Echolocation in People – Definitions and Applications

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Echolocation – Bats, Dolphins
Echolocation – Bats, Dolphins ... People
Source Localization requires sound source, e.g. cars, voices

Echolocation requires sound reflecting surface
Echolocation in People

Echolocation / SONAR

Passive
Echoes in Ambient sound field (traffic, other people)

Active
Echoes from Self-Generated sounds (hissing, whistling, mouth clicking, speech, finger snaps, cane taps, foot steps, etc.)

Hybrid
Sensory substitution devices (i-glasses, K-sonar, sonic eye)
Listening to previously recorded active echolocation
Echolocation in People

Echolocation / SONAR

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- Echoes in Ambient sound field (traffic, other people)

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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

Echolocation / SONAR

Passive

Echoes in Ambient sound field (traffic, other people)

Active

Echoes from Self-generated sounds (hissing, whistling, mouth clicking, speech, finger snaps, cane taps, foot steps, etc.)

Hybrid

Sensory substitution devices (i-glasses, K-sonar, sonic eye)
Listening to previously recorded active echolocation
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

Amplitude (a.u.)

Time (ms)
Mouth Clicks & Echoes

Object on the right side

Object Straight Ahead
Mouth Clicks

Object 150cm away

Object 85 cm away
Signals for Human Echolocation

Time (ms)

4"

3"

0"

0"
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

Adult sensory support team

Durham County Council
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

Blind Echo-Experts

Proportion of trials collided

- Echo
- Cane
- Both

Head height
Ground
Results - Collisions

Blind Echo-Experts

Proportion of trials collided

- Head height
- Ground

Echo | Cane | Both
Results - Collisions

Blind Echo-Experts

Proportion of trials collided

Sighted Echo-Naive

Head height

Ground

Blind Echo-Naive

Head height

Ground
Results - Collisions

Blind Echo-Experts

Proportion of trials collided

- Echo
- Cane
- Both

Head height
Ground
Results - Collisions

Blind Echo-Experts

Proportion of trials collided

- Head height
- Ground

Echo | Cane | Both
--- | --- | ---

0.2 | 0.8 | 0.4
Results - Collisions

Blind Echo-Experts

Proportion of trials collided

- Echo
- Cane
- Both

Sighted Echo-Naive

- Echo
- Cane
- Both

Blind Echo-Naive

- Head height
- Ground
Results – Walking Speed

Blind Echo-Experts

Movement Speed (mm/s)

Sighted Echo-Naive

Blind Echo-Naive

Movement Speed (mm/s)
Results – Walking Speed

Blind Echo-Experts

Sighted Echo-Naive

Blind Echo-Naive

Movement Speed (mm/s)

- Head height
- Ground

Echo | Cane | Both

0 | 100 | 200 | 300 | 400 | 500 | 600 | 700

0 | 100 | 200 | 300 | 400 | 500 | 600 | 700

0 | 100 | 200 | 300 | 400 | 500 | 600 | 700

0 | 100 | 200 | 300 | 400 | 500 | 600 | 700
Results – Walking Speed

Blind Echo-Experts

Movement Speed (mm/s)

- Echo
- Cane
- Both

Sighted Echo-Naive

- Echo
- Cane
- Both

Blind Echo-Naive

- Echo
- Cane
- Both

Legend:
- □ Head height
- ■ Ground
Results – Impact Speed Head Obstacle

![Impact speed (mm/s) graph]

- **Echo**: Approximately 150 mm/s
- **Cane**: Approximately 450 mm/s
- **Both**: Approximately 200 mm/s
Results – Impact Speed Head Obstacle

Impact speed (mm/s)

- Echo
- Cane
- Both

Impact speed (mm/s)
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

SPACE BISECTION

Was the second stimulus closer to the first or to the third sound?
Spatial-Cognitive (Re)Habilitation

Gori et al (2014) Brain
Active Echolocation can replace vision for calibration of auditory space

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!

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BRITISH COUNCIL

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