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Perception of room size and the ability of self localization in a virtual environment. Loudspeaker experiment

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Content

- Introduction to the joint experiment of 2 groups
- Listening experiment setup
- Results and evaluation
- Conclusions and further work

Introduction

- auditory information -
  - supplement to visual info
  - often enough on its own
  - for a blind or a visually impaired person, a crucial source of information
- experiments - normal-sighted persons
  - self-localization in a room and room size assessment
  - auditory cues of virtual acoustic environments
  - recreation by a multichannel loudspeaker system (Ambisonics)

Listening experiment setup

- tests were performed in the Auralization Laboratory at the University of Zagreb
- loudspeaker system in a quasi-spherical 4-8-4 configuration
- capable of handling up to 2nd order 3D Ambisonics recordings and up to 3rd order 2D Ambisonics recordings

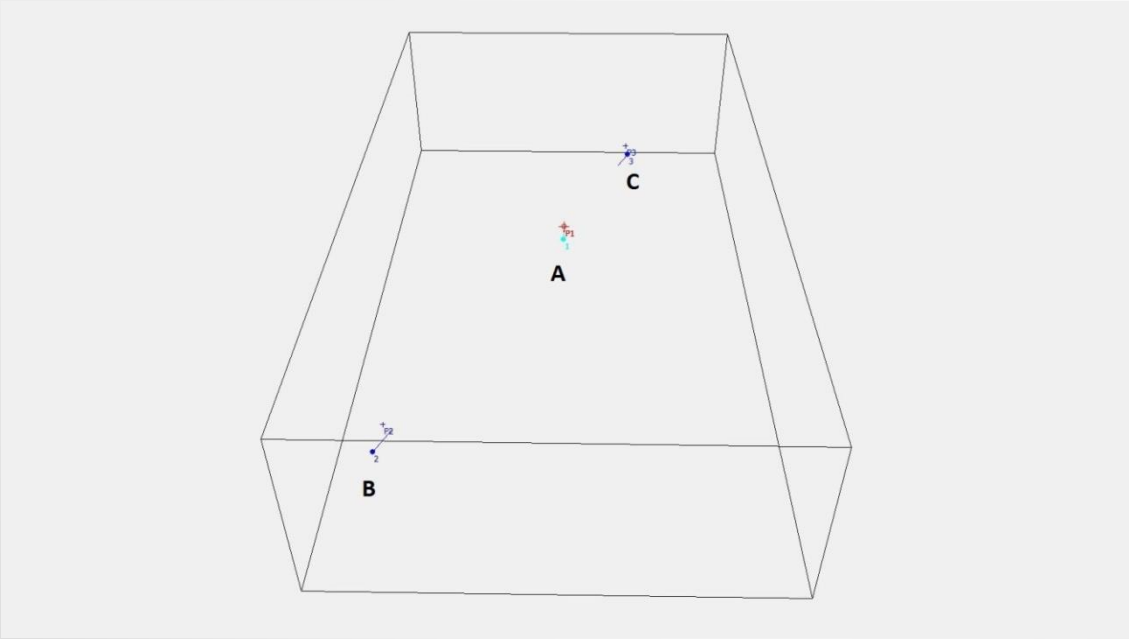
Listening experiment setup

- stimuli – impulsive sounds
  1. hand claps
  2. footsteps
- acoustic conditions
  1. hard reflexive floor, all other surfaces treated
  2. absorption - α = 0.1 , 0.2, 0.4
  3. scattering
     - s = 0.05 on all surfaces
     - 0.9 on the ceiling (0.05 on other surfaces)
     - 0.9 on the left wall (0.05 on other surfaces)

Listening experiment setup

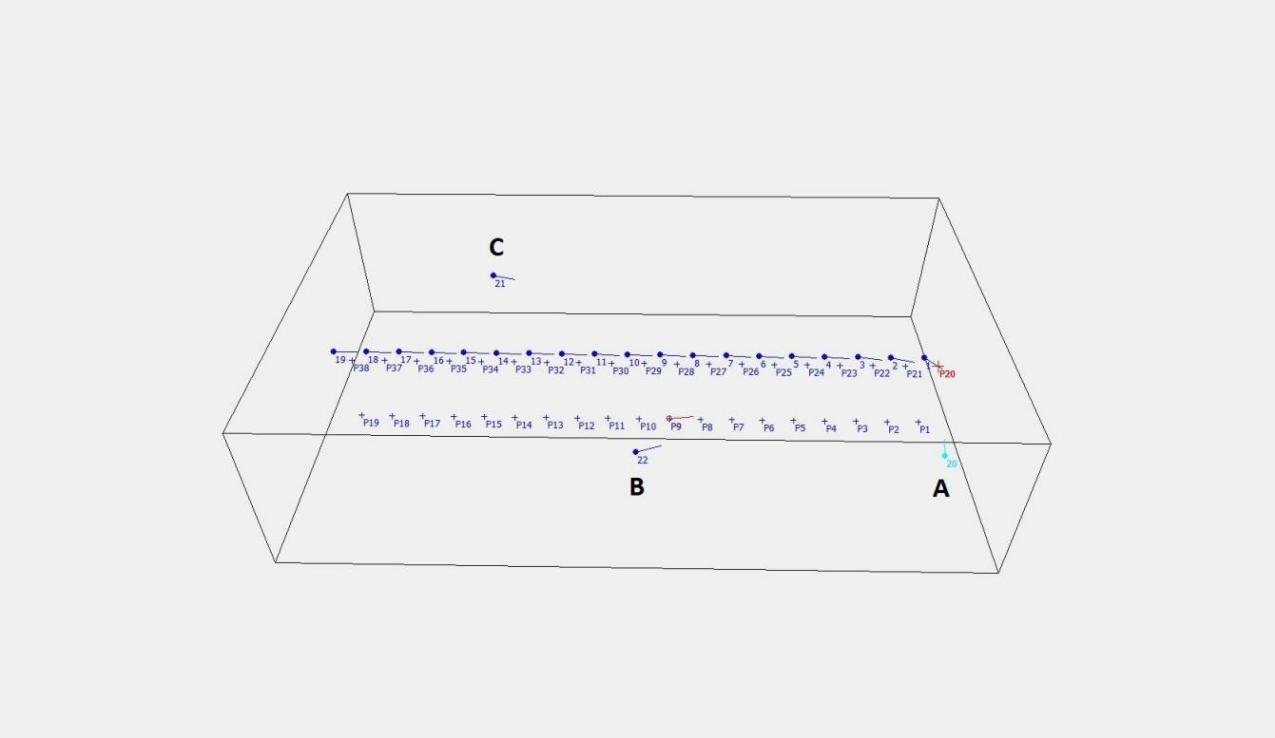
- 36 listeners
  - age range 21-28
  - no hearing impariment
  - variable knowledge on acoustics/music
- test procedure
  - reproduction - 2nd order 3D Ambisonics
  - 9 different acoustic treatments
  - self-localization - three positions in a room (A, B and C)
  - room size assessment - four rooms (1, 2, 3 and 4)
  - task: listen to three (or four) recordings for each acoustic treatment and put the positions (ABC, CBA, BCA,… 6 possible) or rooms (1234,4132,2143,…24 possible) in correct order

Room 1 – Self localization experiment



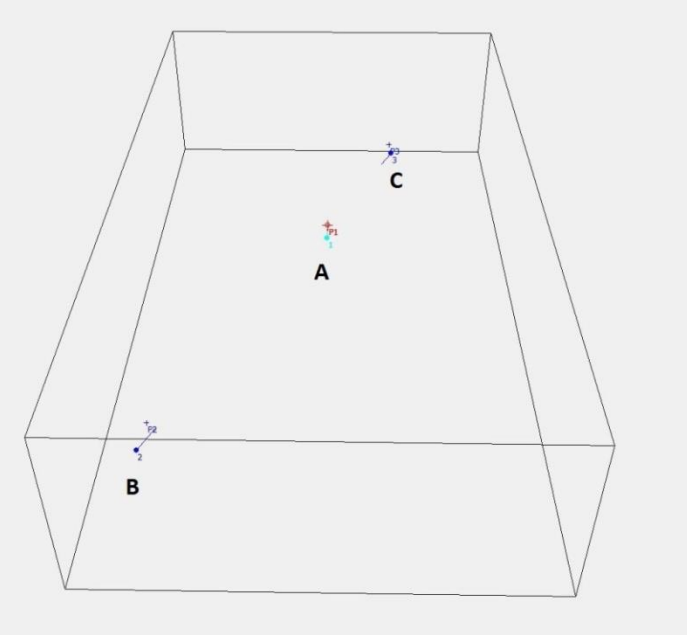
- self-localization - hand claps (own)
- room size assessment - central position - hand claps (own)
- 12 m x 7 m x 3 m = 252 m^3 - medium size

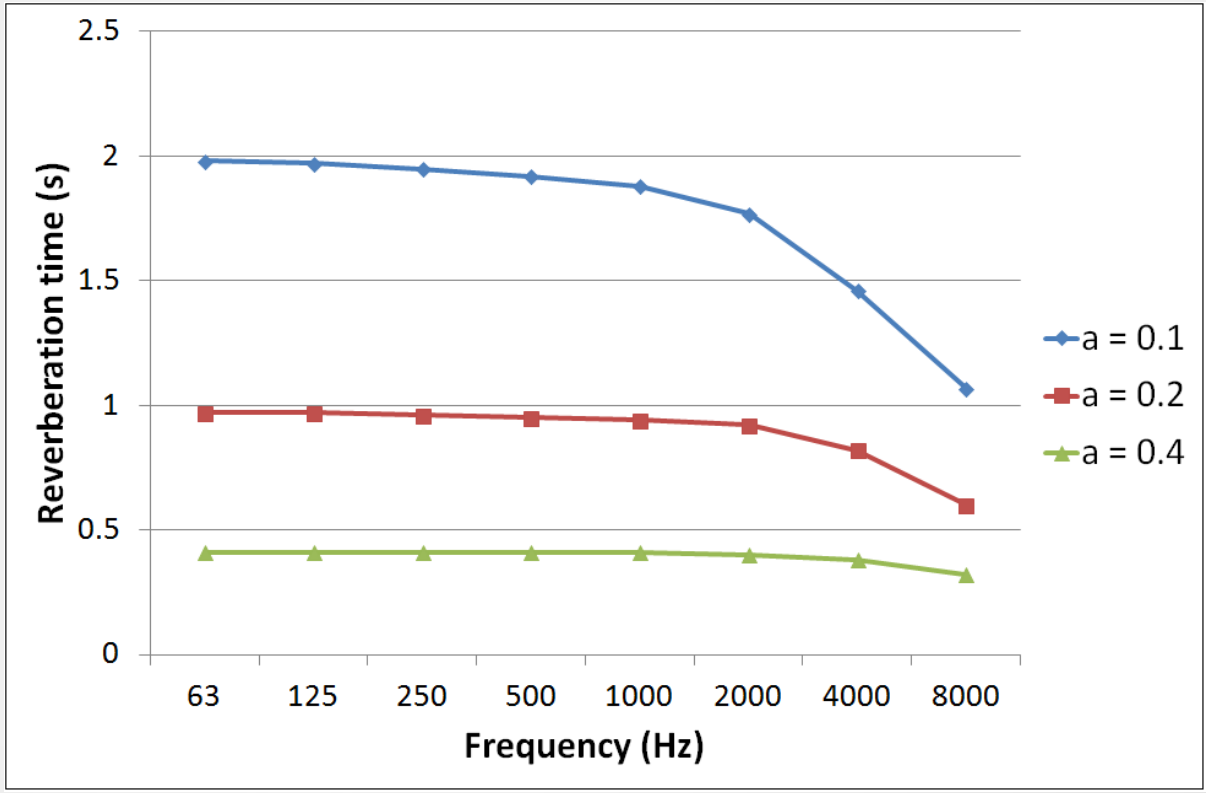
Room 1 – Room size assesment



- self-localization - footsteps (of someone else)
- room size - footsteps (own)
- 12 m x 7 m x 3 m = 252 m^3 - medium size

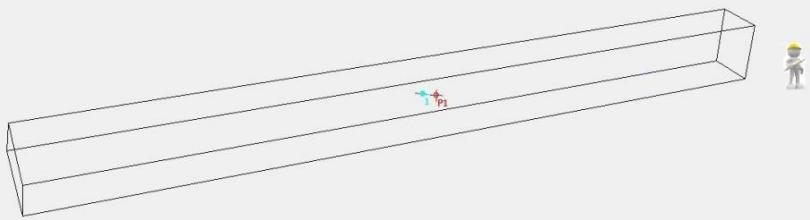
Room 1

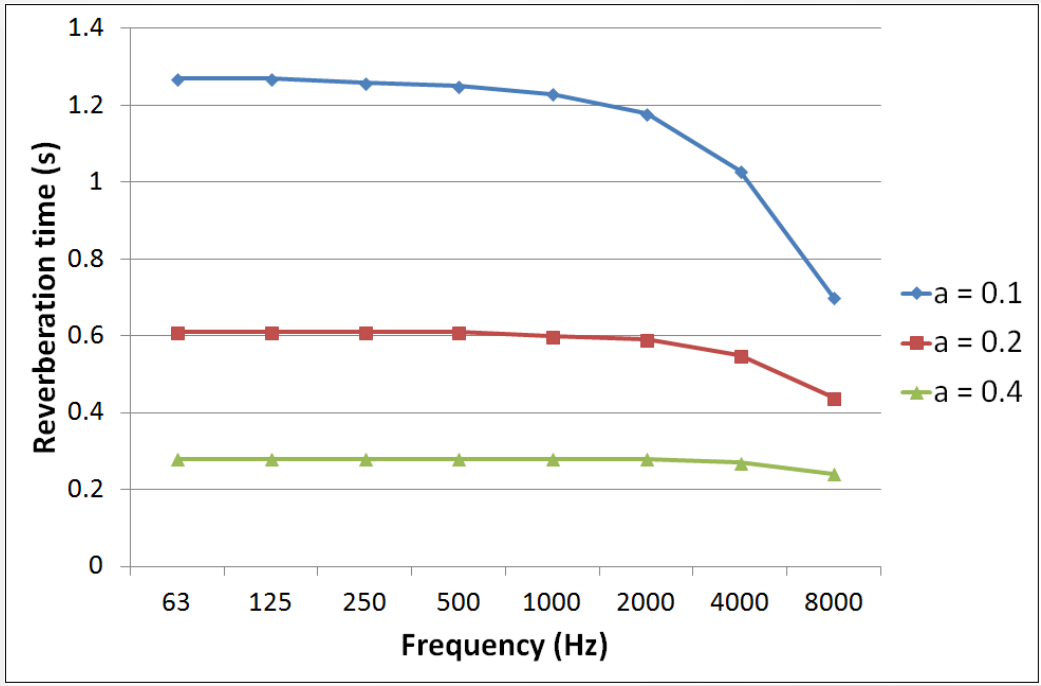




- self-localization - hand claps (own)
- room size assessment - central position - hand claps (own)
- 12 m x 7 m x 3 m = 252 m^3 - medium size

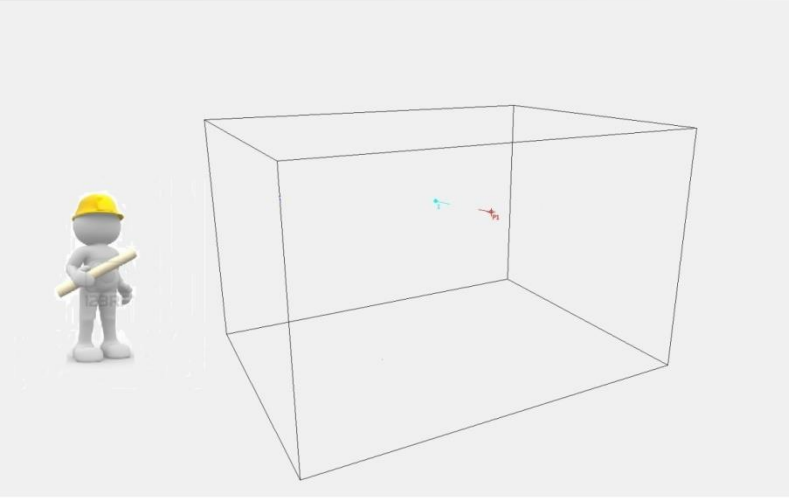
Room 2

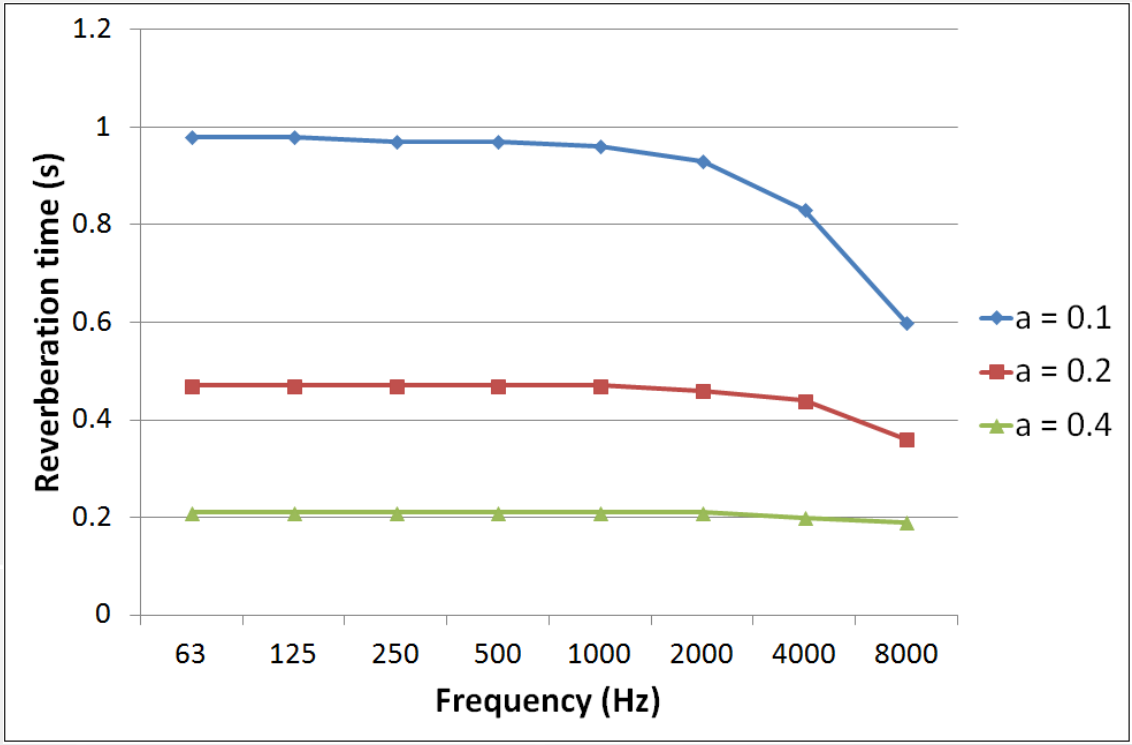




- room size assessment
- 35 m x 2.4 m x 3 m = 252 m^3 - hallway

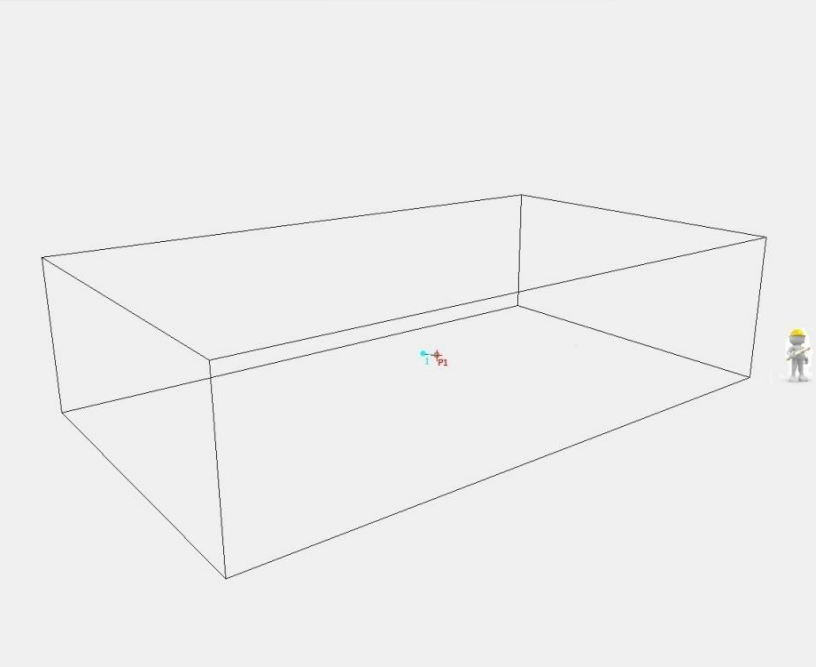
Room 3

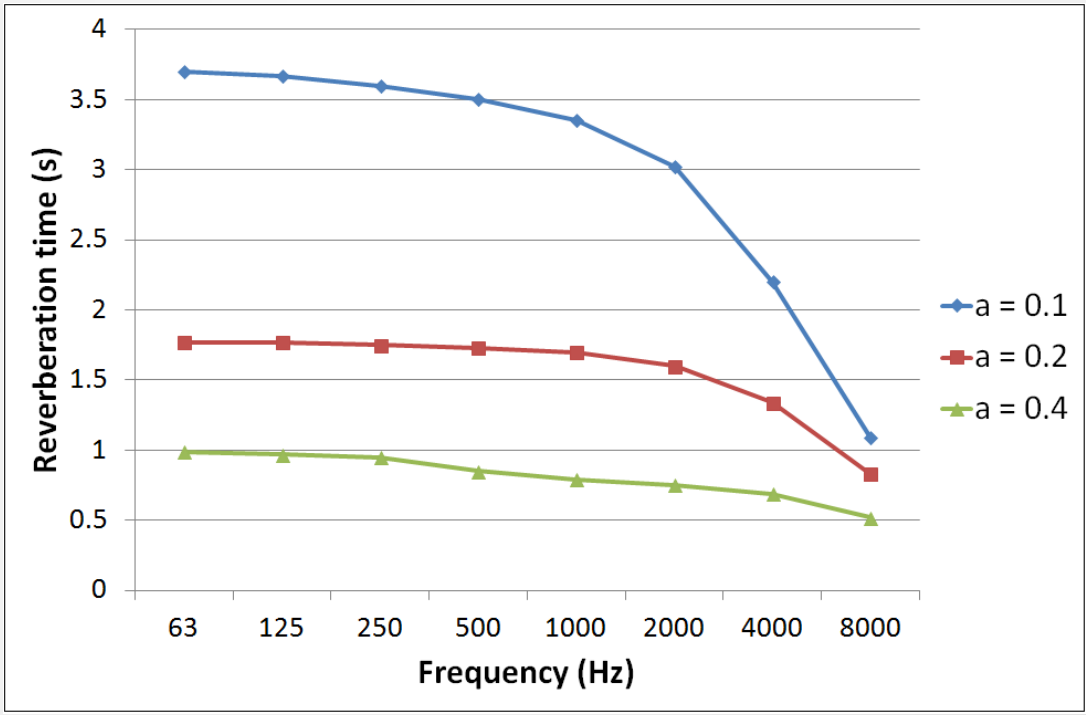




- room size assessment
- 4 m x 3 m x 2.5 m = 30 m^3 - small

Room 4





- room size assessment
- 24 m x 14 m x 6 m = 2016 m^3 - large

Results - X^2-statistics

Hand claps		Scattering coefficient ( )		
df = 5		all 0.05	ceiling 0.9	wall 0.9
Absorption coefficient ( )	0.1	χ^2 = 23.18 *p* < 0.001	χ^2 = 6.94 *p* = 0.225	χ^2 = 4.12 *p* = 0.533
	0.2	χ^2 = 0.94 *p* = 0.967	χ^2 = 3.41 *p* = 0.637	χ^2 = 4.12 *p* = 0.533
	0.4	χ^2 = 7.65 *p* = 0.177	χ^2 = 2.35 *p* = 0.798	χ^2 = 0.24 *p* = 0.999

Footsteps		Scattering coefficient ( )		
df = 5		all 0.05	ceiling 0.9	wall 0.9
Absorption coefficient ( )	0.1	χ^2 = 10.18 *p* = 0.070	χ^2 = 4.88 *p* = 0.430	χ^2 = 0.65 *p* = 0.986
	0.2	χ^2 = 20.41 *p* = 0.001	χ^2 = 8.06 *p* = 0.153	χ^2 = 10.53 *p* = 0.062
	0.4	χ^2 = 2.41 *p* = 0.790	χ^2 = 3.82 *p* = 0.575	χ^2 = 1.00 *p* = 0.963

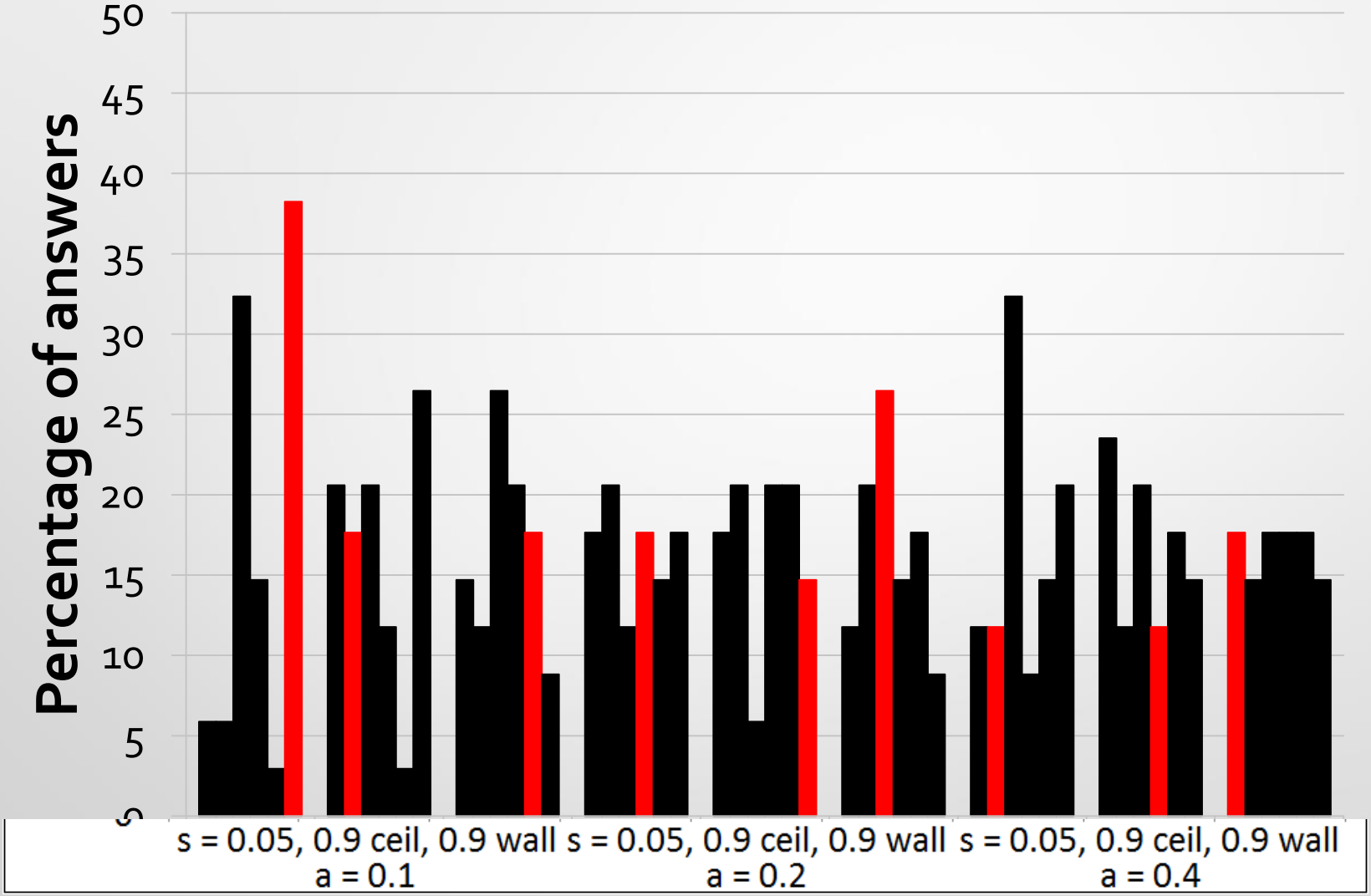
self-localization

Hand claps		Scattering coefficient ( )		
df = 23		all 0.05	ceiling 0.9	wall 0.9
Absorption coefficient ( )	0.1	χ^2 = 197.3 *p* < 0.001	χ^2 = 228.0 *p* < 0.001	χ^2 = 162.6 *p* < 0.001
	0.2	χ^2 = 32.00 *p* = 0.100	χ^2 = 98.67 *p* < 0.001	χ^2 = 209.3 *p* < 0.001
	0.4	χ^2 = 120.0 *p* < 0.001	χ^2 = 102.6 *p* < 0.001	χ^2 = 73.33 *p* < 0.001

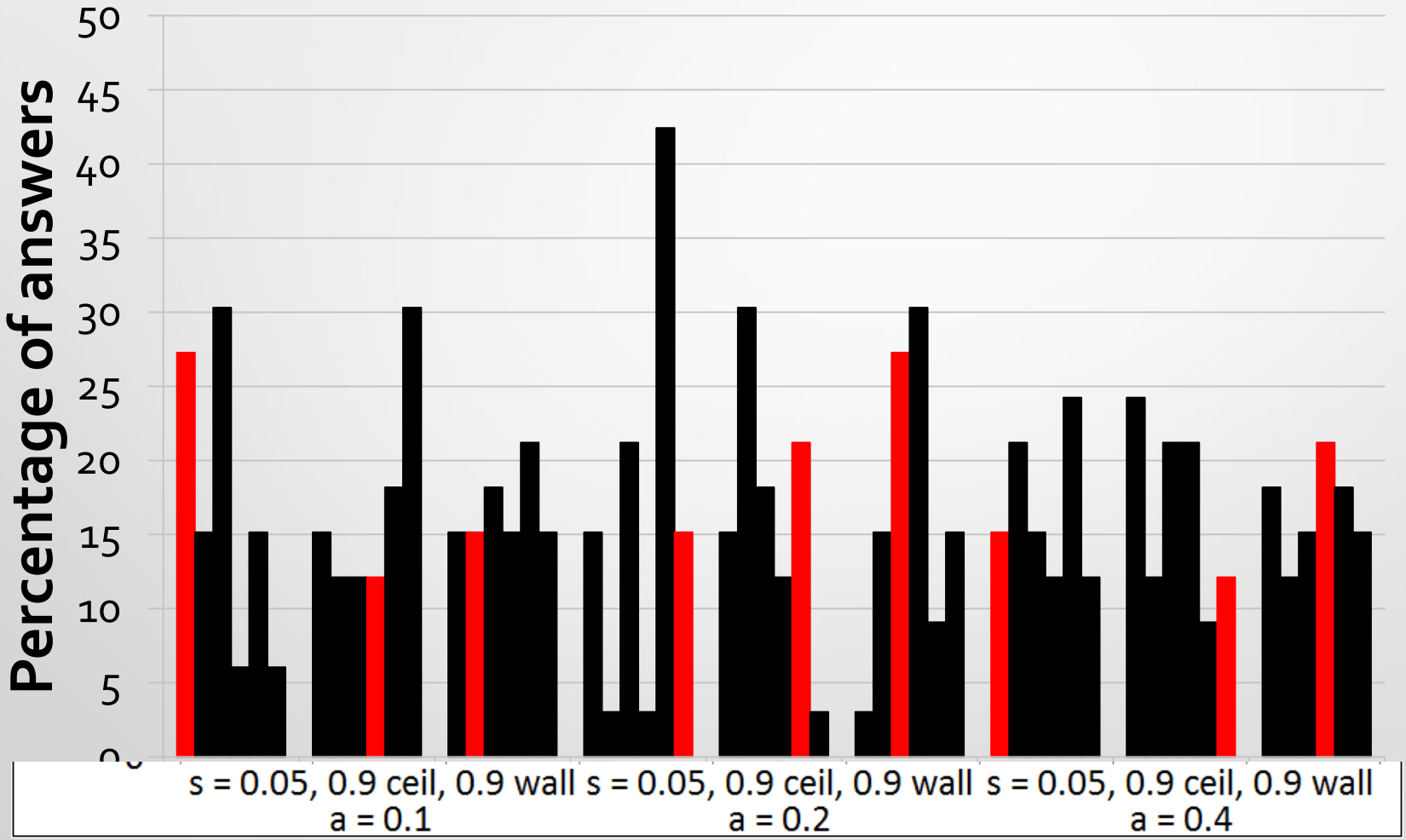
Footsteps		Scattering coefficient ( )		
df = 23		all 0.05	ceiling 0.9	wall 0.9
Absorption coefficient ( )	0.1	χ^2 = 119.2 *p* < 0.001	χ^2 = 163.1 *p* < 0.001	χ^2 = 179.6 *p* < 0.001
	0.2	χ^2 = 142.6 *p* < 0.001	χ^2 = 141.2 *p* < 0.001	χ^2 = 130.2 *p* < 0.001
	0.4	χ^2 = 116.5 *p* < 0.001	χ^2 = 89.11 *p* < 0.001	χ^2 = 138.4 *p* < 0.001

room size assessment

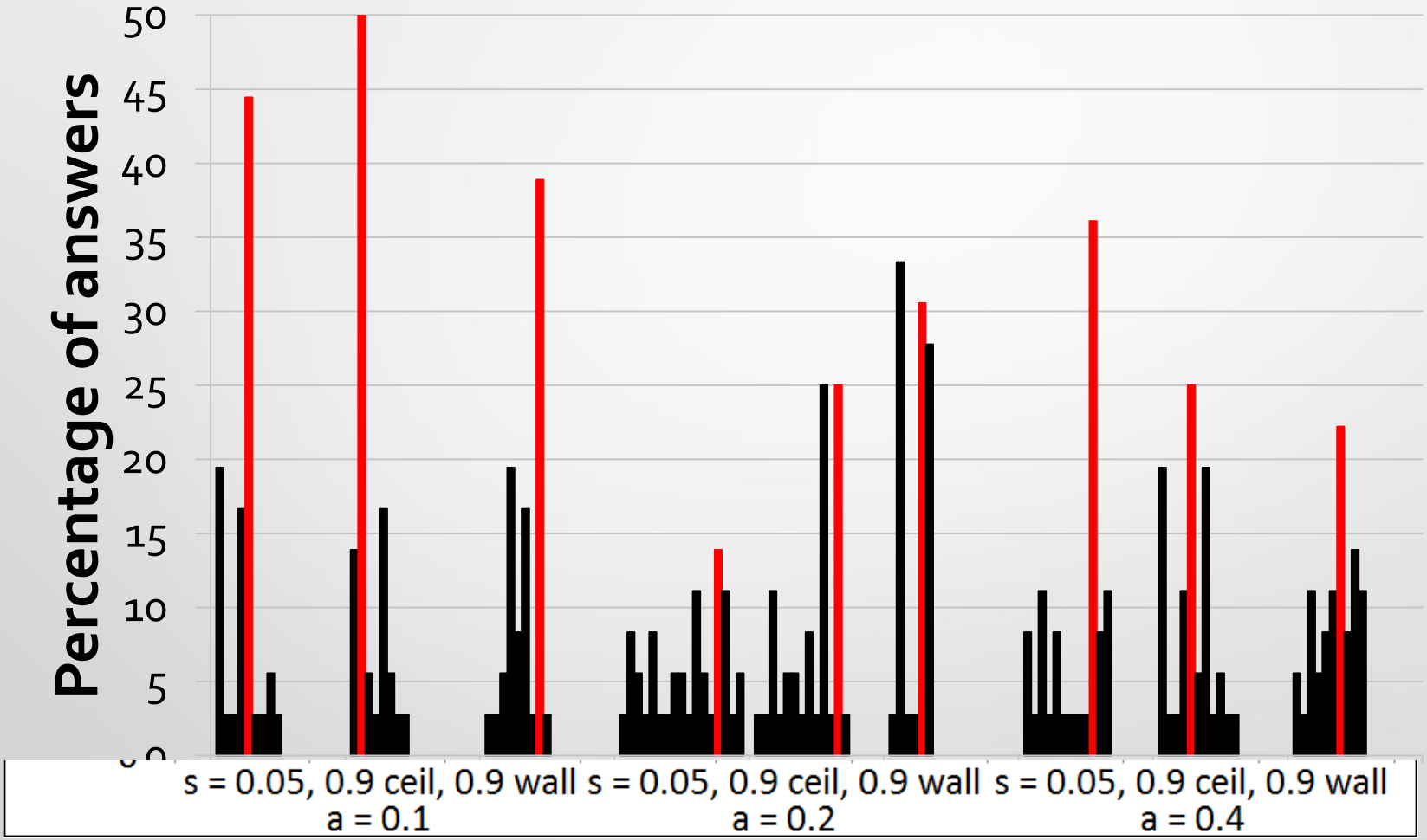
Results - self-localization - handclaps



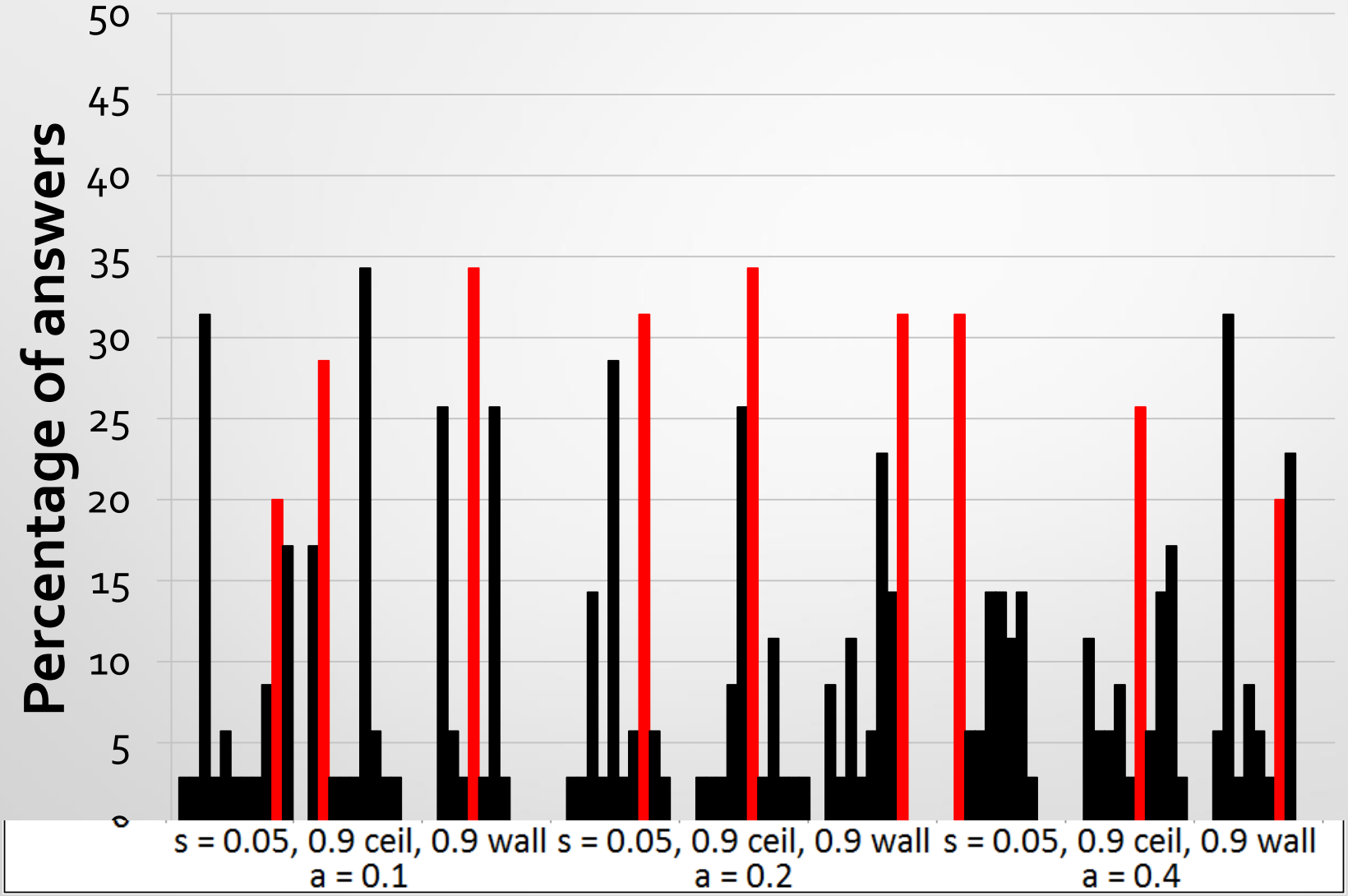
Results - self-localization - footsteps



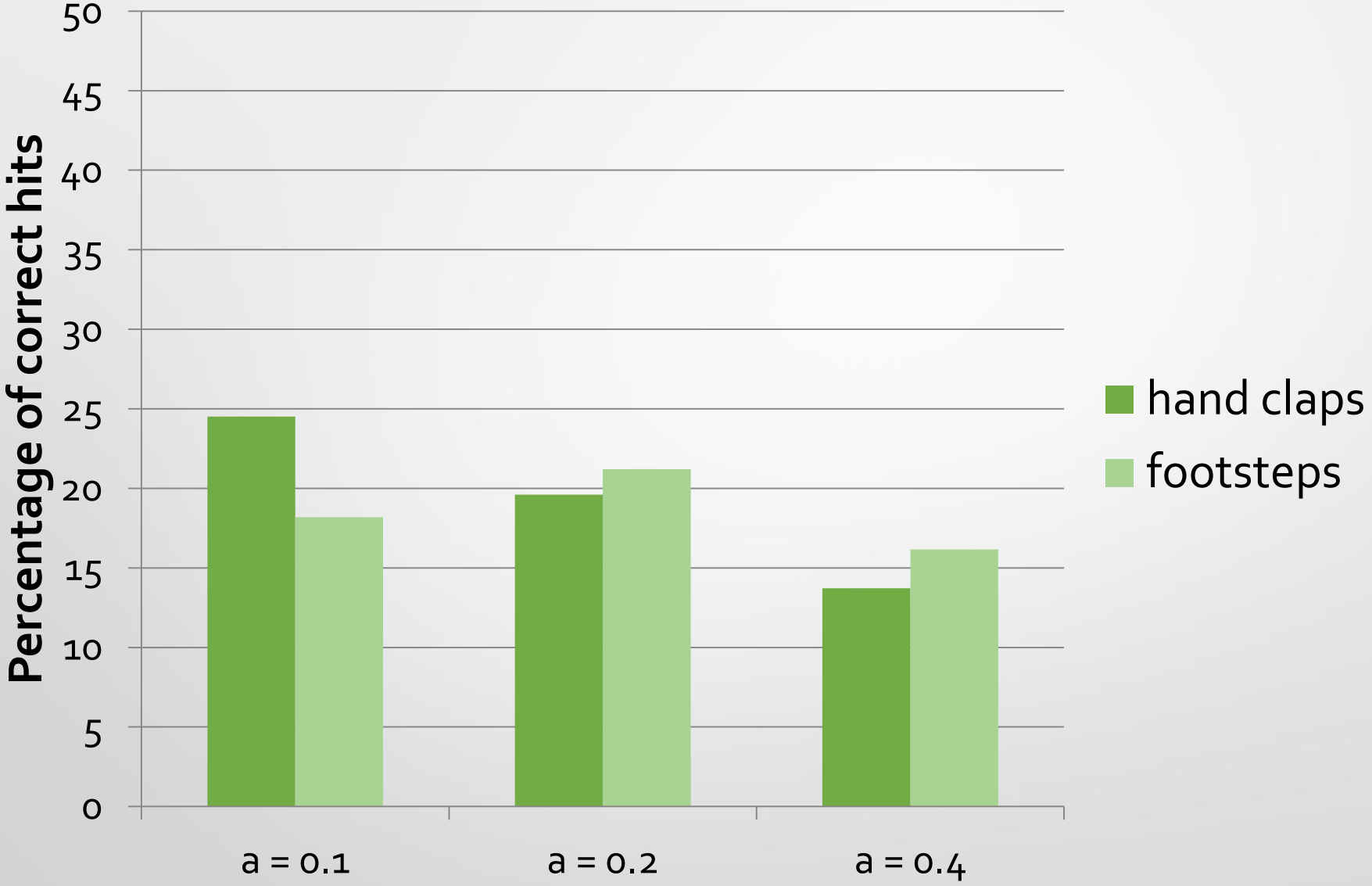
Results - room size assessment - handclaps



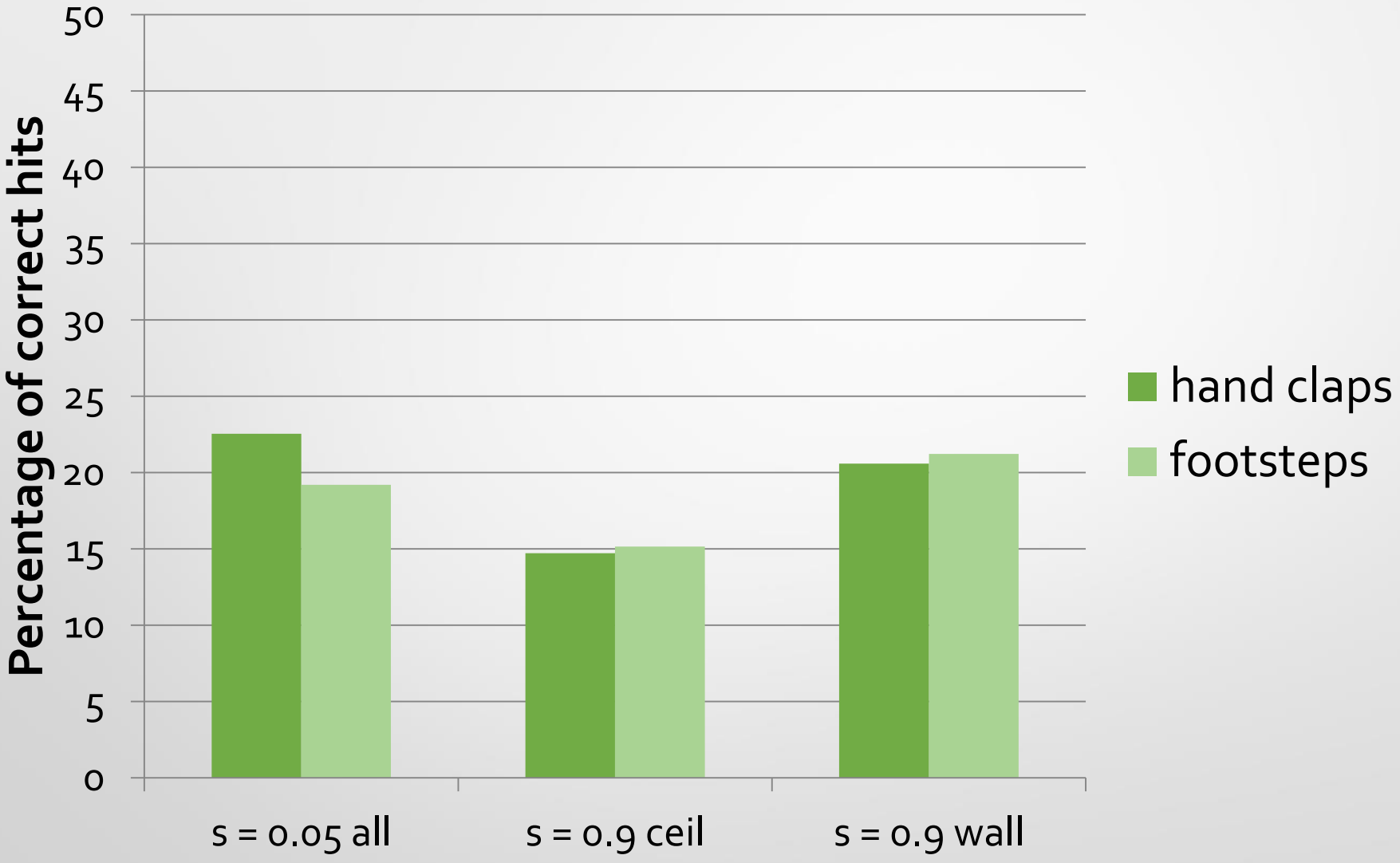
Results - room size assessment - footsteps



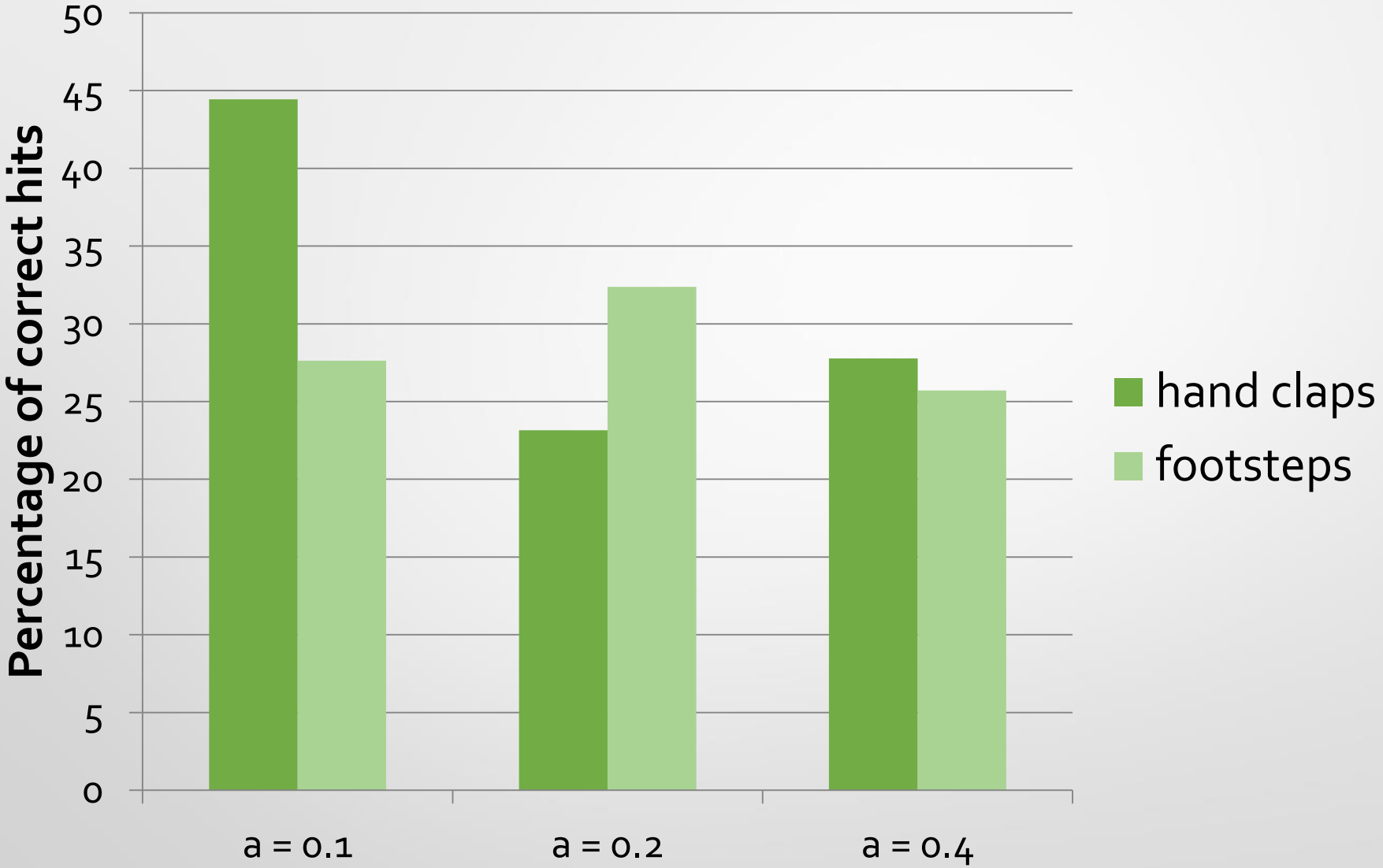
Results - self-localization - absorption



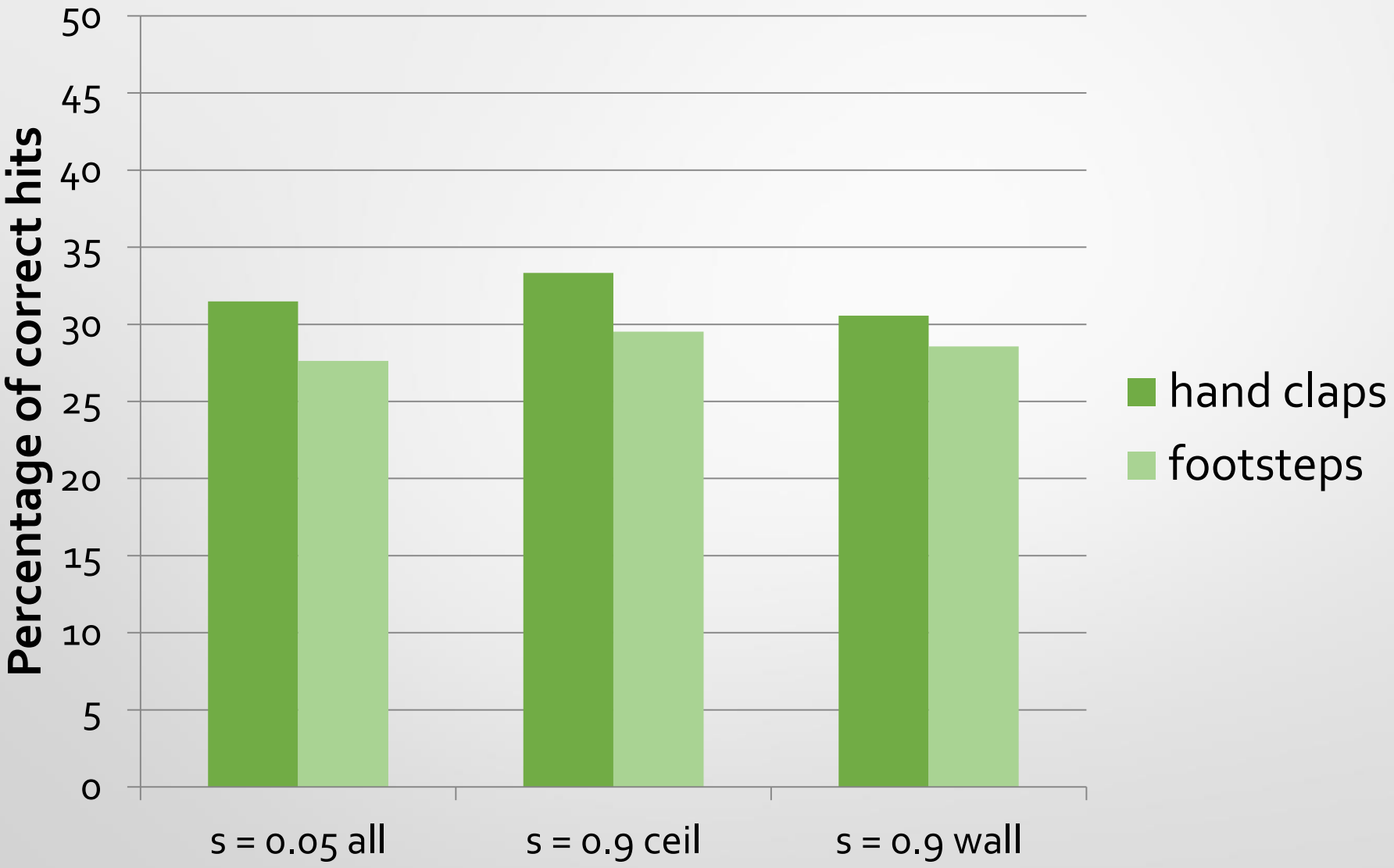
Results - self-localization - diffusion



Results - room size assessment - absorption



Results - room size assessment - diffusion



Conclusions

- ability of self-localization - not well developed (no need)
  - already obtained visually
  - increase of absorption further reduces this ability (0.4 too much, expected in studios and control rooms only)
  - diffusion on the ceiling makes it more difficult
- ability to assess room size - more pronounced
  - develops from everyday experience (use of different spaces)
  - reduced with increased absorption
  - stable with changes in diffusive properties
  - medium-sized room often confused with others
- future work
  - redo the experiments with blind (visually impaired persons)

Thank you for your attention!

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