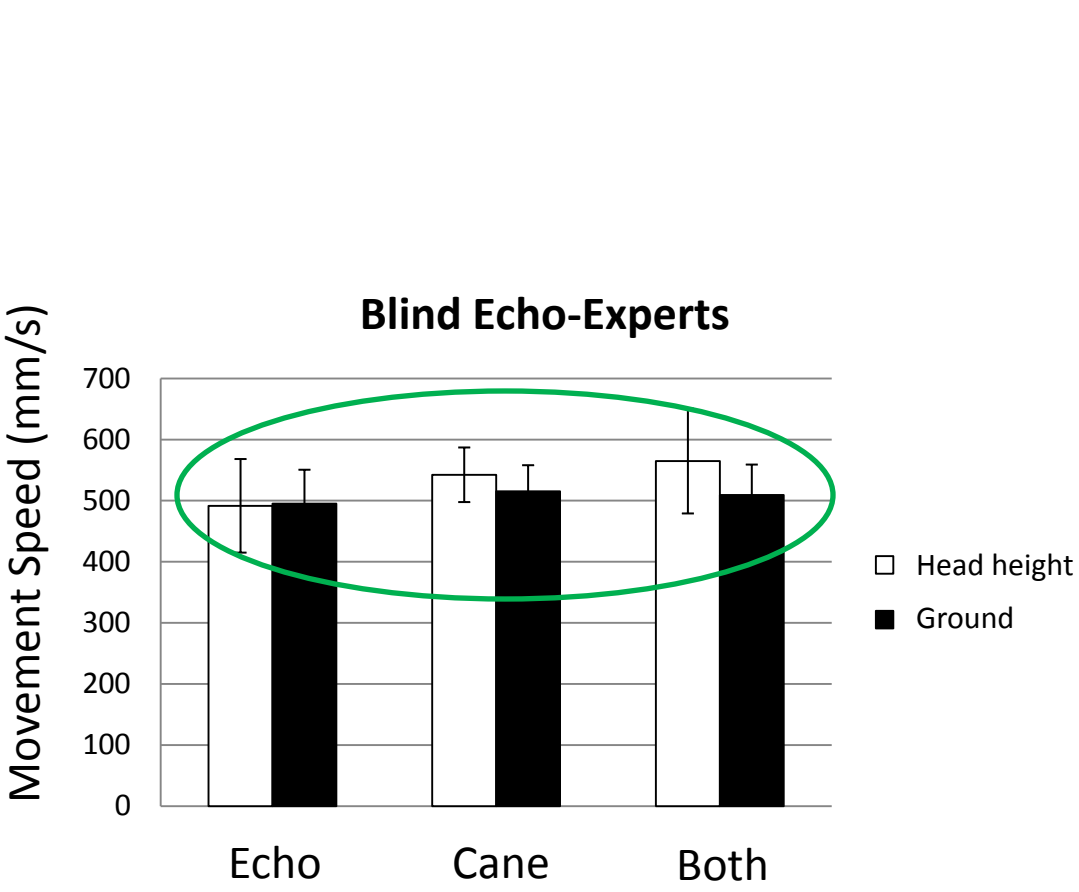

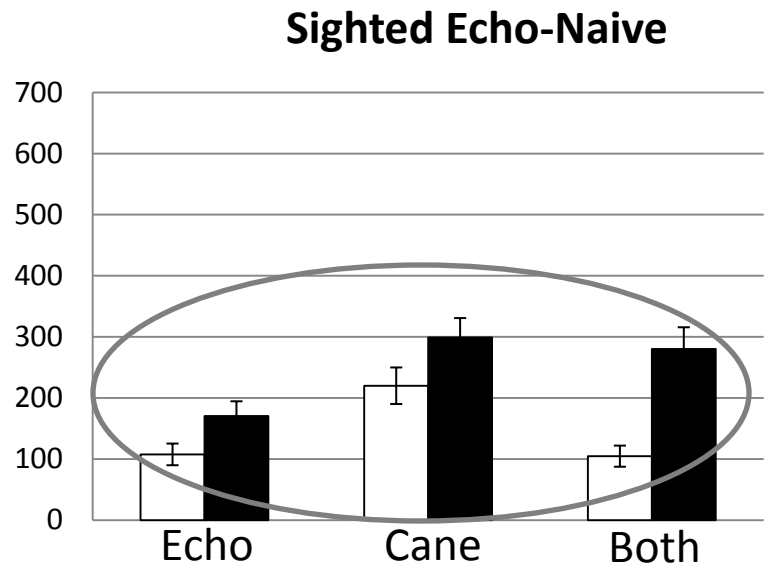

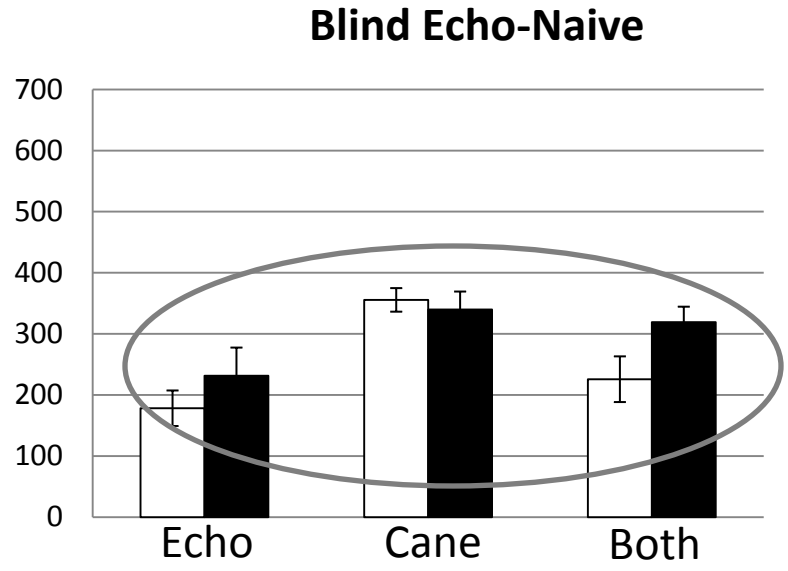

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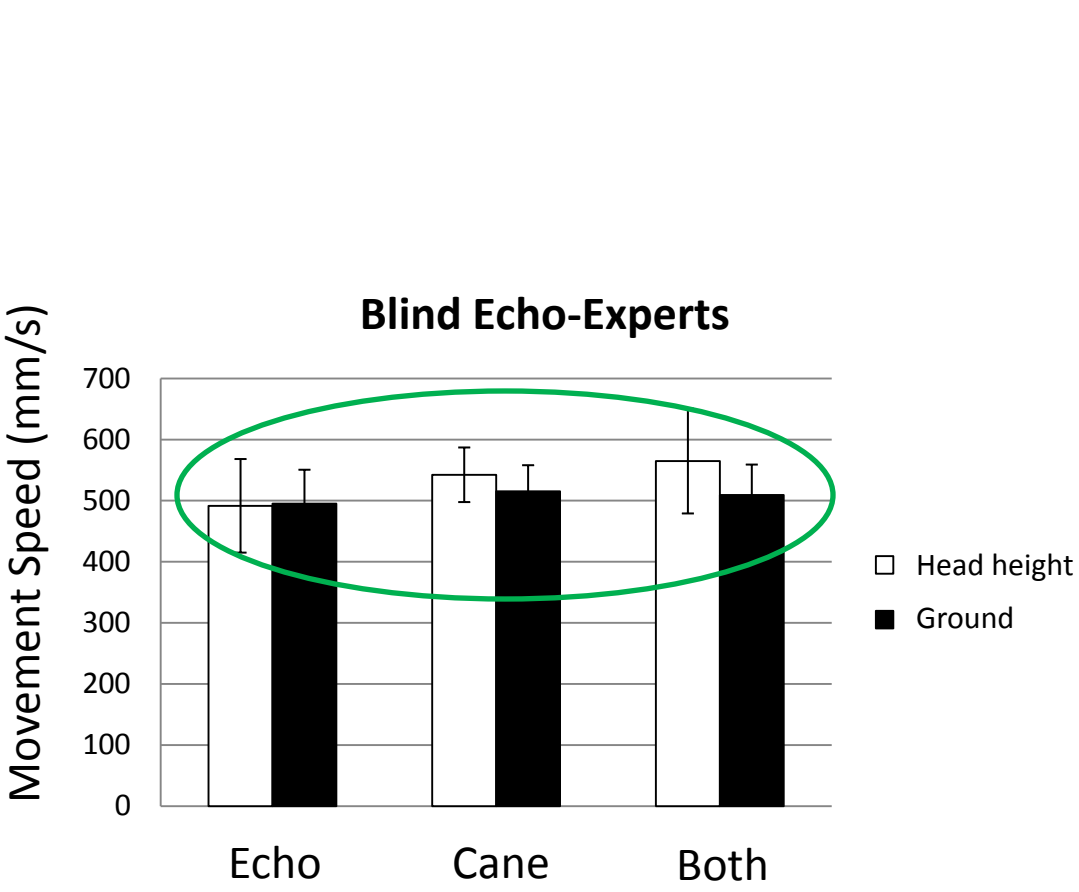
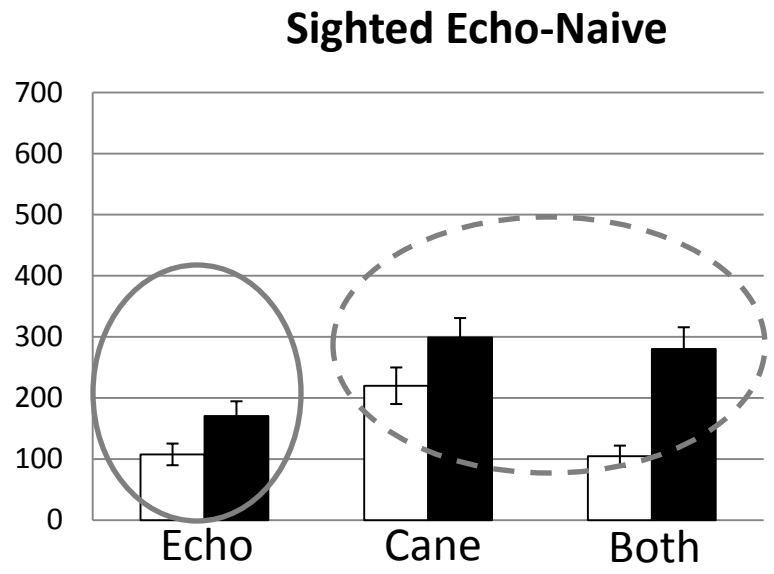
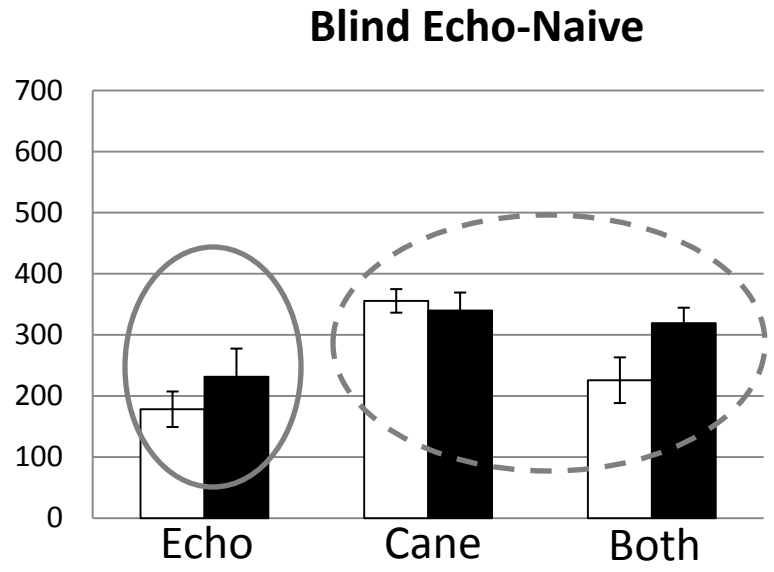
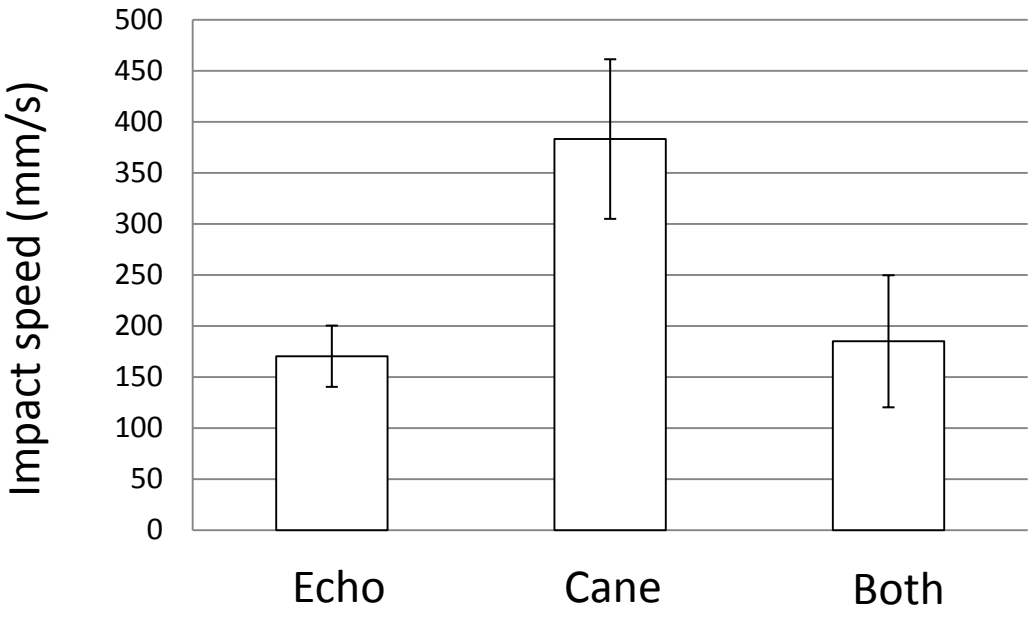






Results – Impact Speed Head Obstacle



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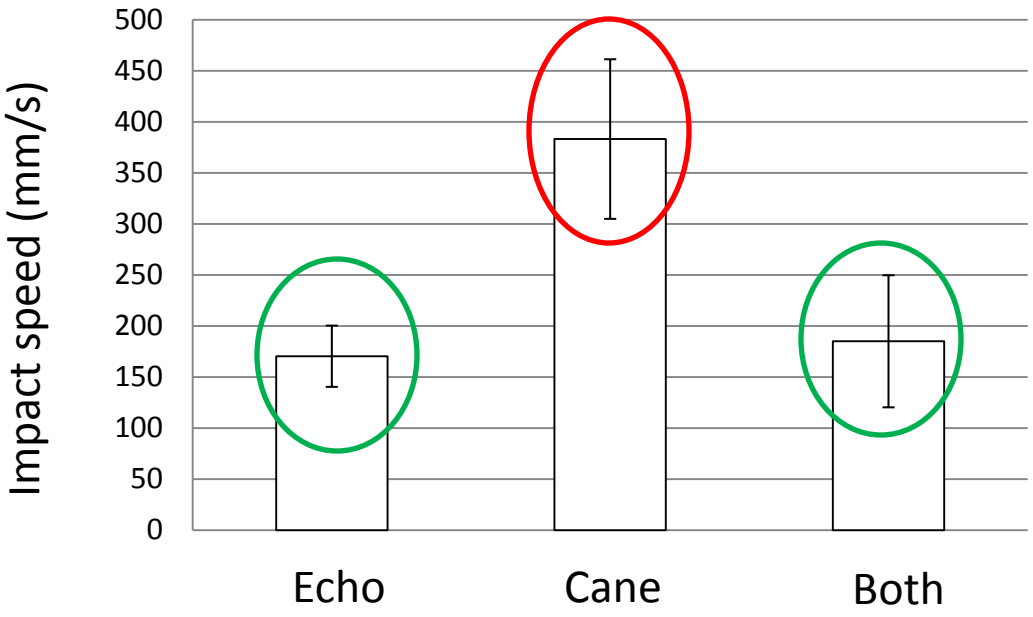
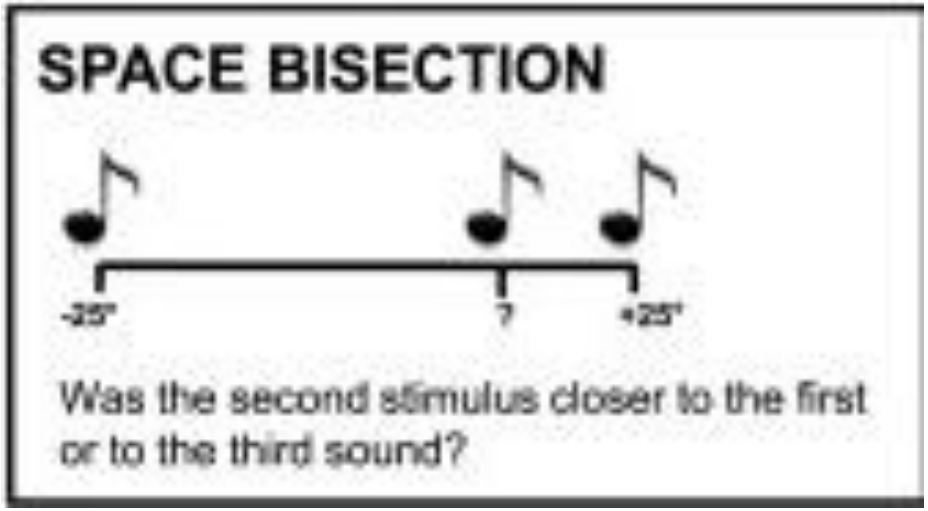


Conclusion

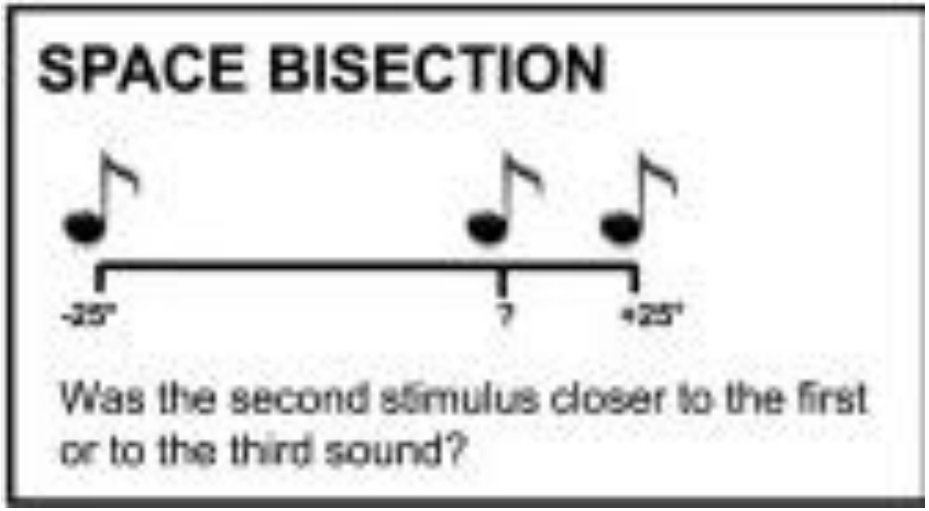
- Click-based echolocation reduces number of collisions & impact speed for obstacles at head height
- Cane reduces number of collisions with obstacles on ground floor
- Echo and Cane can be used together without loss of effectivity of either technique

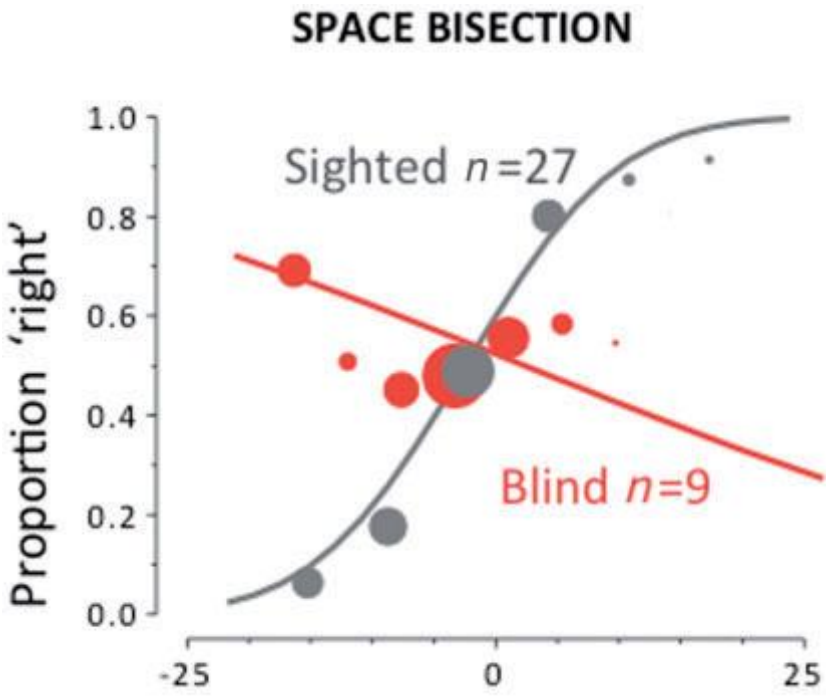
Spatial-Cognitive (Re)Habilitation

- People who are blind from birth show deficits in spatial processing, in particular relationships between objects
- This can present for example as difficulty judging the relative position of two sounds



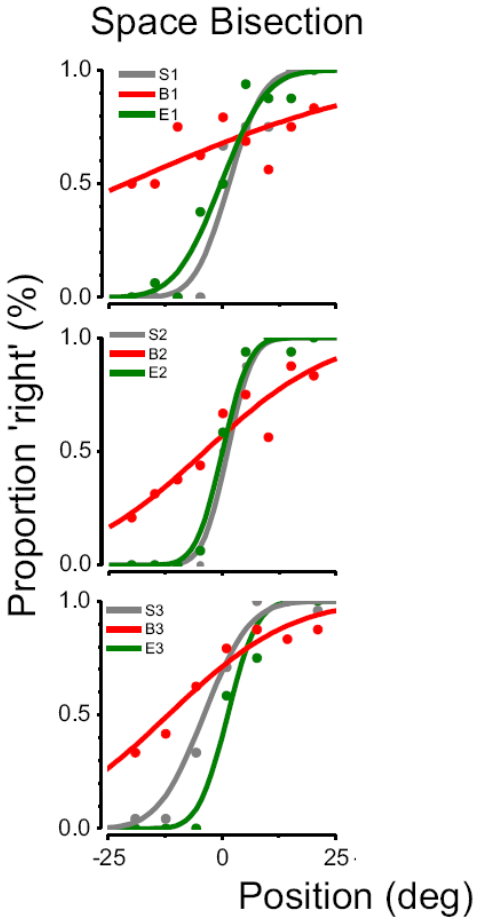
Spatial-Cognitive (Re)Habilitation





Gori et al (2014) Brain

Active Echolocation can replace vision for calibration of auditory space



Vercillo et al (2015) Neuropsychologia

Summary

- Echolocation is the ability to use reflected sound to obtain spatial information
- Active echolocation can provide sensory benefits to people who are totally blind
  - Increased ability to move in unfamiliar places
  - Avoiding obstacles at head height
- Active echolocation might be a useful tool to rehabilitate spatial processing deficits

Thank you!

Contact info: lore.thaler@durham.ac.uk
01913343290

Funding:

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