LISTENERS' RESPONSE TO STRING QUARTET PERFORMANCES RECORDED IN VIRTUAL ACOUSTICS

Song Hui Chon
Doyuen Ko
Sungyoung Kim

Virtual Acoustics

- An active acoustic system alters the acoustics of a room by imposing responses synthesized from pre-recorded impulse responses of another space
- Offers flexibility to tailor the acoustics of a *multi-purpose* concert venue for the demands of a specific event
- The purpose is to provide an environment that is more enjoyable both to the performers and the audience

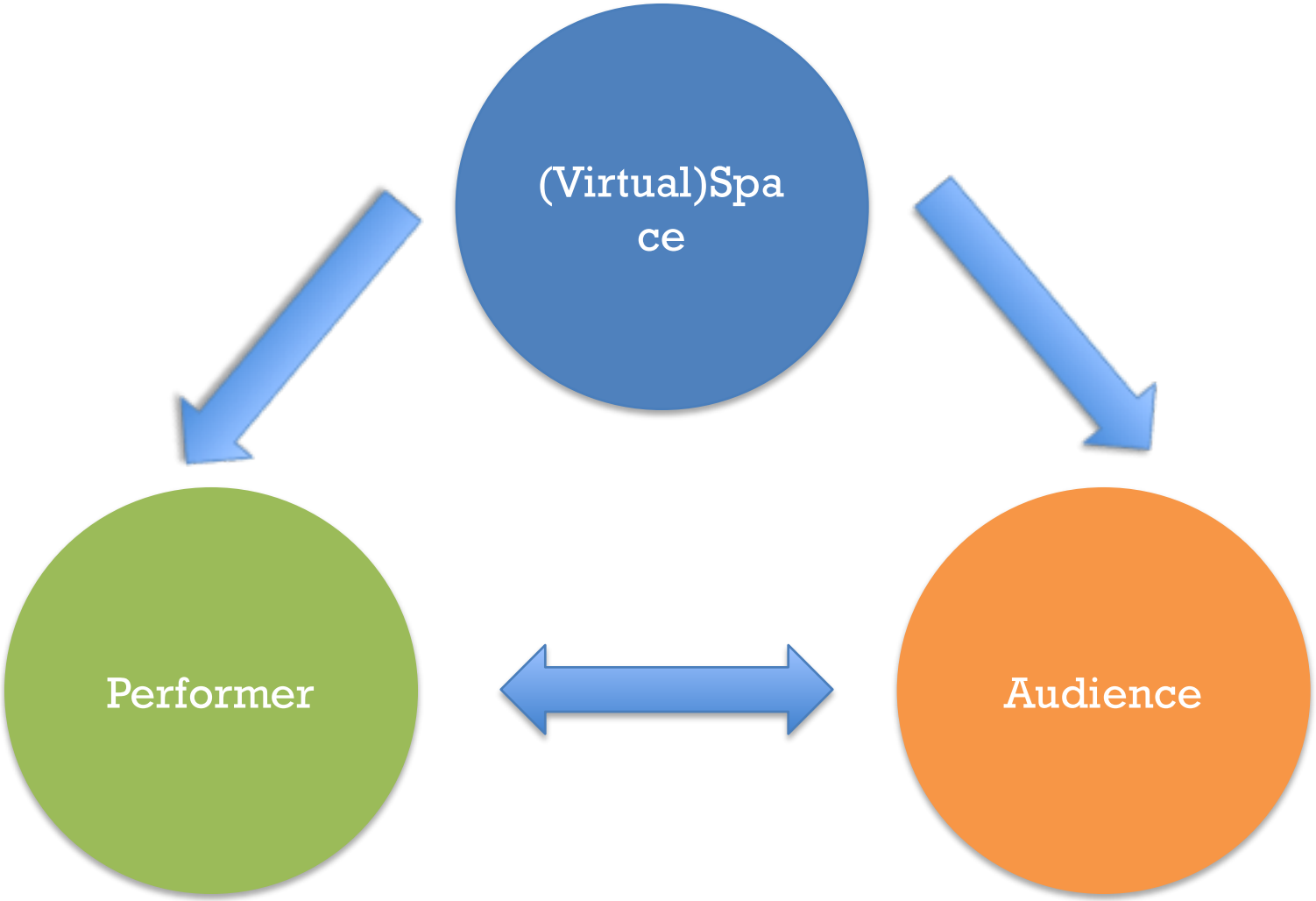
Haydn's Study

Photo by Tom Beghin

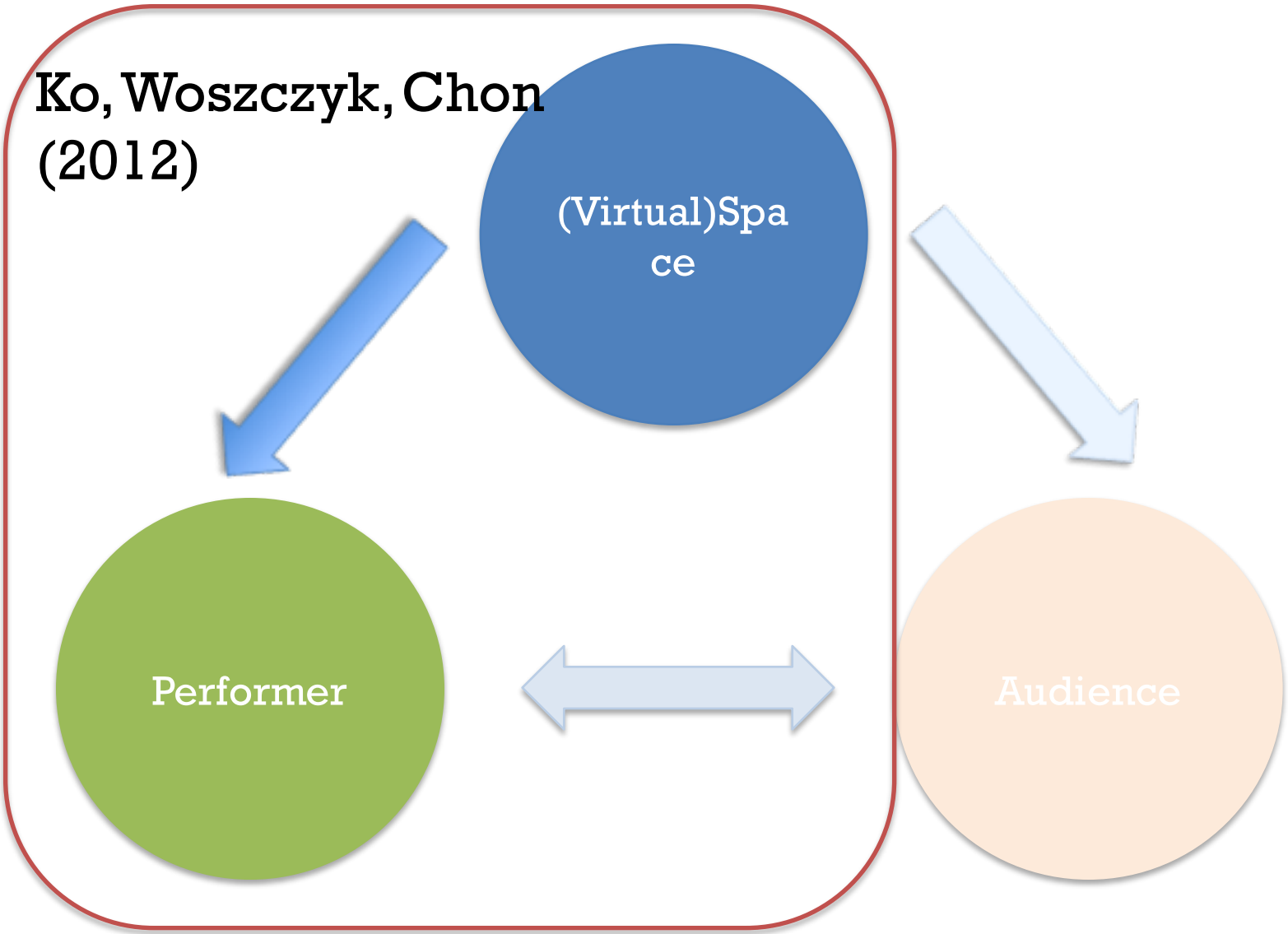
Music Room at Esterhaza

Photo by Tom Beghin

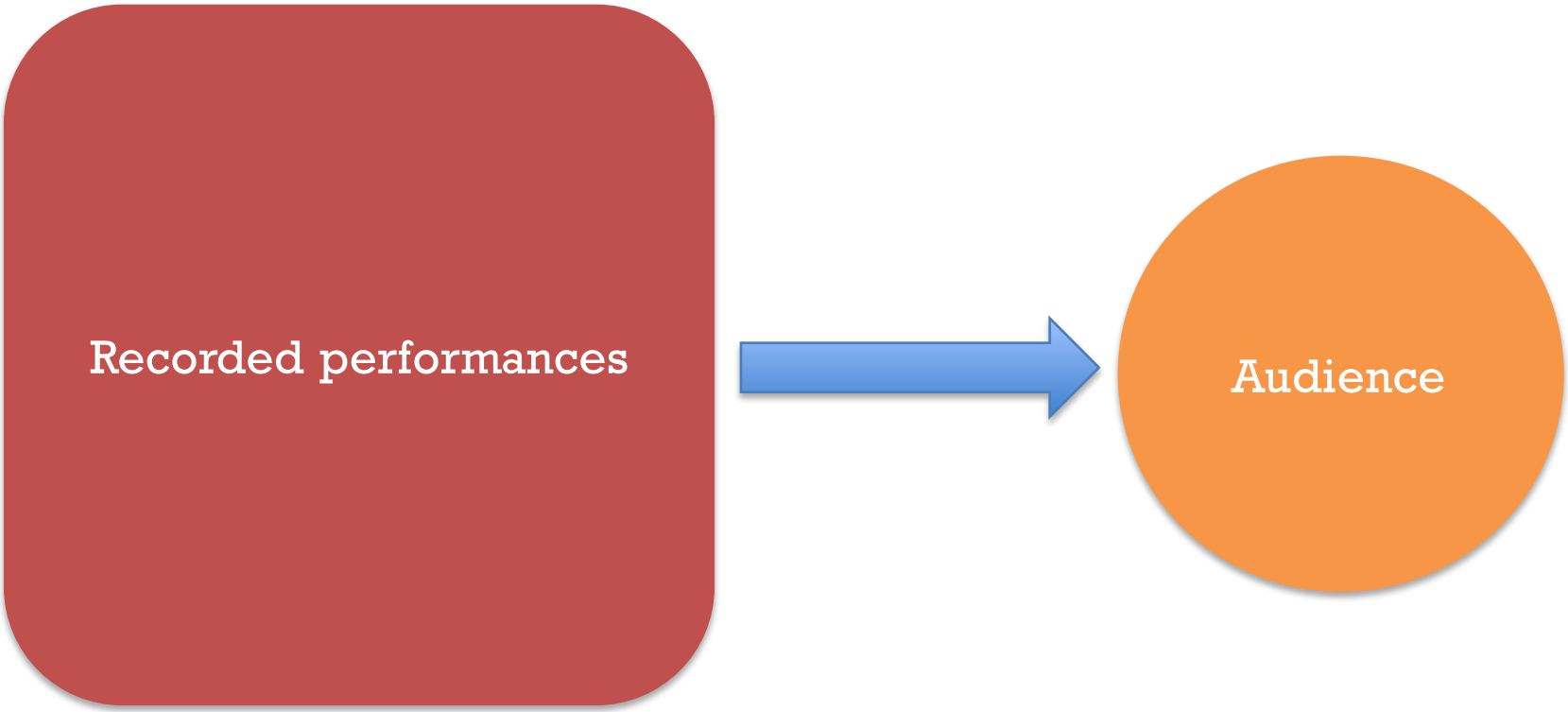
Motivation



Motivation



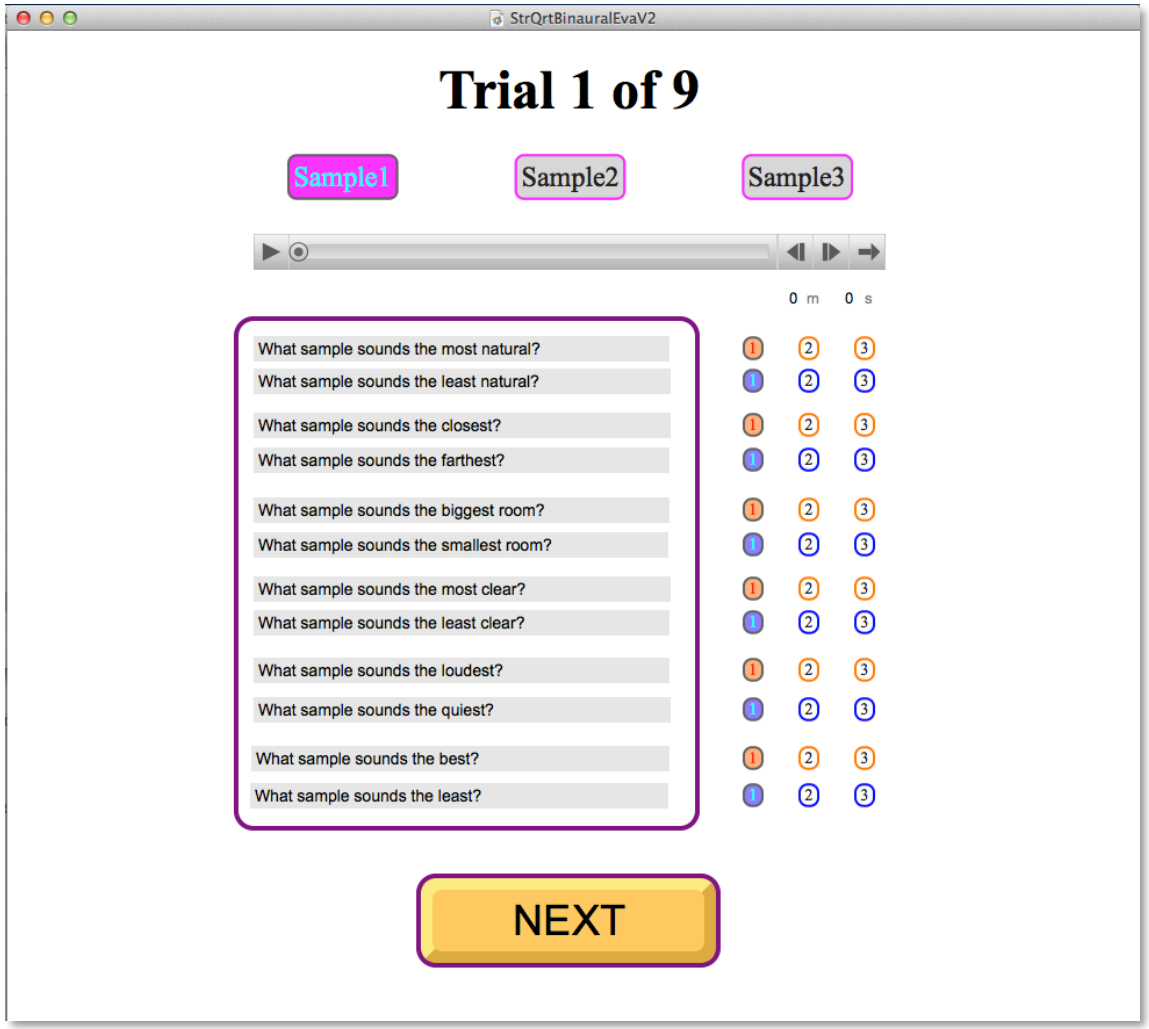
Motivation



Recording Setup

	Condition 1	Condition 2	Condition 3
T_{30} (seconds)	1.38	1.74	2.08
Level (dBC)	88.2	88.2	88.3
C80 (dB)	14.4	13.7	13.1
ST1 (dB)	-13.8	-13.2	-13.1
IACC	0.46	0.43	0.41
LF (125-500Hz)	0.208	0.214	0.223

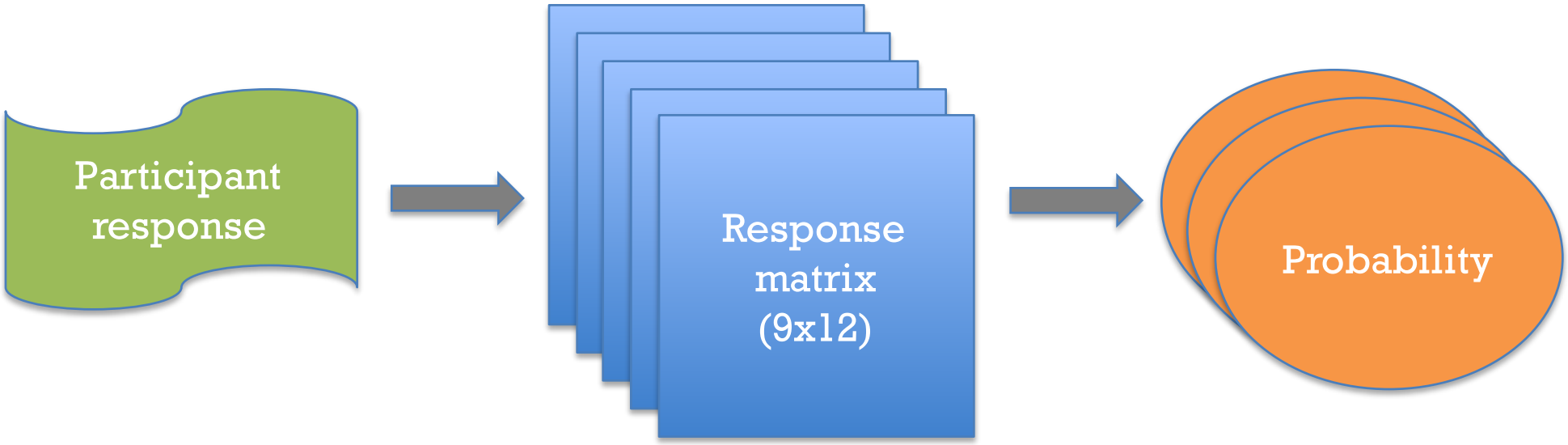
Experiment


StrQrtBinauralEvaV2
Trial 1 of 9
Sample1
Sample2
Sample3
0 m 0 s
What sample sounds the most natural?
What sample sounds the least natural?
What sample sounds the closest?
What sample sounds the farthest?
What sample sounds the biggest room?
What sample sounds the smallest room?
What sample sounds the most clear?
What sample sounds the least clear?
What sample sounds the loudest?
What sample sounds the quiest?
What sample sounds the best?
What sample sounds the least?
NEXT

Experiment

Criterion	Question
Naturalness	1. Which sample sounds the most natural? 2. Which sample sounds the least natural?
Source distance	3. Which sample sounds the farthest? 4. Which sample sounds the closest?
Room size	5. Which sample sounds like the biggest room? 6. Which sample sounds like the smallest room?
Clarity	7. Which sample sounds the most clear? 8. Which sample sounds the least clear?
Loudness	9. Which sample sounds the loudest? 10. Which sample sounds the quietest?
Preference	11. Which sample sounds the best? 12. Which sample sounds the worst?

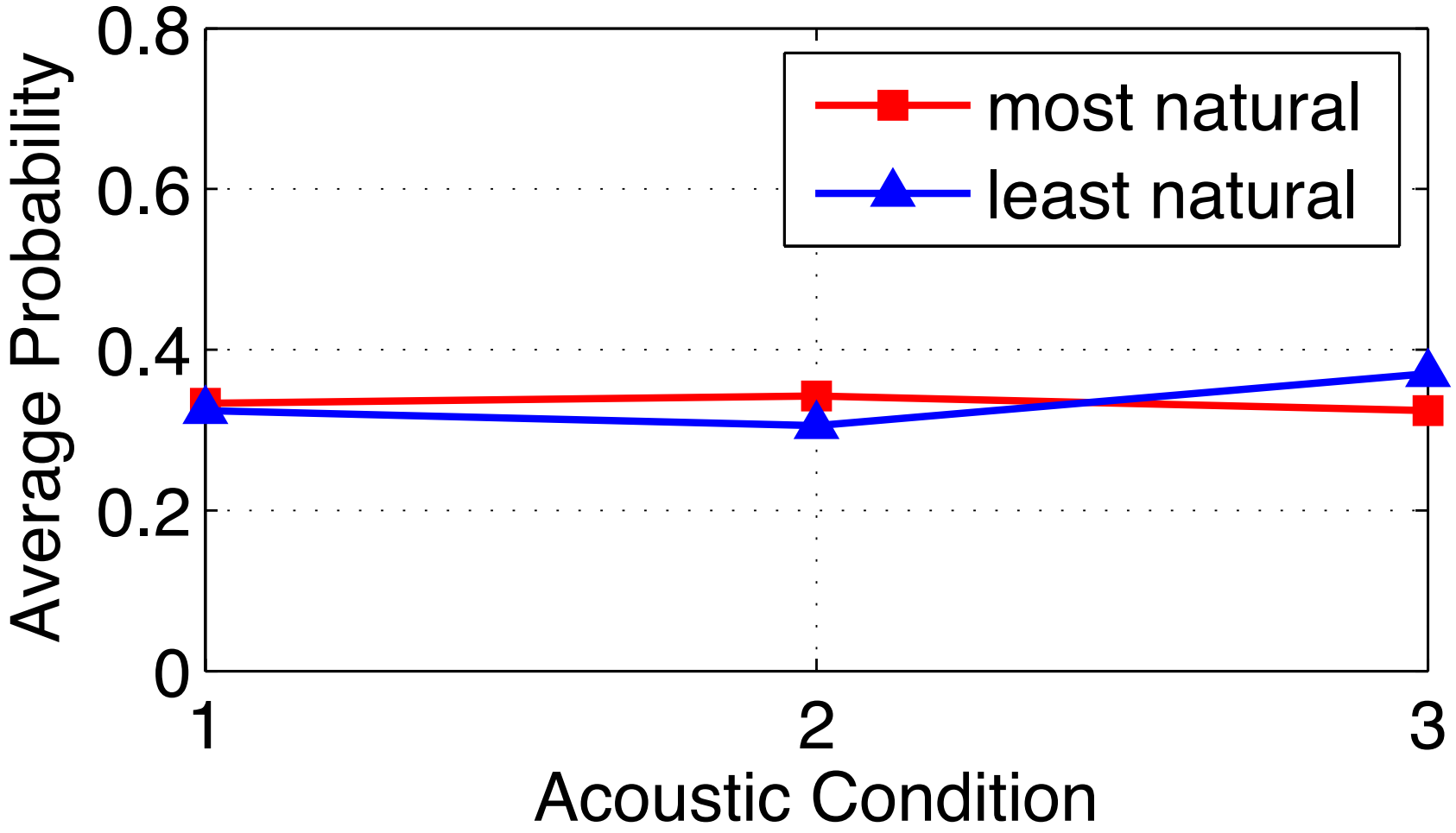
Data Analysis



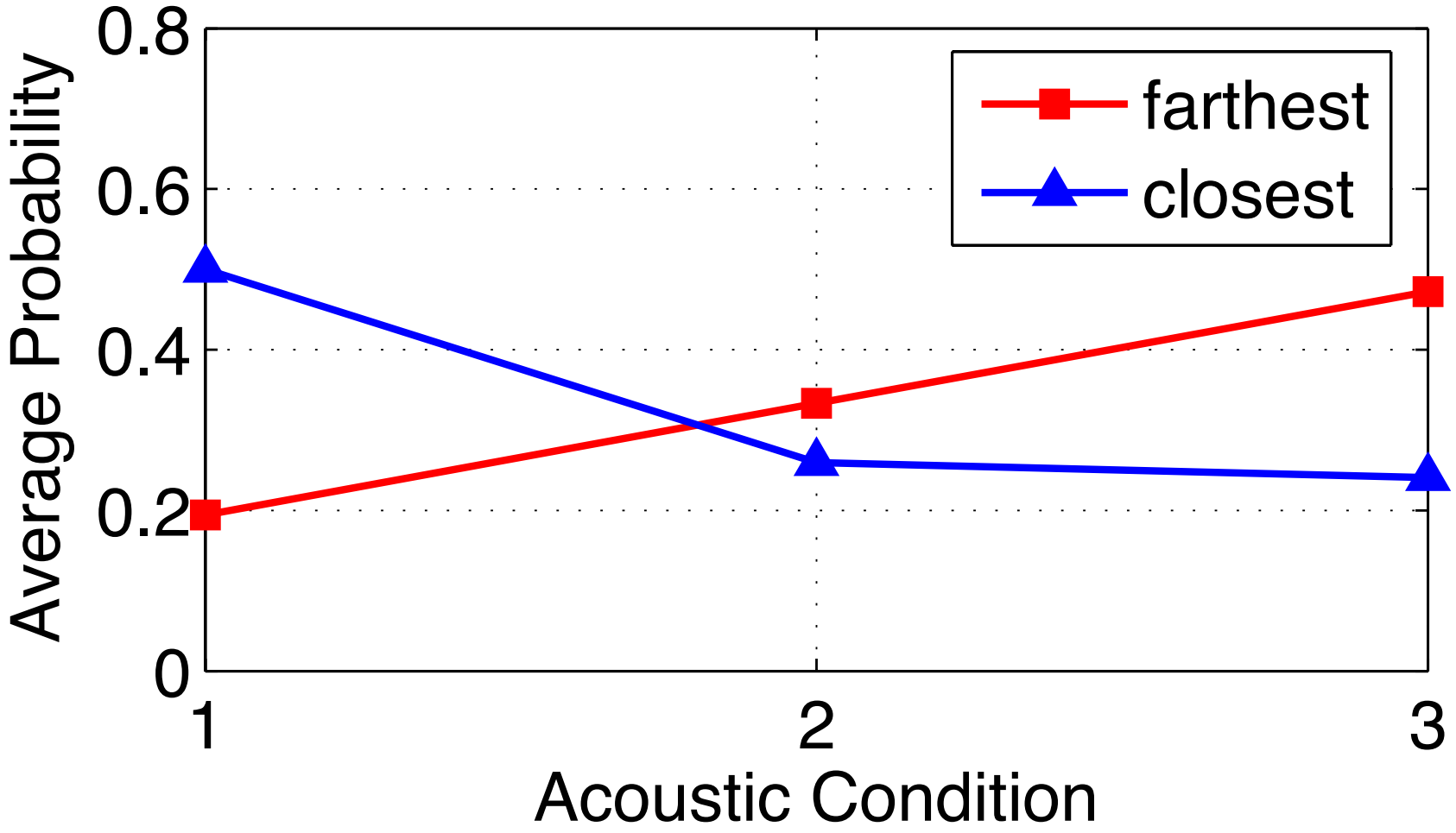
Result

Criterion	Question	$F(2, 24)$	p
Naturalness	1. most natural? 2. least natural?	0.046 0.769	.955 .475
Source distance	**3. farthest?** **4. closest?**	25.246 11.997	< .001* < .001*
Room size	**5. biggest room?** **6. smallest room?**	49.017 62.715	< .001* < .001*
Clarity	**7. most clear?** **8. least clear?**	16.529 13.658	< .001* < .001*
Loudness	**9. loudest?** **10. quietest?**	3.729 4.458	.039* .023*
Preference	**11. best?** 12. worst?	3.465 3.239	.048* .057

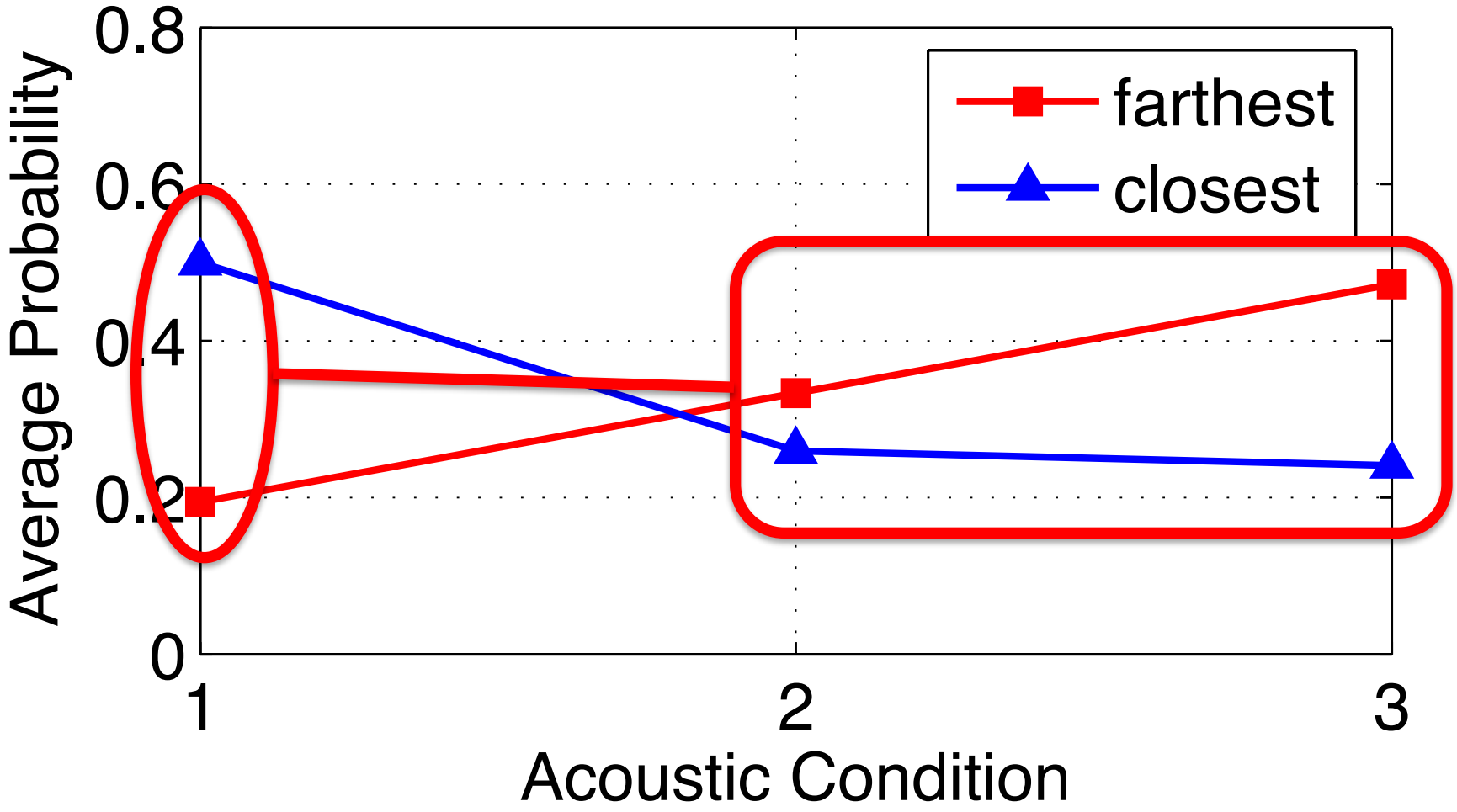
Naturalness



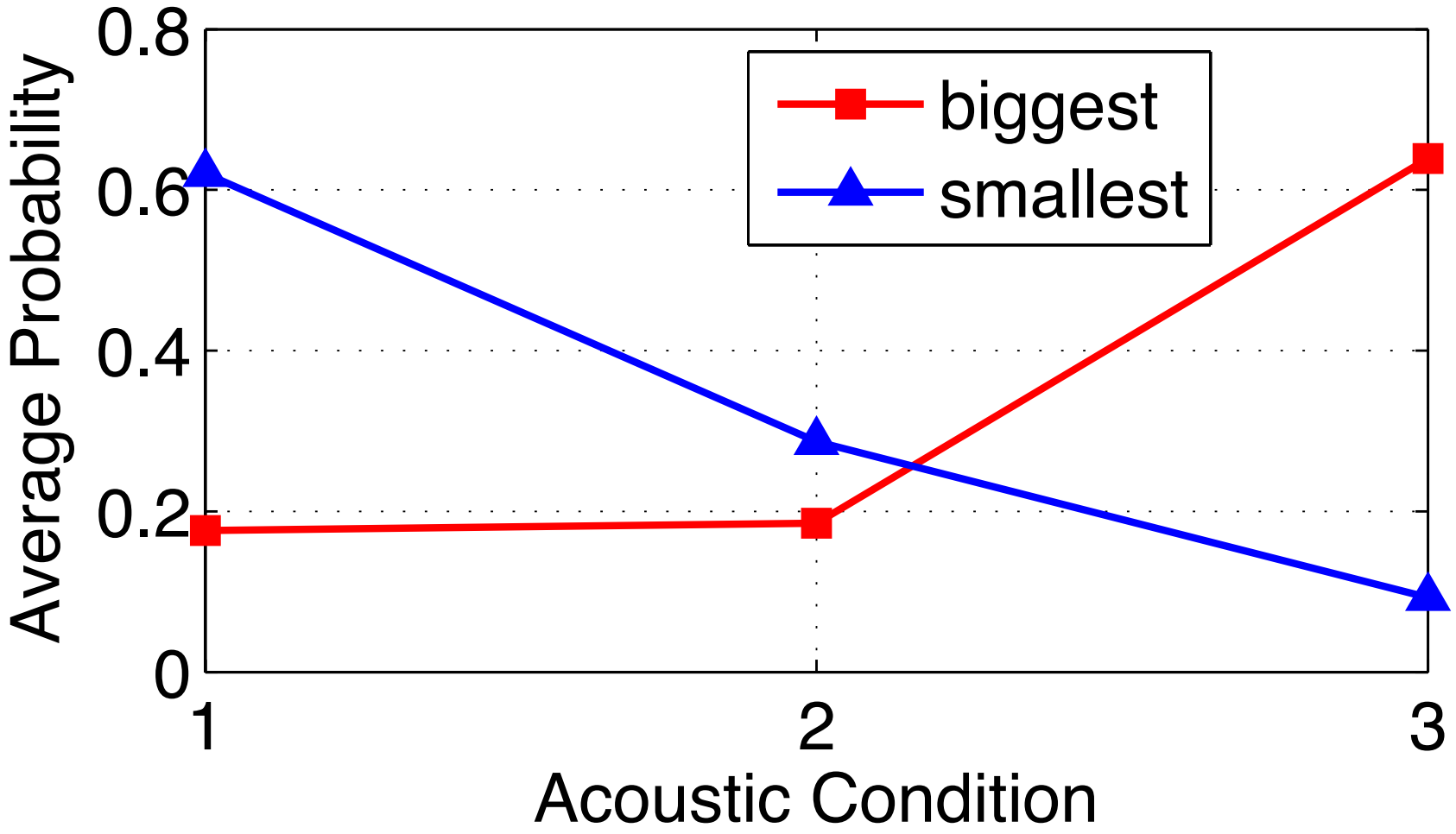
Source Distance



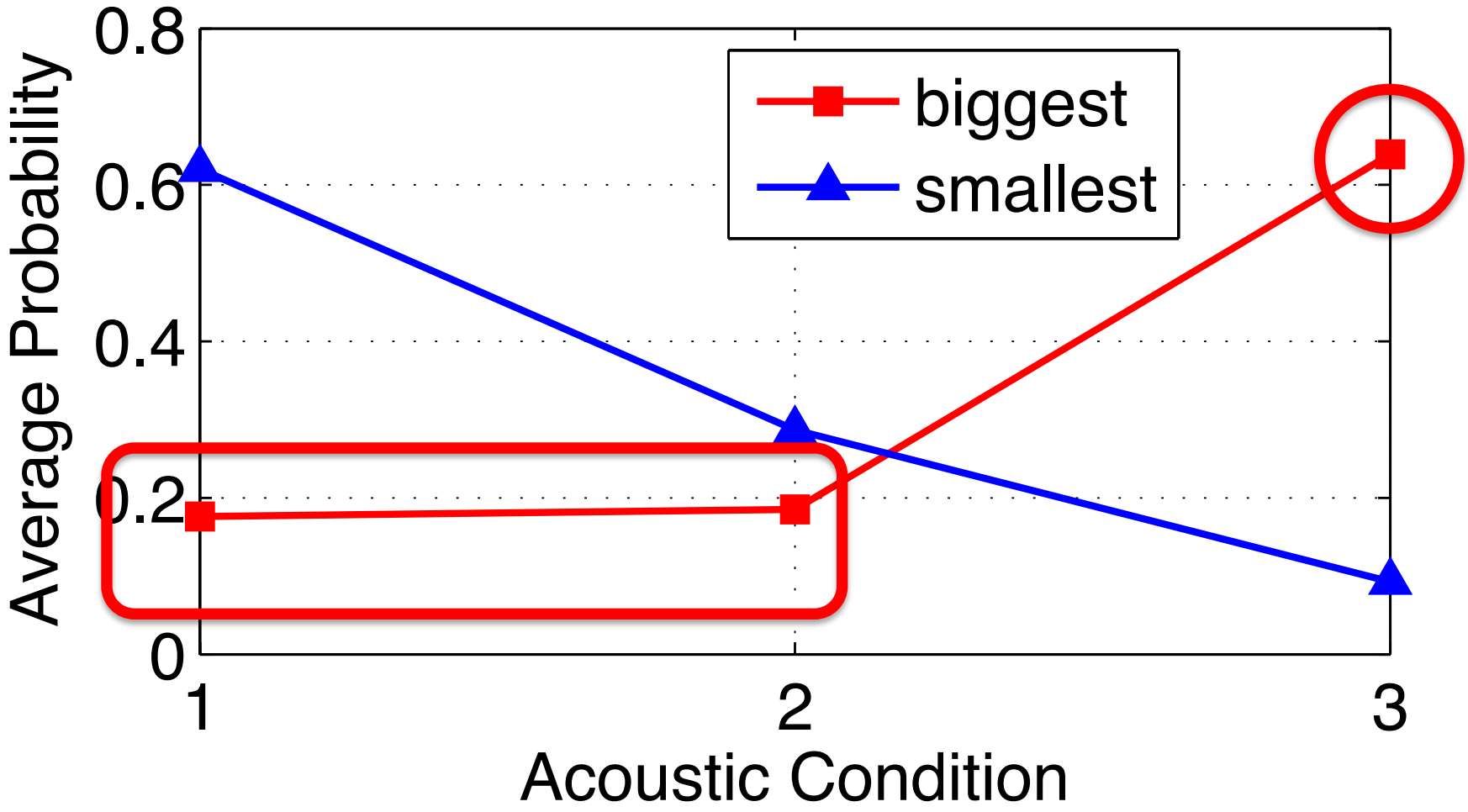
Source Distance



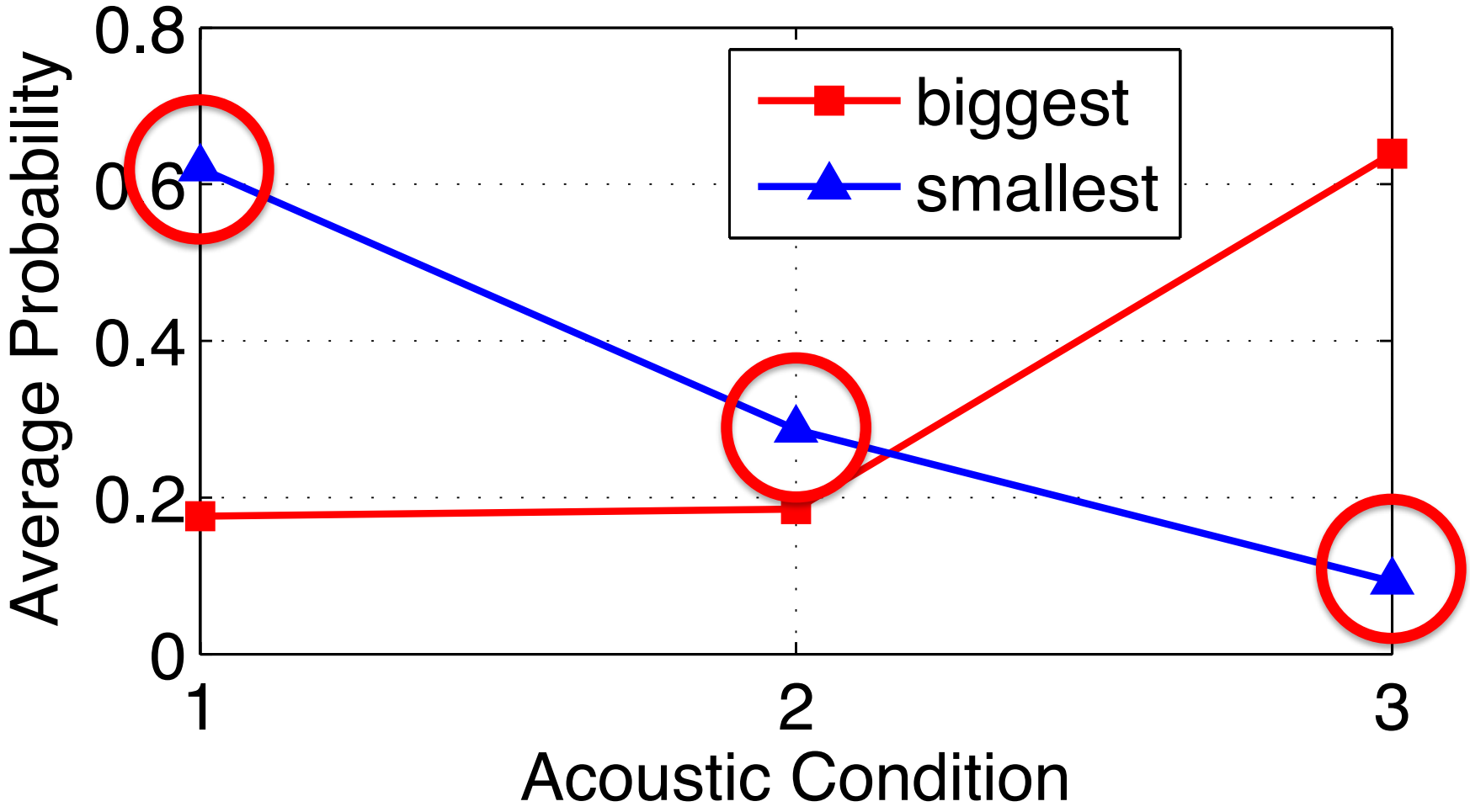
Room Size


0.8
0.6
0.4
0.2
0
Average Probability
biggest
smallest
1
2
3
Acoustic Condition

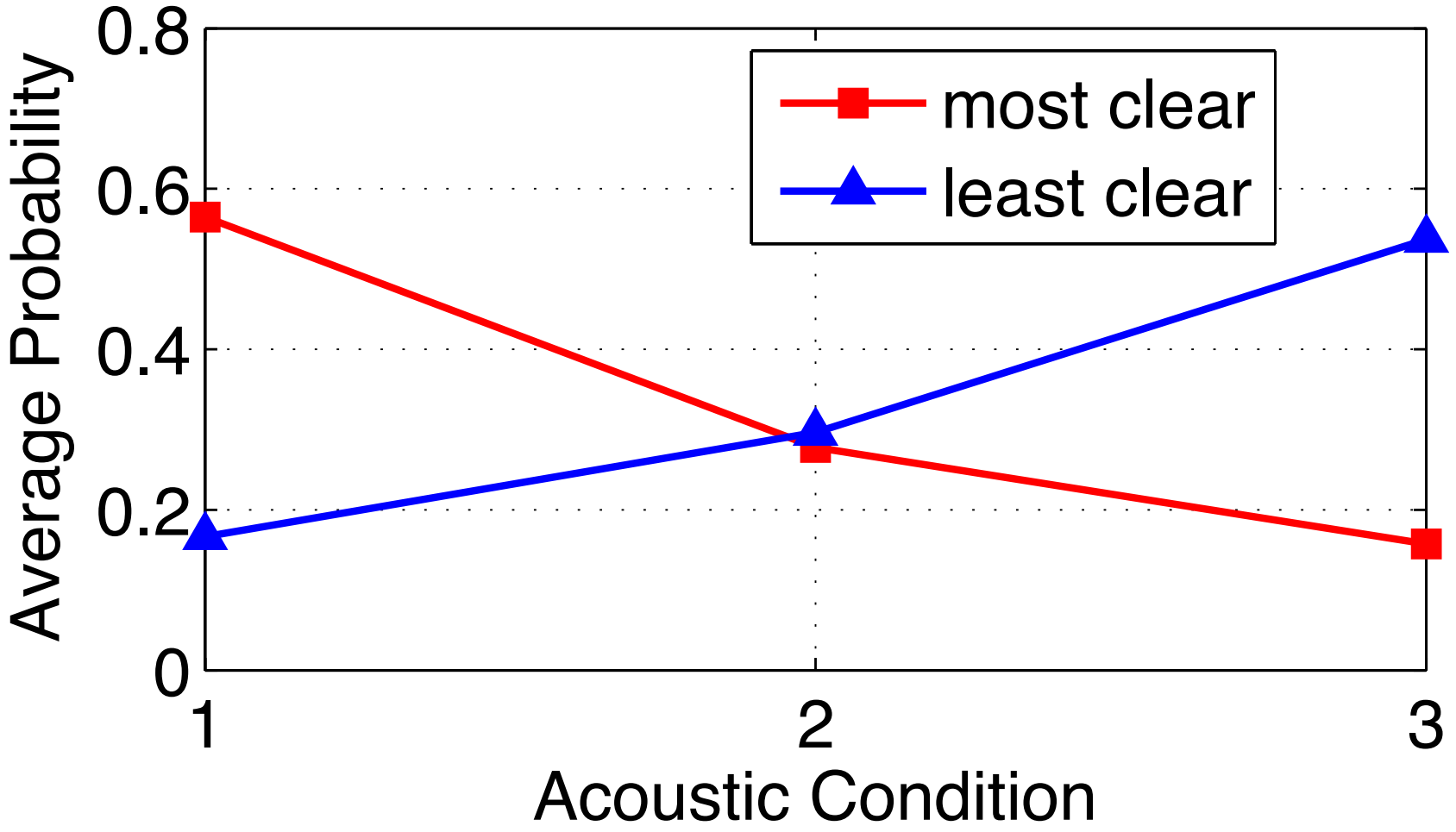
Room Size


0.8
0.6
0.4
0.2
0
Average Probability
biggest
smallest
1
2
3
Acoustic Condition

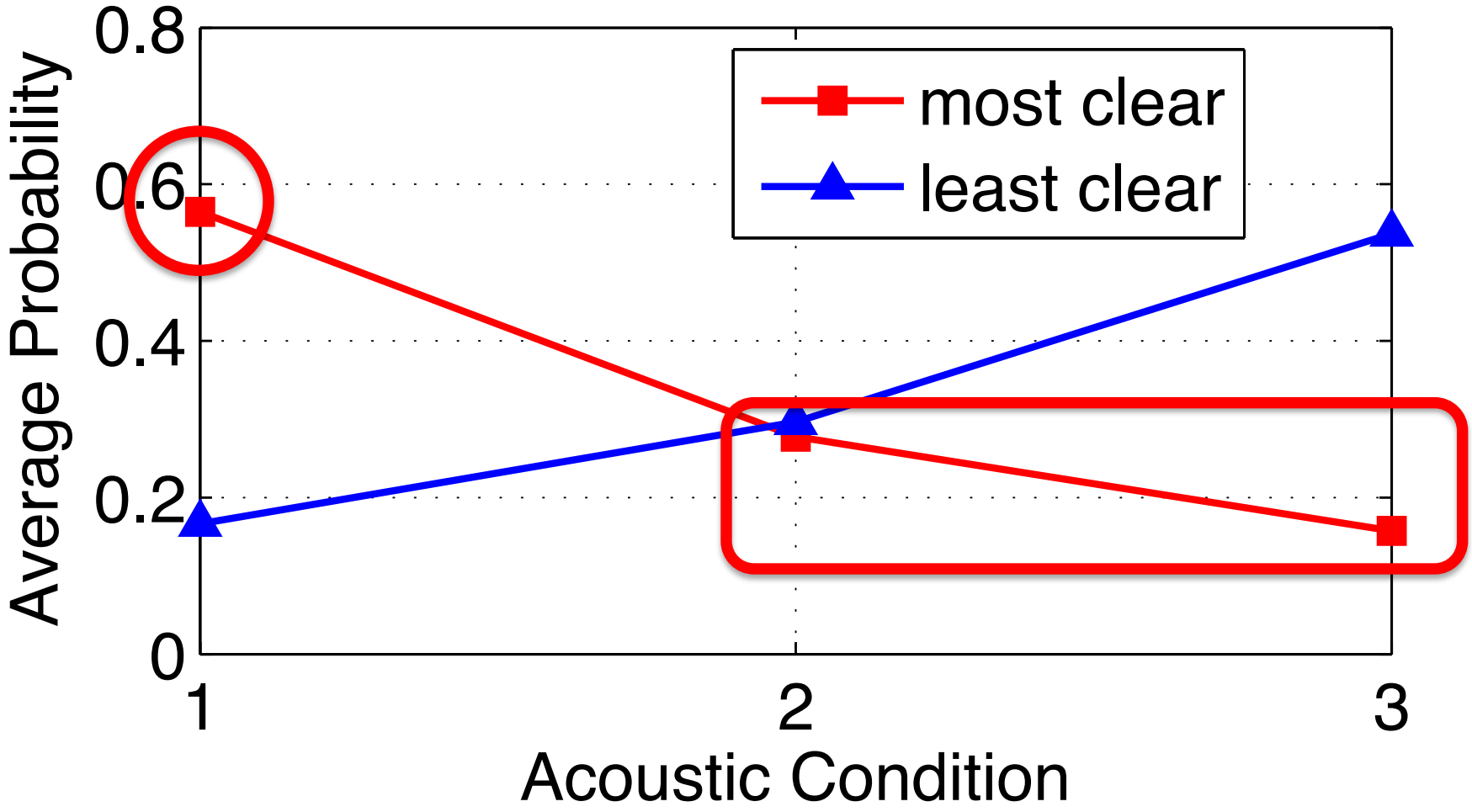
Room Size


0.8
0.6
0.4
0.2
0
Average Probability
biggest
smallest
1
2
3
Acoustic Condition

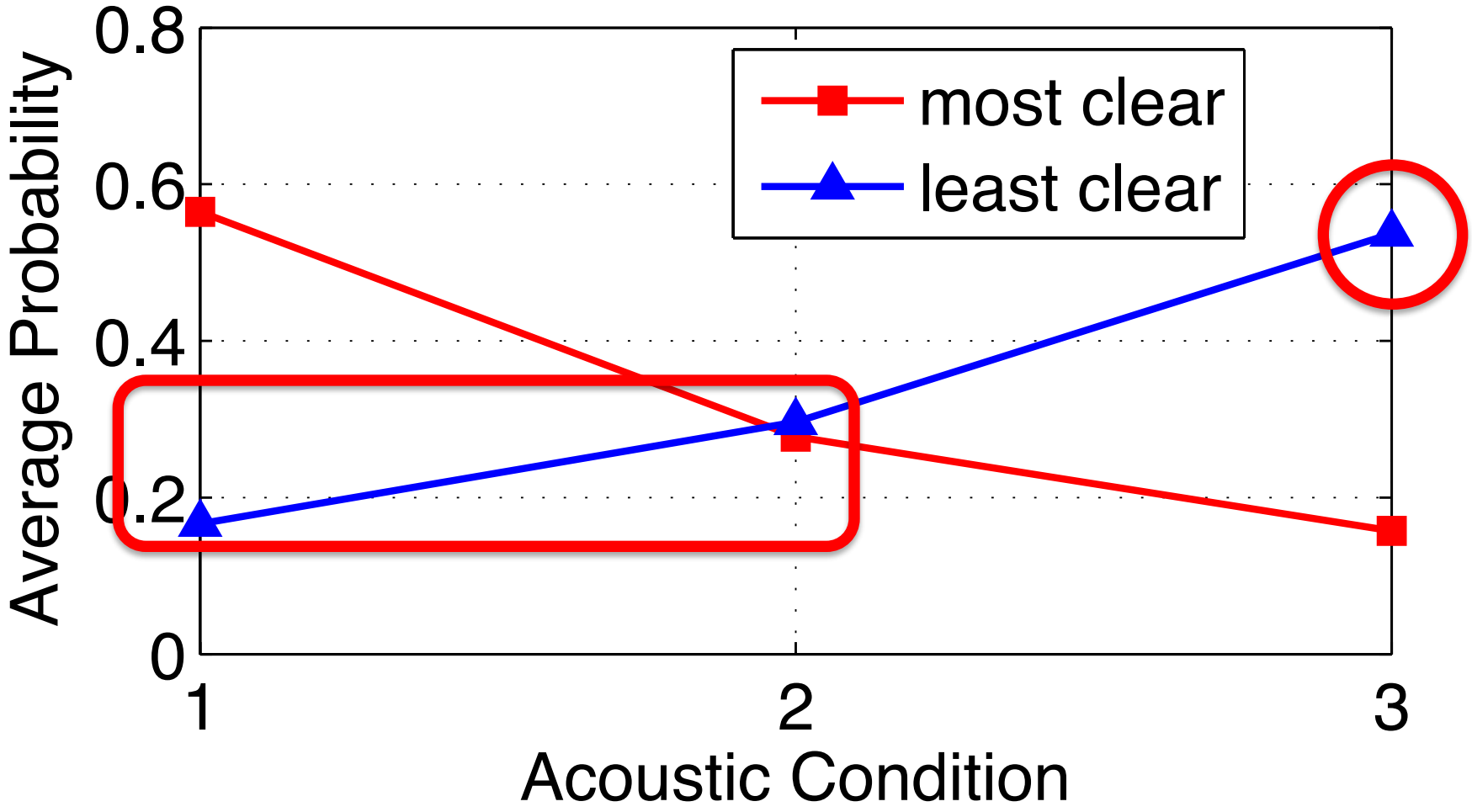
Clarity


0.8
0.6
0.4
0.2
0
Average Probability
1
2
3
Acoustic Condition
most clear
least clear

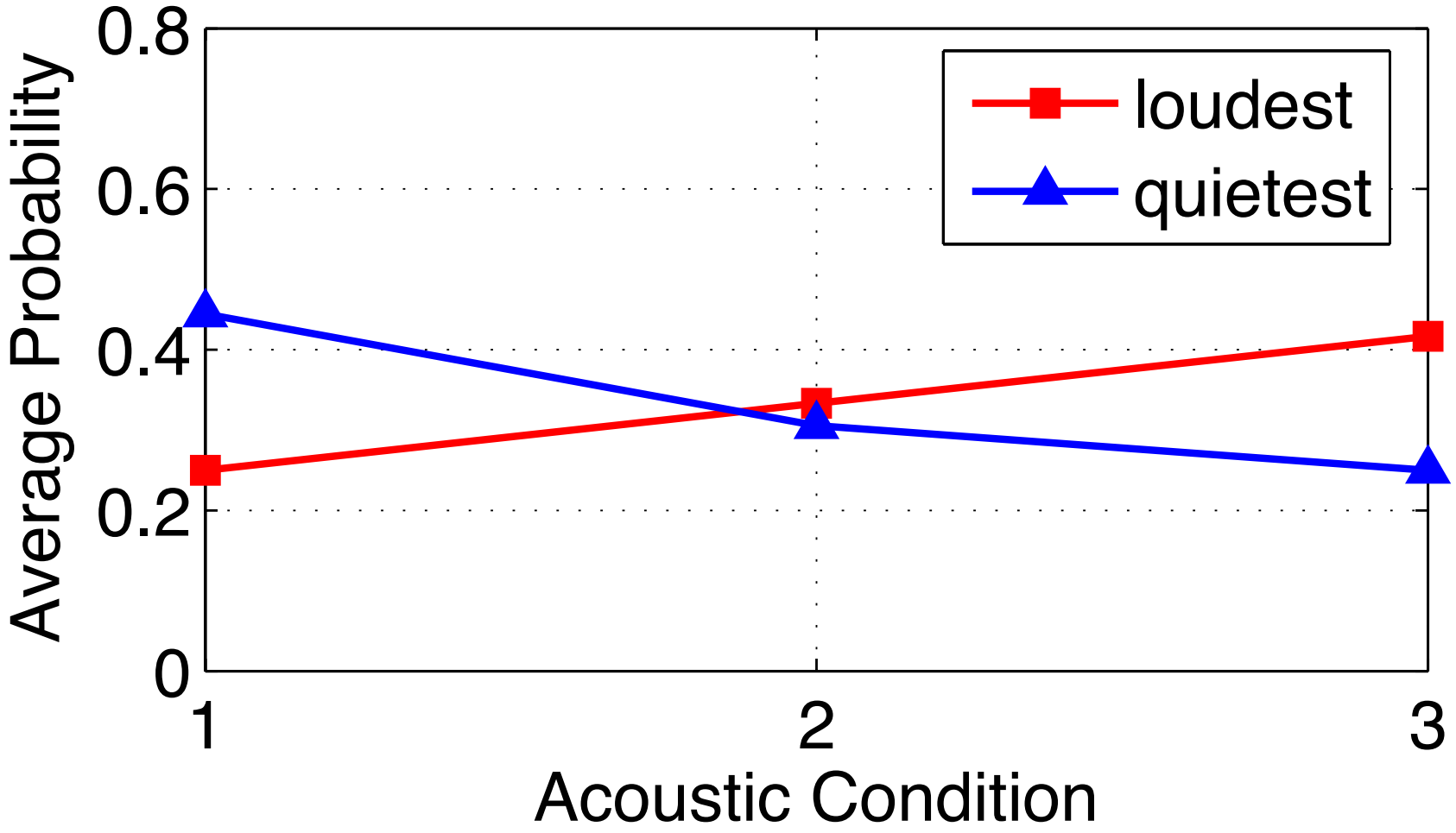
Clarity


0.8
0.6
0.4
0.2
0
Average Probability
1
2
3
Acoustic Condition
most clear
least clear

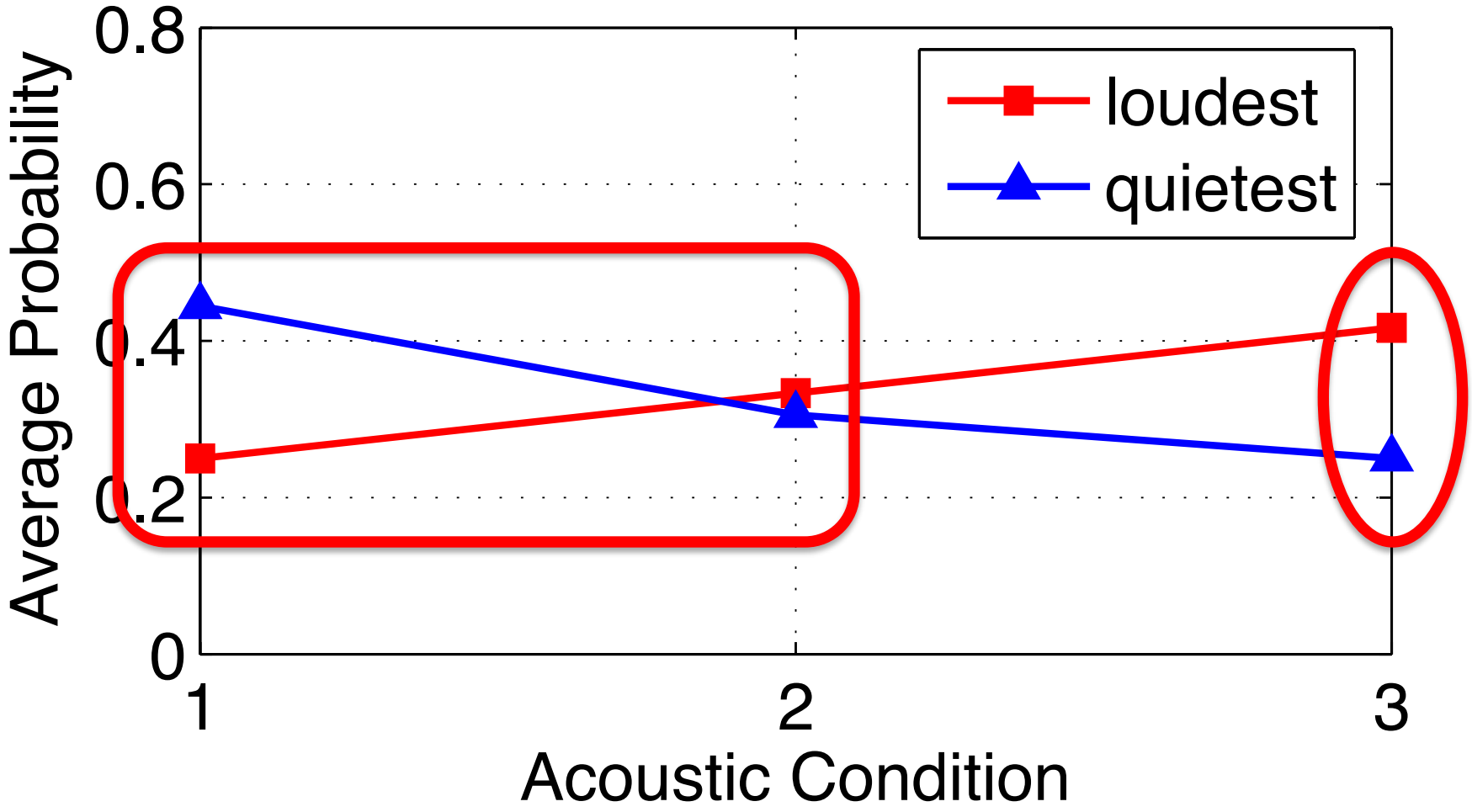
Clarity


0.8
0.6
0.4
0.2
0
Average Probability
1
2
3
Acoustic Condition
most clear
least clear

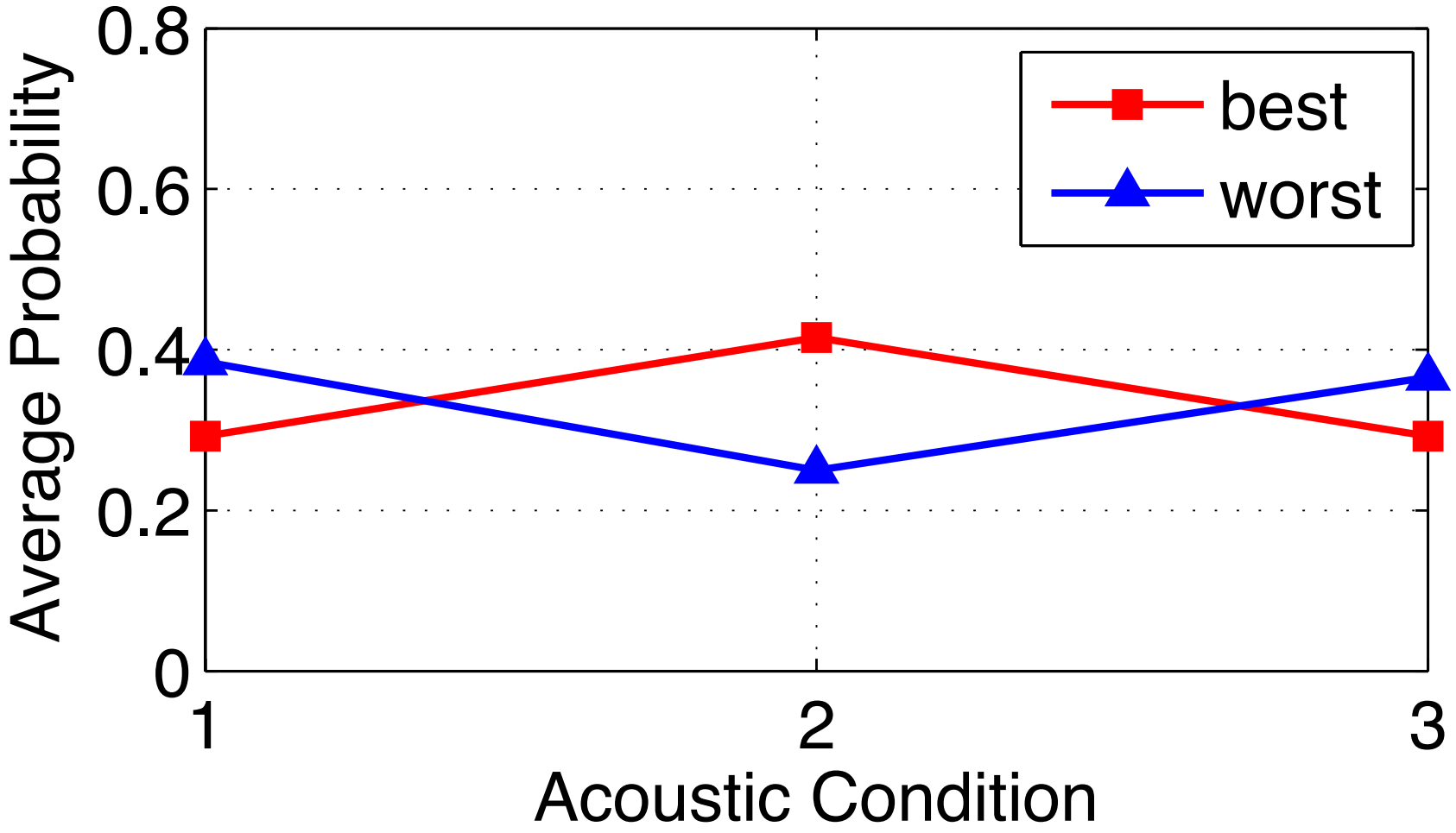
Loudness


0.8
0.6
0.4
0.2
0
Average Probability
1
2
3
Acoustic Condition
loudest
quietest

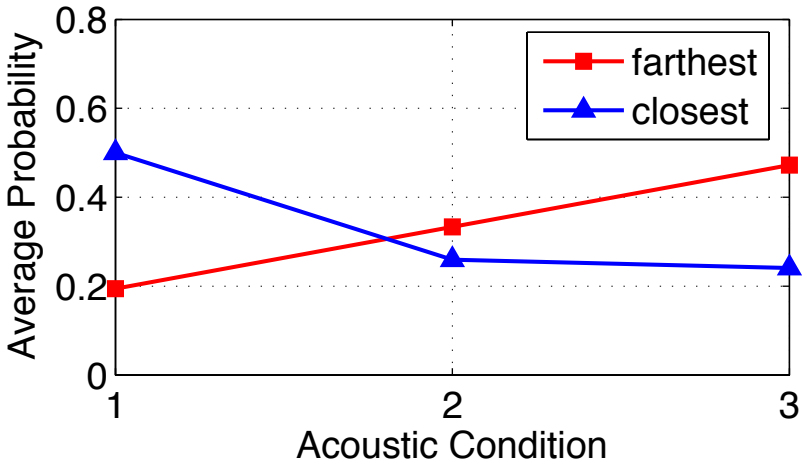
Loudness

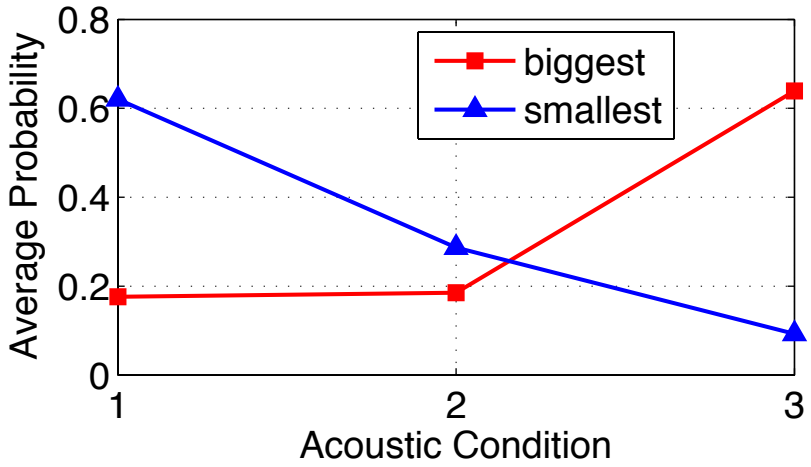

0.8
0.6
0.4
0.2
0
Average Probability
1
2
3
Acoustic Condition
loudest
quietest

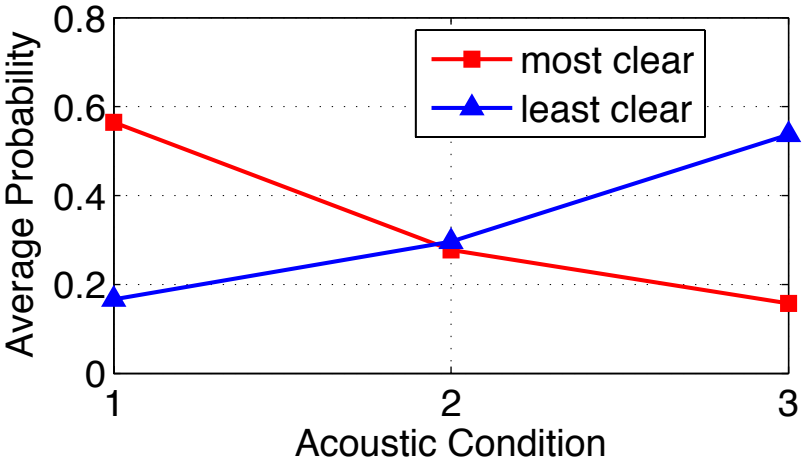
Preference

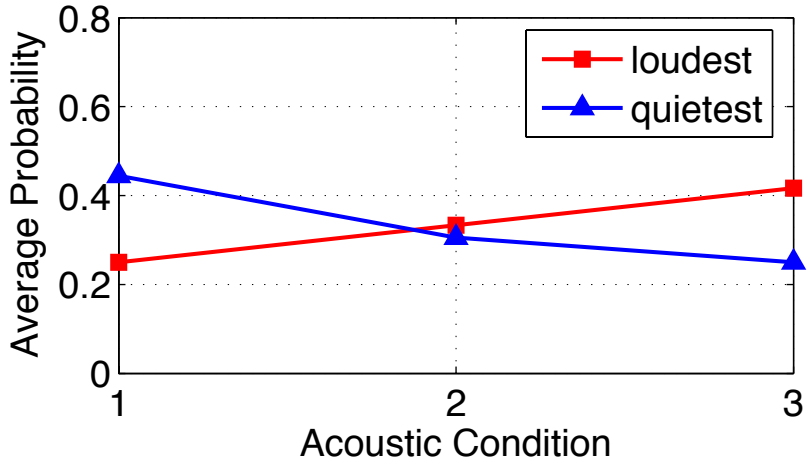

0.8
0.6
0.4
0.2
0
Average Probability
1
2
3
Acoustic Condition
best
worst

Summary

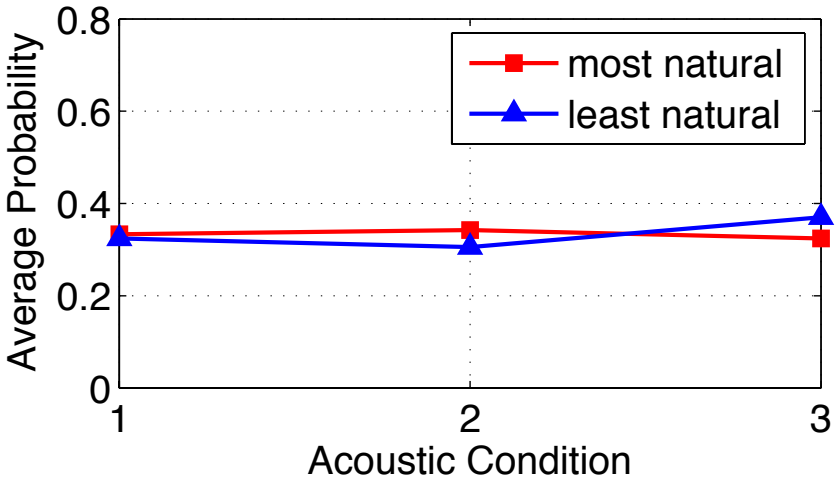

0.8
0.6
0.4
0.2
0
Average Probability
farthest
closest
1
2
3
Acoustic Condition

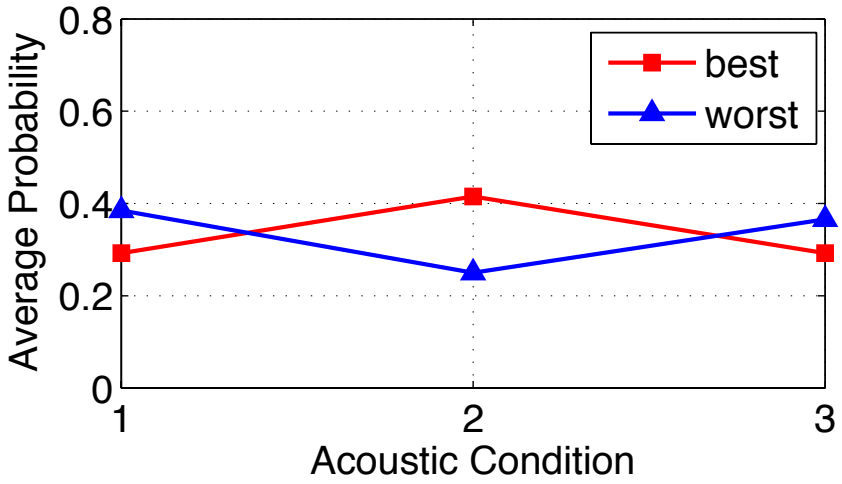

0.8
0.6
0.4
0.2
0
Average Probability
biggest
smallest
1
2
3
Acoustic Condition


0.8
0.6
0.4
0.2
0
Average Probability
most clear
least clear
1
2
3
Acoustic Condition


0.8
0.6
0.4
0.2
0
Average Probability
loudest
quietest
1
2
3
Acoustic Condition

Summary


0.8
0.6
0.4
0.2
0
Average Probability
most natural
least natural
1
2
3
Acoustic Condition


0.8
0.6
0.4
0.2
0
Average Probability
best
worst
1
2
3
Acoustic Condition

Summary

- Listening experiment with excerpts performed in virtual acoustic conditions
- Data showed no systematic effect of music (or string quartet groups)
- Listeners perceived differences in room acoustics in recorded samples
  - Source distance, room size, clarity, loudness
- Listener data showed no difference in naturalness
  - Implies a virtual acoustic system can improve the perception of space and performance while maintaining naturalness
- While performers strongly preferred enhanced acoustics (Conditions 2 and 3), this pattern was not found in the listener data
  - In need of more participants?

Caveat

- Stimuli were recorded samples and not live performances
  - Listeners' experiences were probably different from performers'
- Cannot verify listener consistency
- Music in diverse styles
  - Difficult to judge the effect of virtual acoustics on different musical styles

Future Works

- Repeat experiment
  - With musicians without experiences with virtual acoustics
  - With general audience
  - In a different system setup (e.g. multichannel surround)
- Musical analysis to extract parameters that would best predict the effect of acoustic conditions on performance
  - Such as micro-timing, (a)synchronicity, pitch accuracy

Understanding how performers and listeners perceive different acoustic conditions will help fine-tune virtual acoustics systems for everyone's pleasure.

Thanks for your attention!

Questions? Comments?