Assessment of Room Size and Position of the Listener by Normal Sighted Persons Based on Acoustic Response of the Room

M. Horvat, K. Jambrošić, J. Francetić, H. Domitrović, M. Rychtarikova, V. Chmelik

Content

- Introduction
- Experimental setup
- Results
- Conclusions

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)

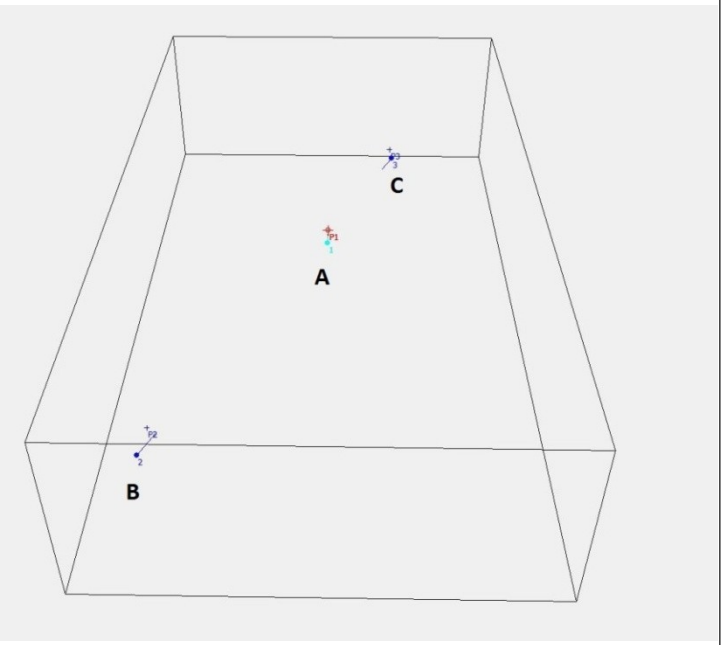
Experimental setup

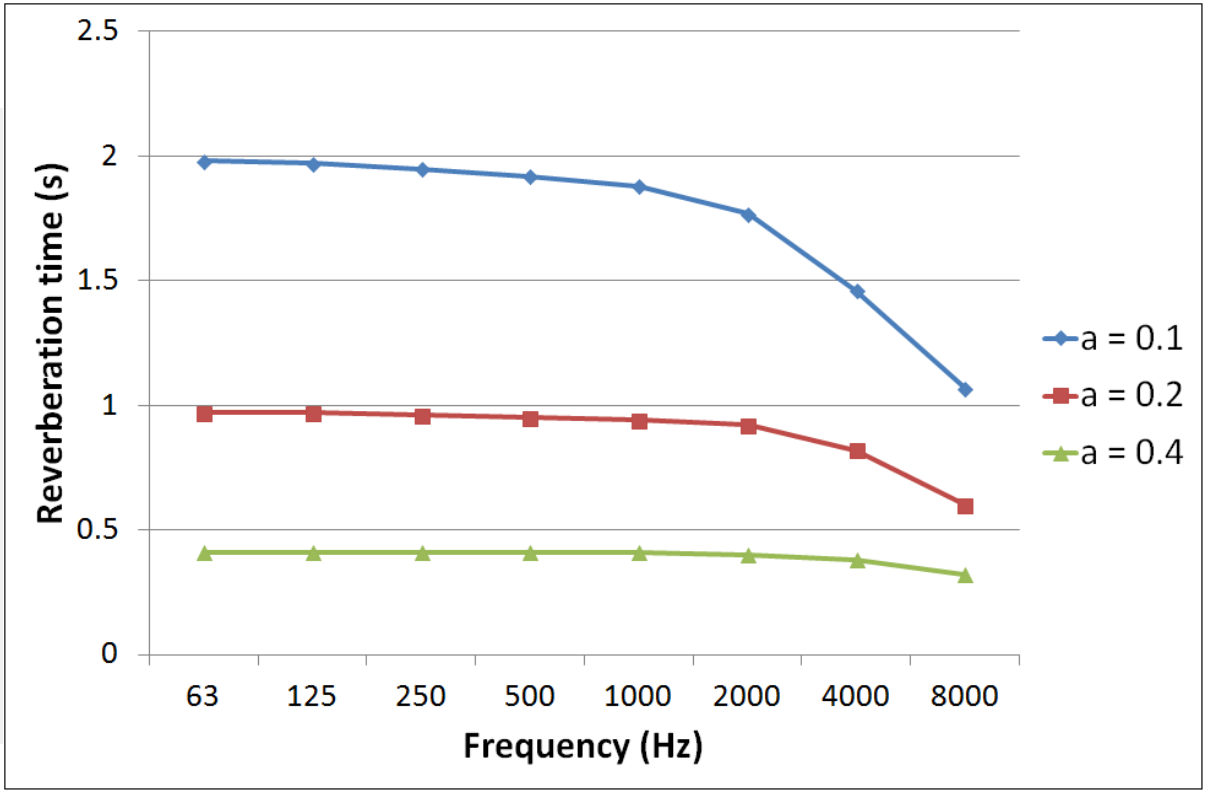
- stimuli - impulsive
  - hand claps
  - footsteps
- acoustic conditions
  - hard reflexive floor, all other surfaces treated
  - absorption - α =
    - 0.1
    - 0.2
    - 0.4
  - diffusion - s =
    - 0.05 on all surfaces
    - 0.9 on the ceiling (0.05 on other surfaces)
    - 0.9 on the left wall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

Experimental 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

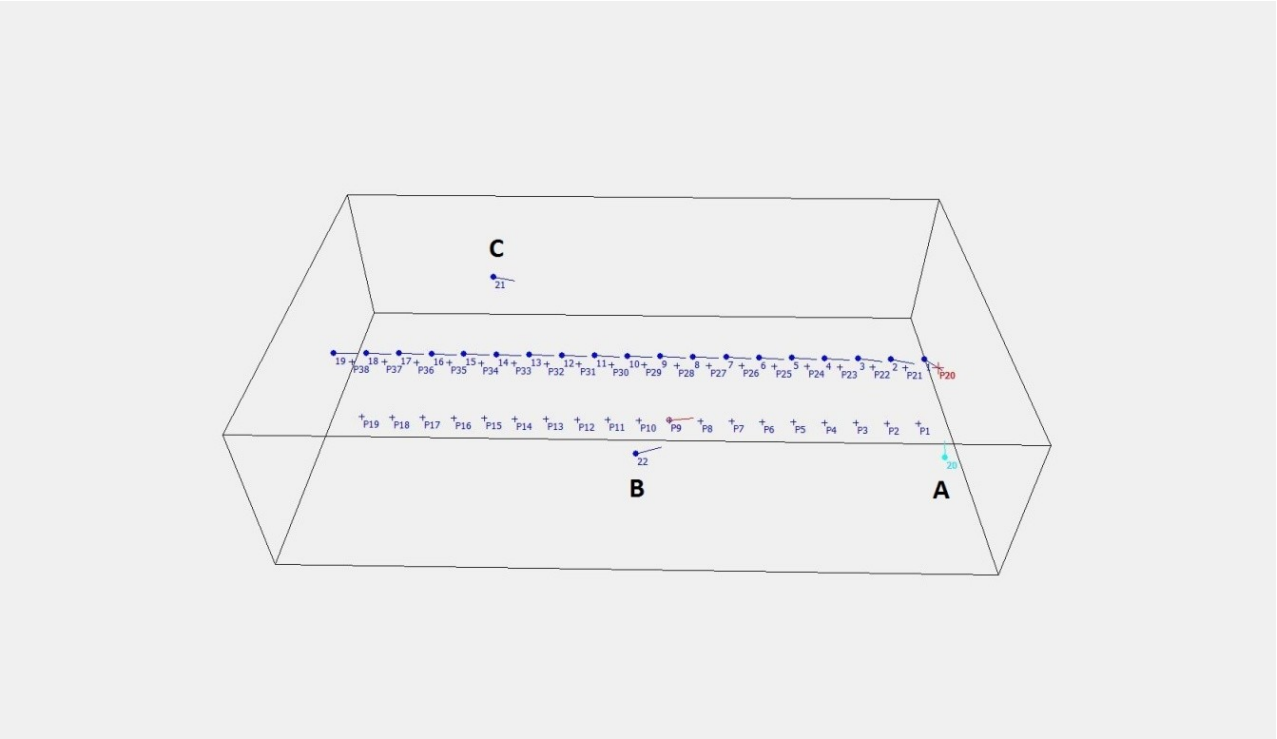
Rooms - 1





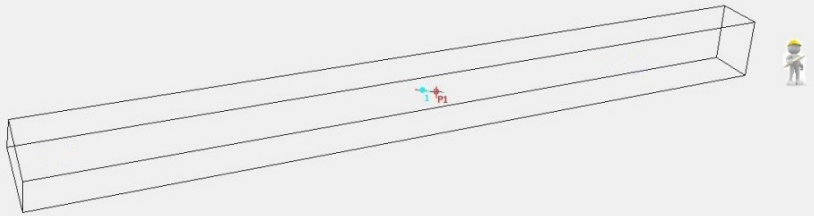
- self-localization - hand claps (own)
- room size assessment - central position - hand claps (own)
- 12 m x 7 m x 3 m = 252 m^3 - medium size

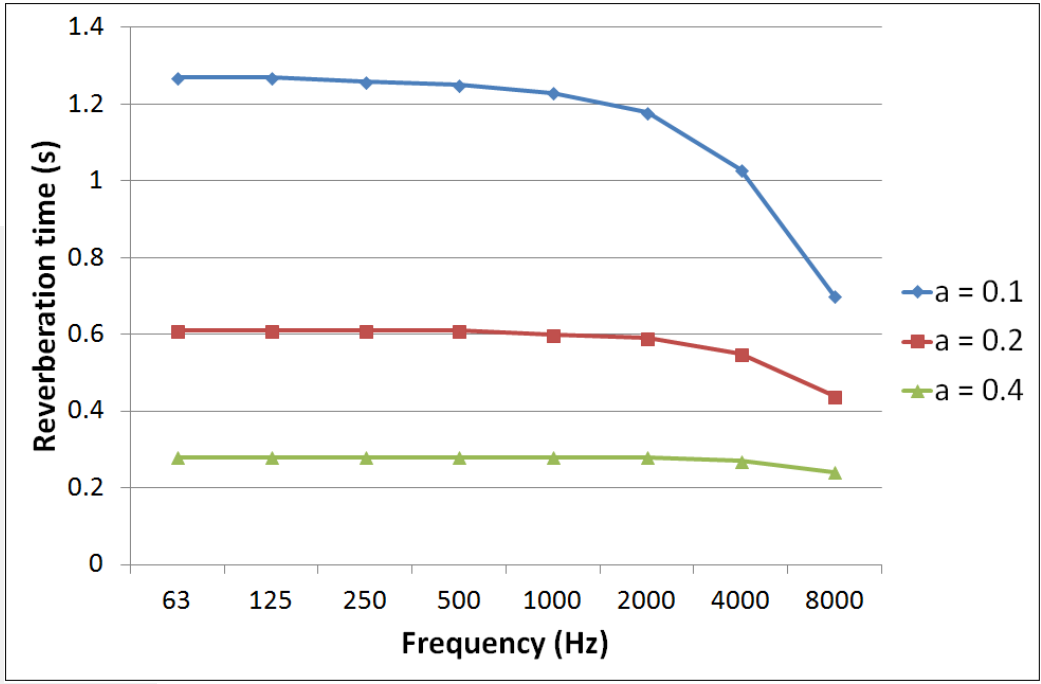
Rooms - 1



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

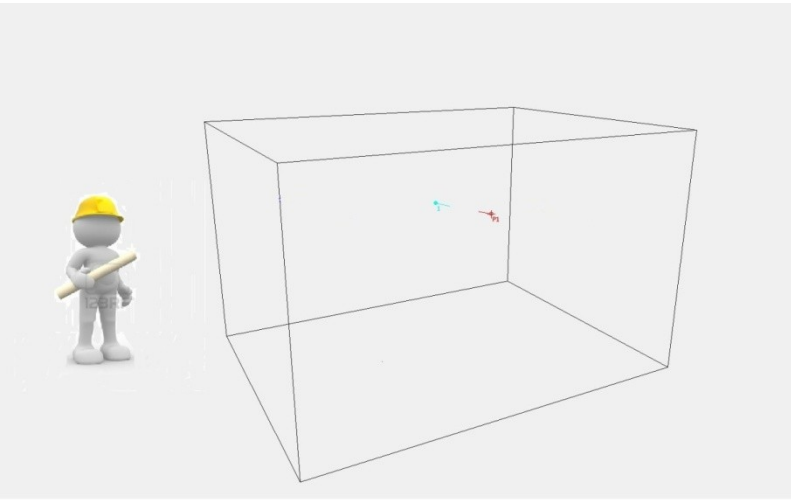
Rooms - 2

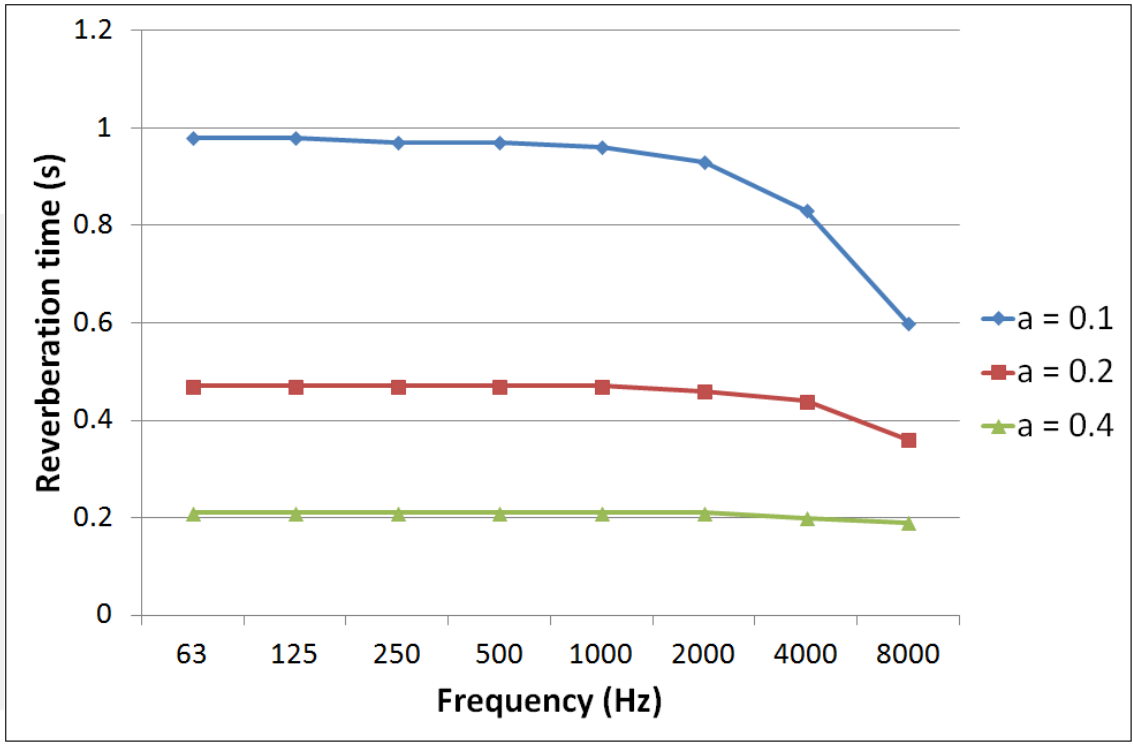




- room size assessment
- 35 m x 2.4 m x 3 m = 252 m^3 - hallway

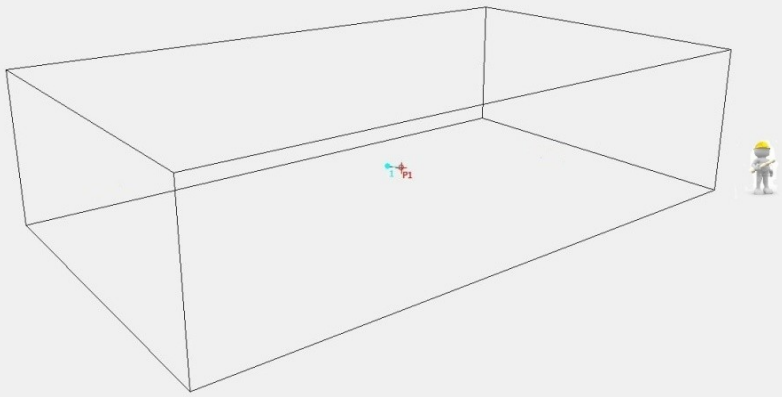
Rooms - 3

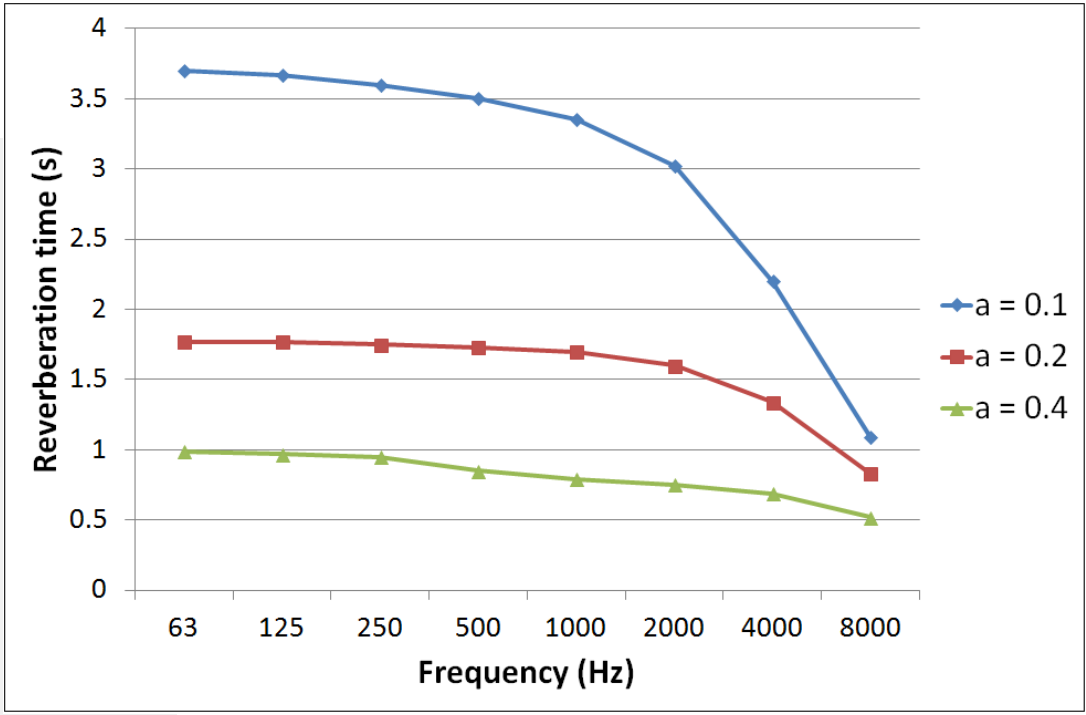




- room size assessment
- 4 m x 3 m x 2.5 m = 30 m^3 - small

Rooms - 4





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

Results - X^2-statistics

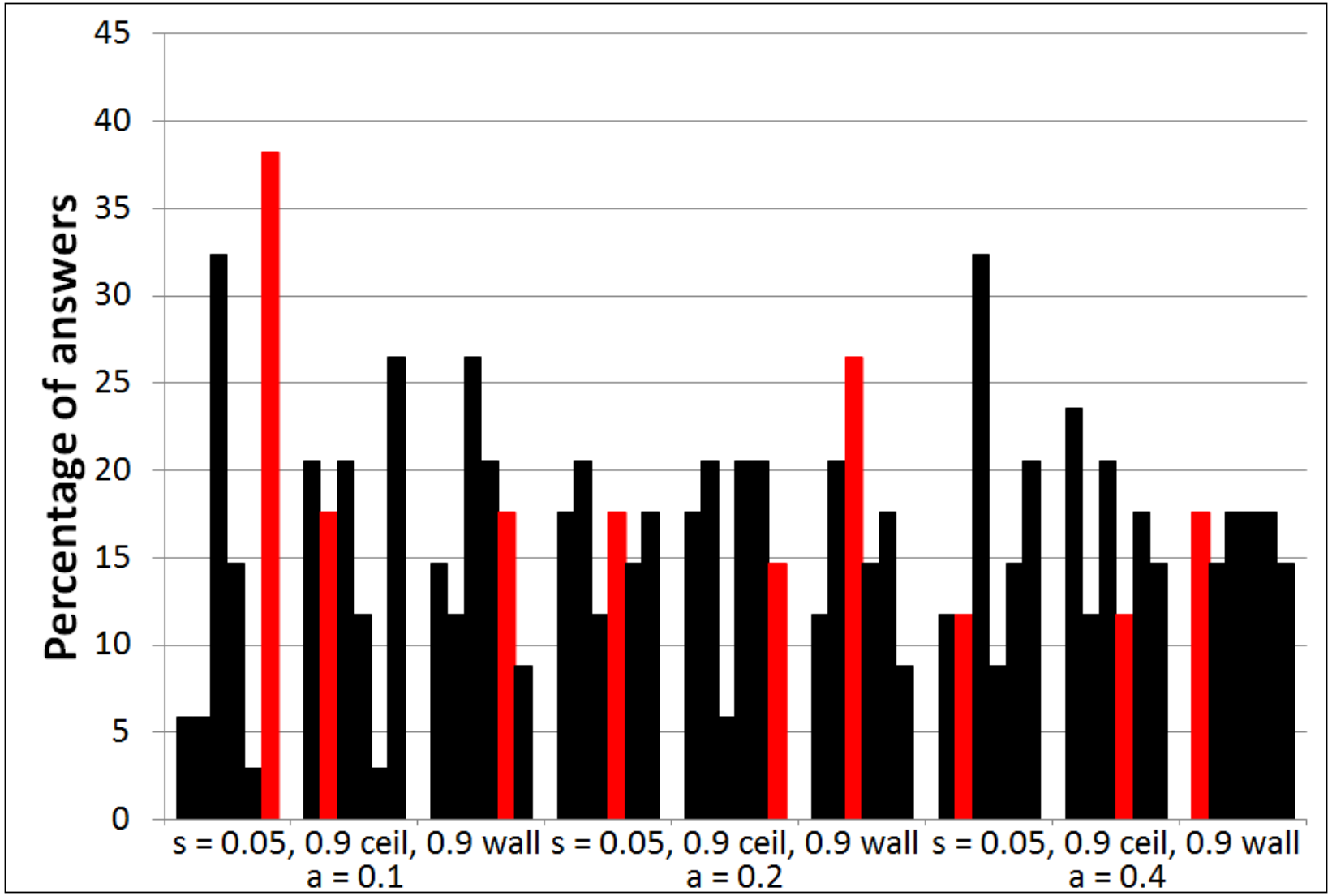
Hand claps		Scattering coefficient ( )		
	$df = 5$	all 0.05	ceiling 0.9	wall 0.9
Absorption coefficient ( )	0.1	$\chi^2 = 23.18$ $p < 0.001$	$\chi^2 = 6.94$ $p = 0.225$	$\chi^2 = 4.12$ $p = 0.533$
	0.2	$\chi^2 = 0.94$ $p = 0.967$	$\chi^2 = 3.41$ $p = 0.637$	$\chi^2 = 4.12$ $p = 0.533$
	0.4	$\chi^2 = 7.65$ $p = 0.177$	$\chi^2 = 2.35$ $p = 0.798$	$\chi^2 = 0.24$ $p = 0.999$
Footsteps		Scattering coefficient ( )		
	$df = 5$	all 0.05	ceiling 0.9	wall 0.9
Absorption coefficient ( )	0.1	$\chi^2 = 10.18$ $p = 0.070$	$\chi^2 = 4.88$ $p = 0.430$	$\chi^2 = 0.65$ $p = 0.986$
	0.2	$\chi^2 = 20.41$ $p = 0.001$	$\chi^2 = 8.06$ $p = 0.153$	$\chi^2 = 10.53$ $p = 0.062$
	0.4	$\chi^2 = 2.41$ $p = 0.790$	$\chi^2 = 3.82$ $p = 0.575$	$\chi^2 = 1.00$ $p = 0.963$

self-localization

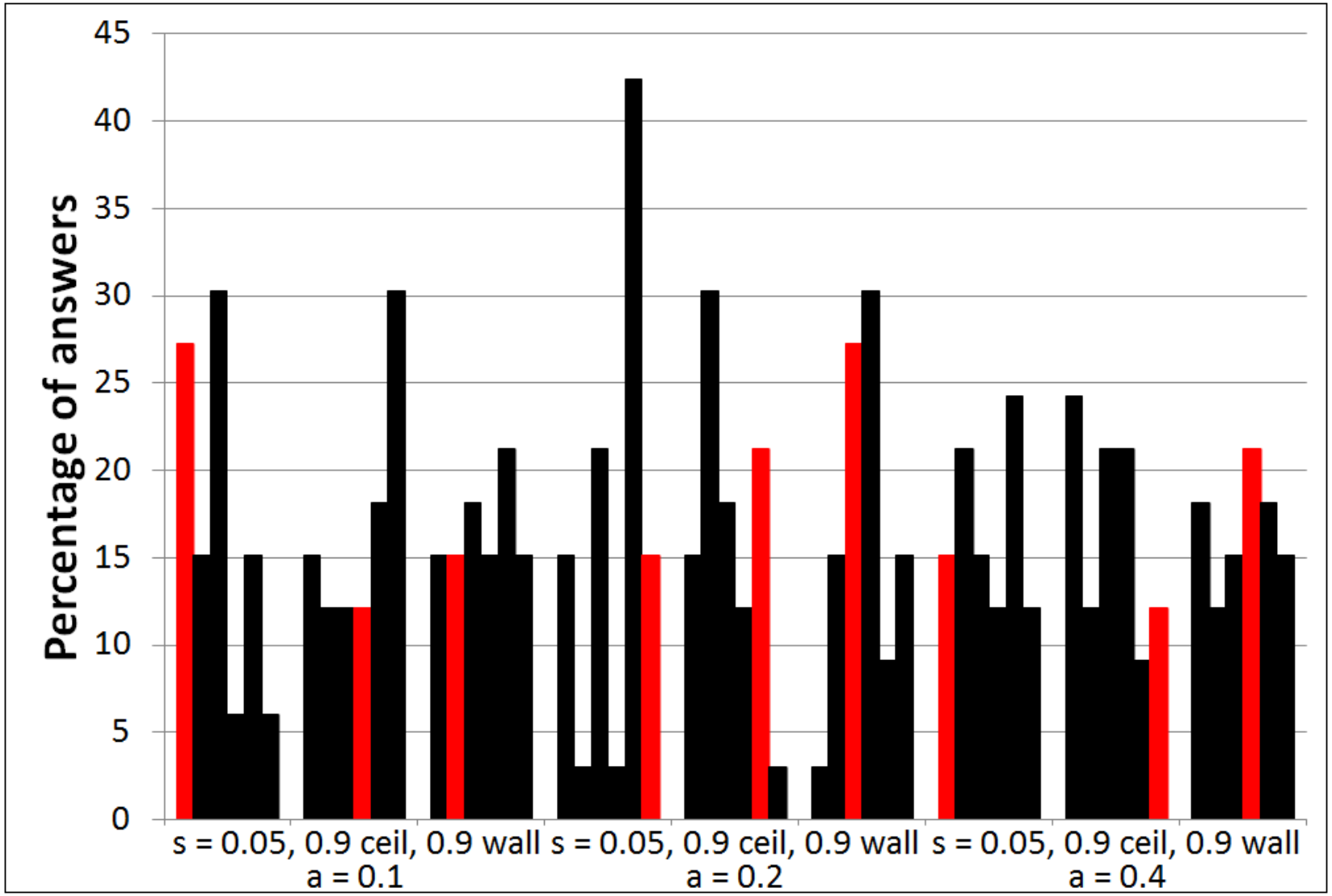
Hand claps		Scattering coefficient ( )		
	$df = 23$	all 0.05	ceiling 0.9	wall 0.9
Absorption coefficient ( )	0.1	$\chi^2 = 197.3$ $p < 0.001$	$\chi^2 = 228.0$ $p < 0.001$	$\chi^2 = 162.6$ $p < 0.001$
	0.2	$\chi^2 = 32.00$ $p = 0.100$	$\chi^2 = 98.67$ $p < 0.001$	$\chi^2 = 209.3$ $p < 0.001$
	0.4	$\chi^2 = 120.0$ $p < 0.001$	$\chi^2 = 102.6$ $p < 0.001$	$\chi^2 = 73.33$ $p < 0.001$
Footsteps		Scattering coefficient ( )		
	$df = 23$	all 0.05	ceiling 0.9	wall 0.9
Absorption coefficient ( )	0.1	$\chi^2 = 119.2$ $p < 0.001$	$\chi^2 = 163.1$ $p < 0.001$	$\chi^2 = 179.6$ $p < 0.001$
	0.2	$\chi^2 = 142.6$ $p < 0.001$	$\chi^2 = 141.2$ $p < 0.001$	$\chi^2 = 130.2$ $p < 0.001$
	0.4	$\chi^2 = 116.5$ $p < 0.001$	$\chi^2 = 89.11$ $p < 0.001$	$\chi^2 = 138.4$ $p < 0.001$

room size assessment

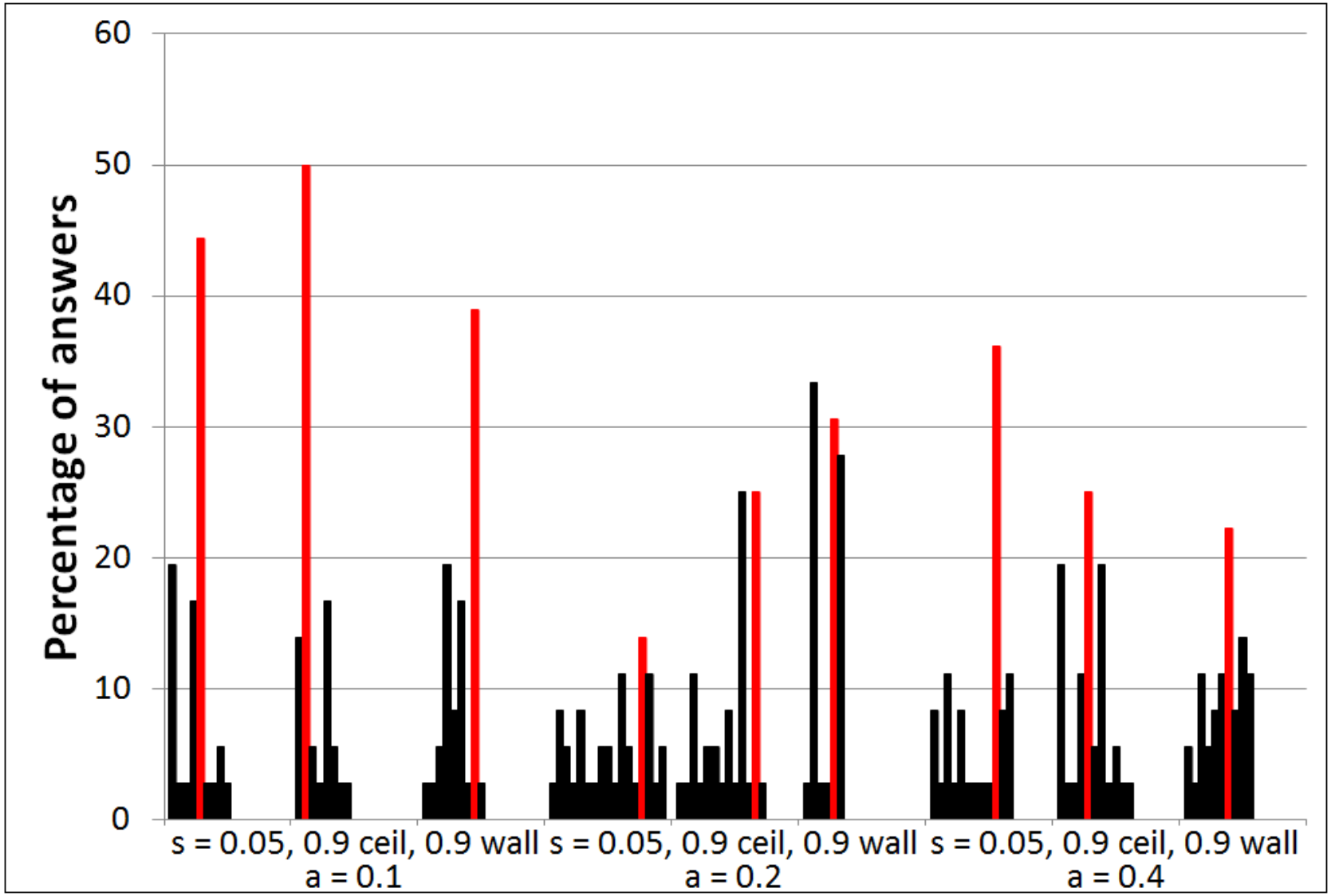
Results - self-localization - handclaps



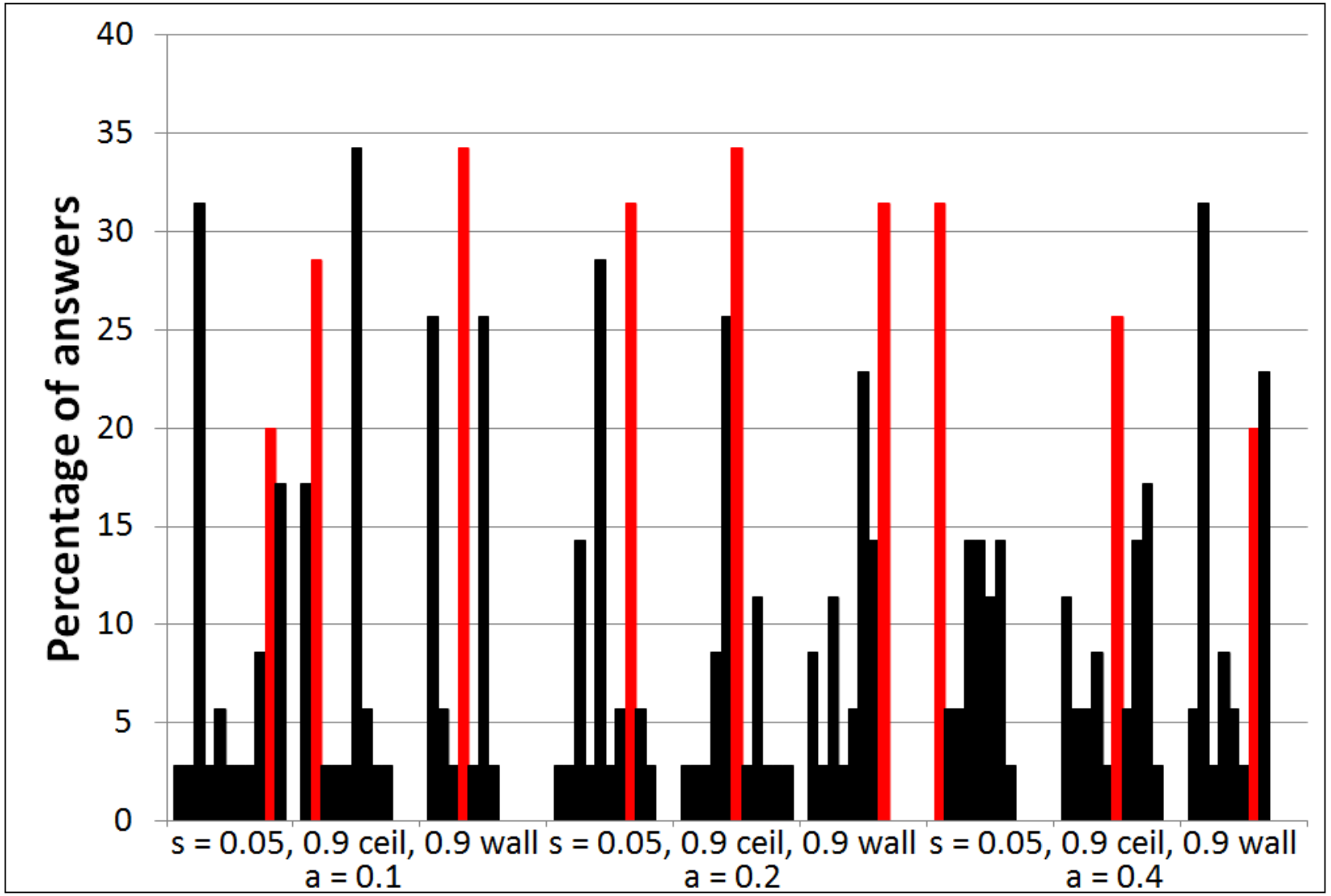
Results - self-localization - footsteps



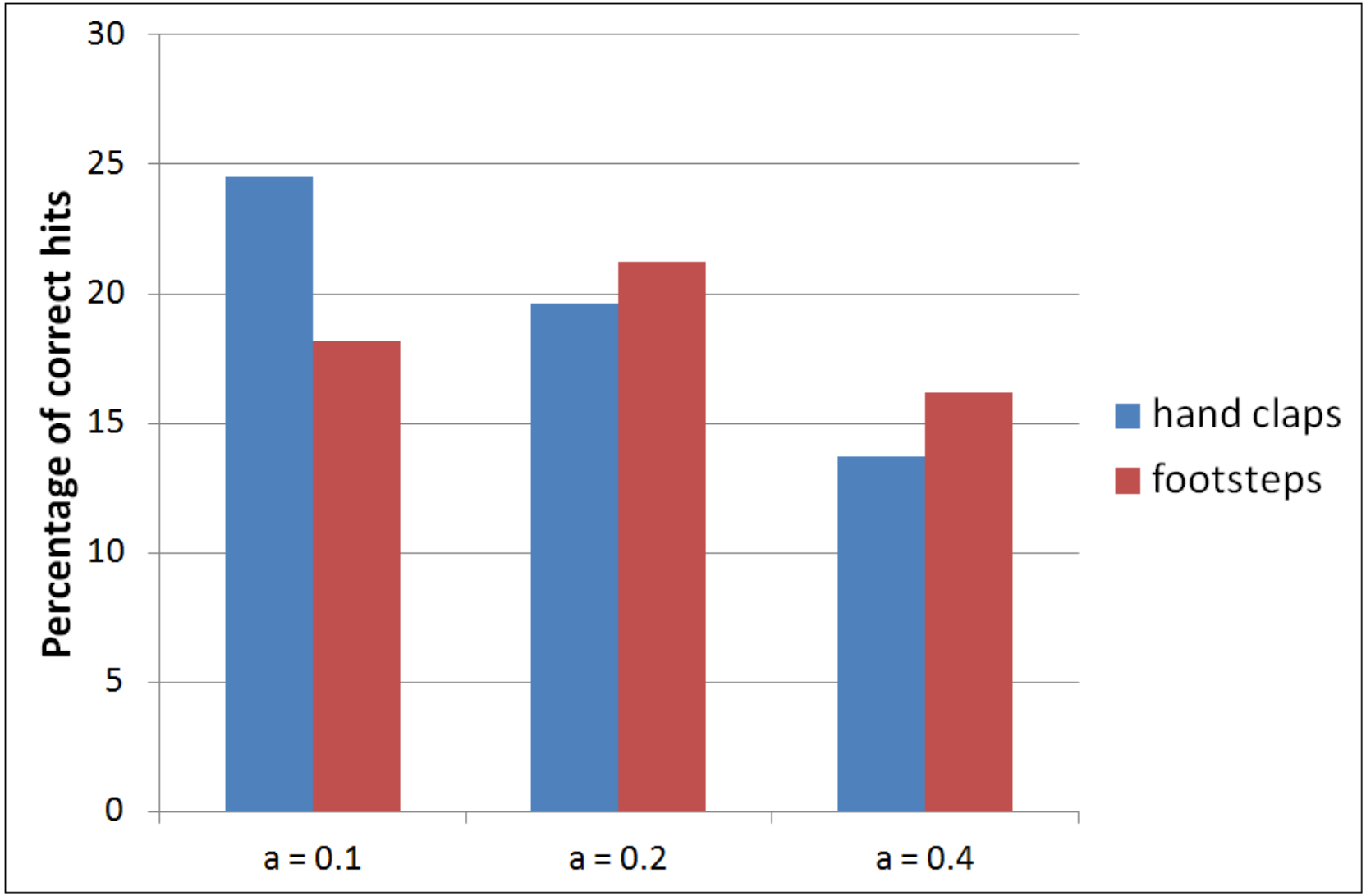
Results - room size assessment - handclaps



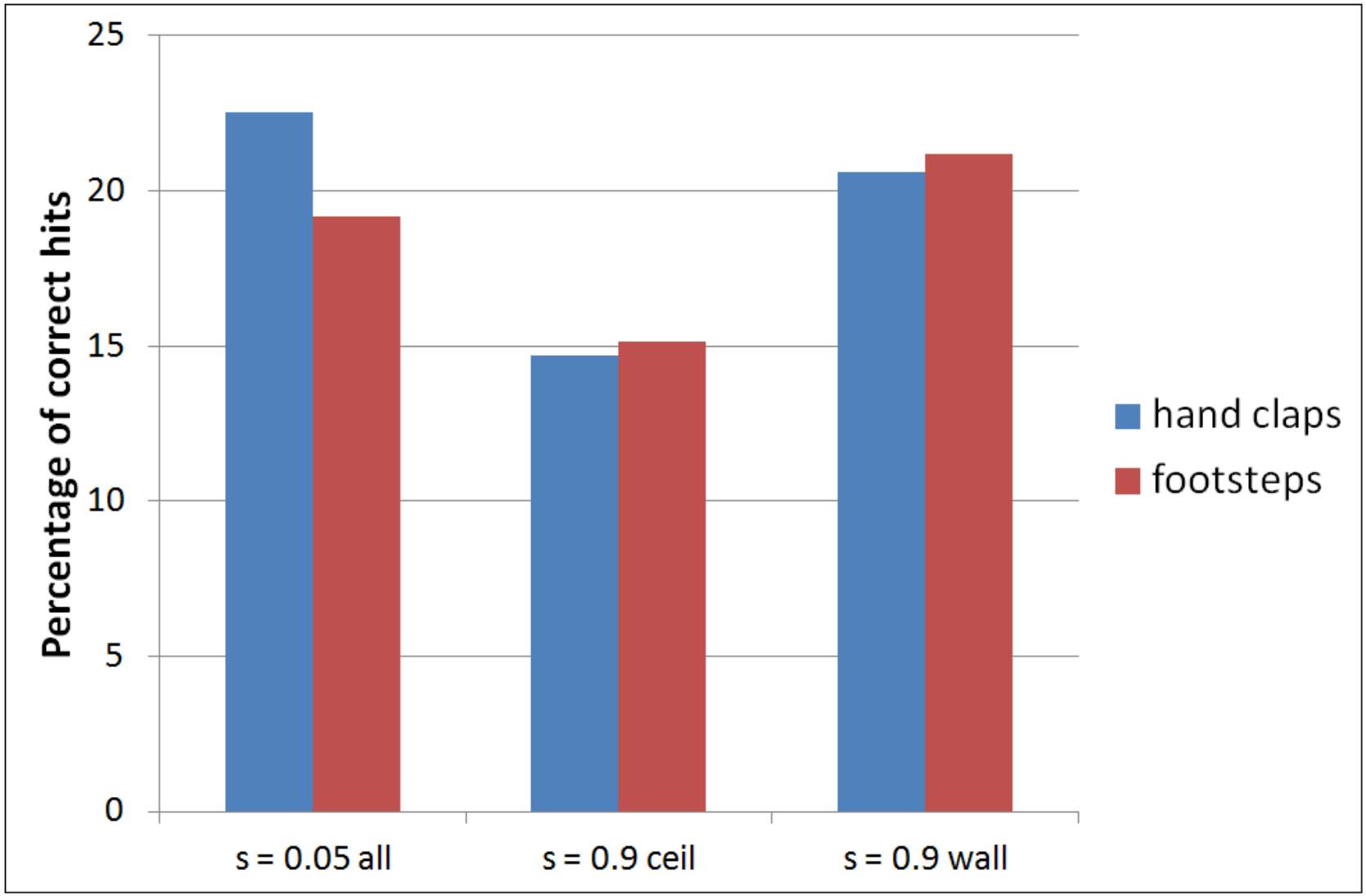
Results - room size assessment - footsteps



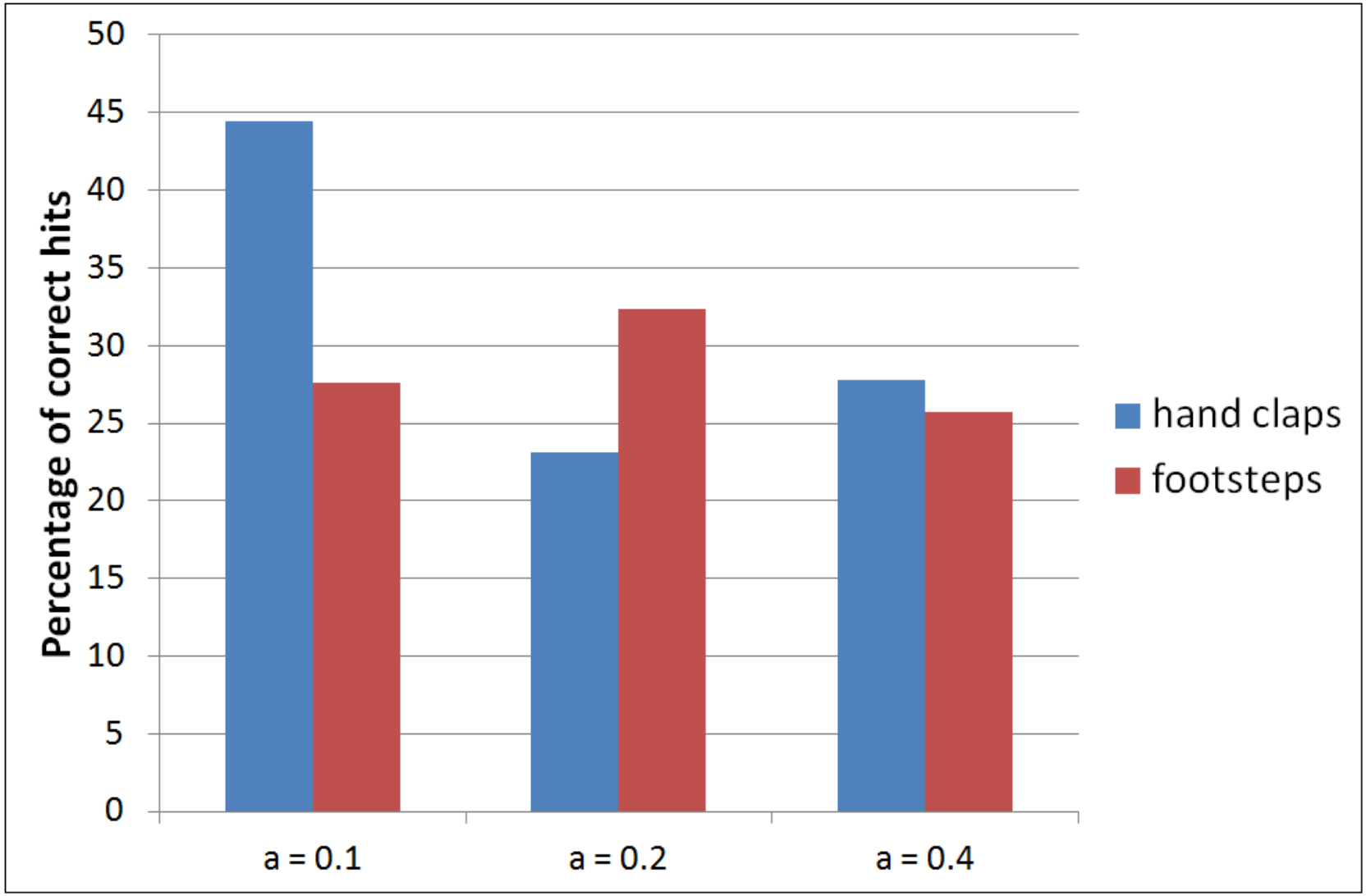
Results - self-localization - absorption



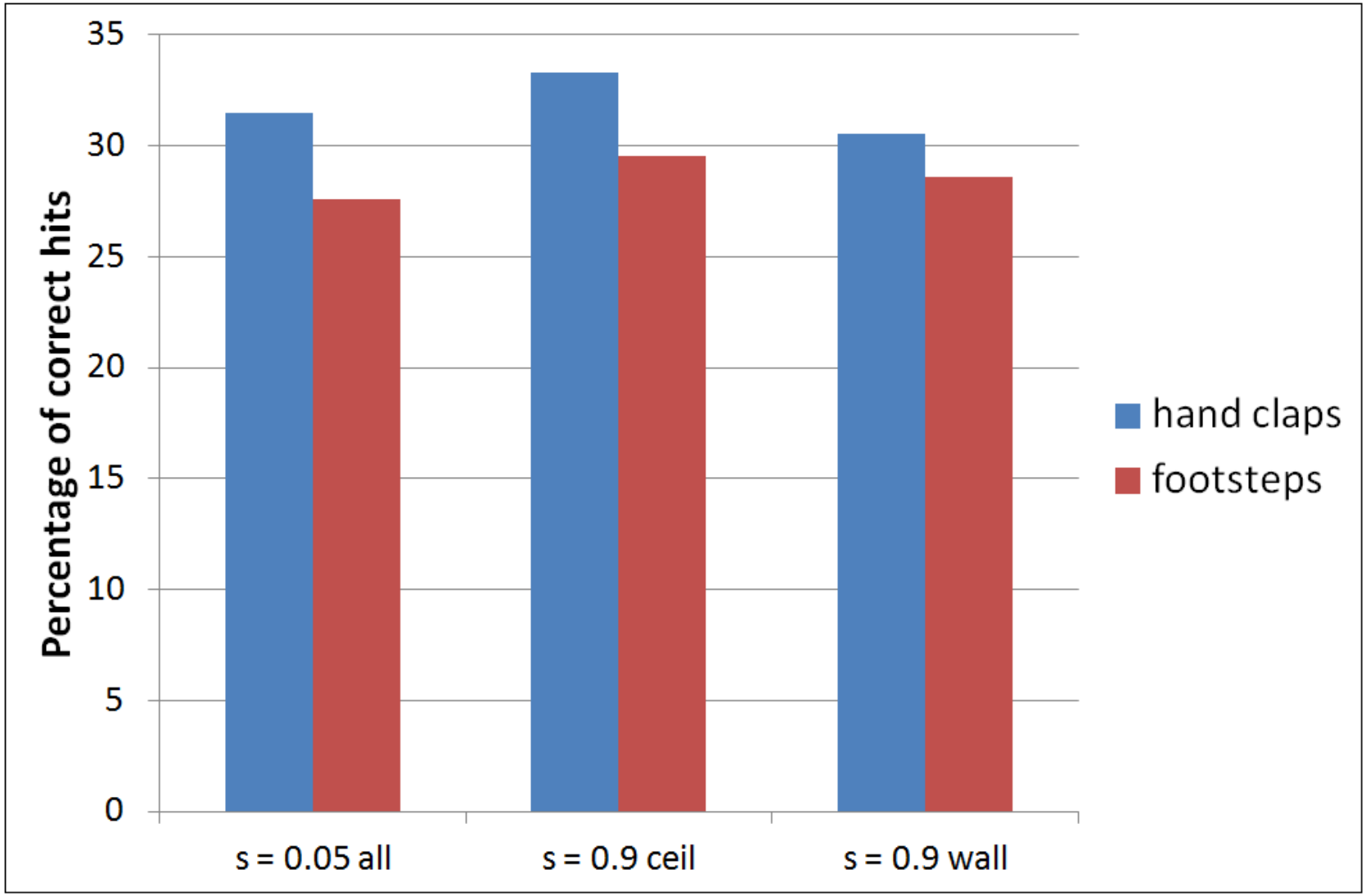
Results - self-localization - diffusion



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!