

Can you be localized in a room by listening to music? – Yes, but only as long as your heart is beating!

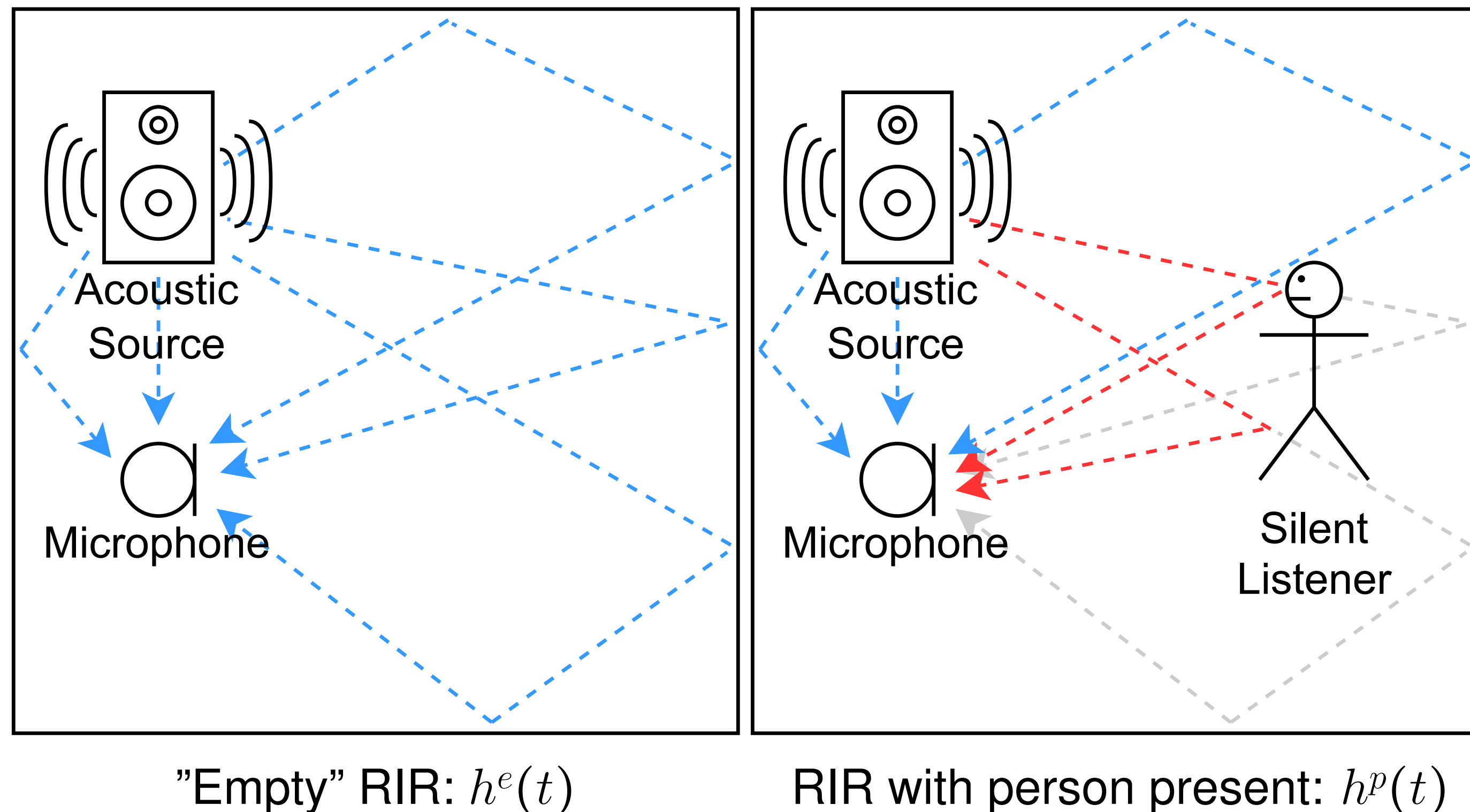
Acoustic Position Estimation of a Silent Listener

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1. Introduction



- **A silent listener alters the room impulse response (RIR)**

⇒ Listener localization theoretically possible given $h^e(t)$ and $h^p(t)$

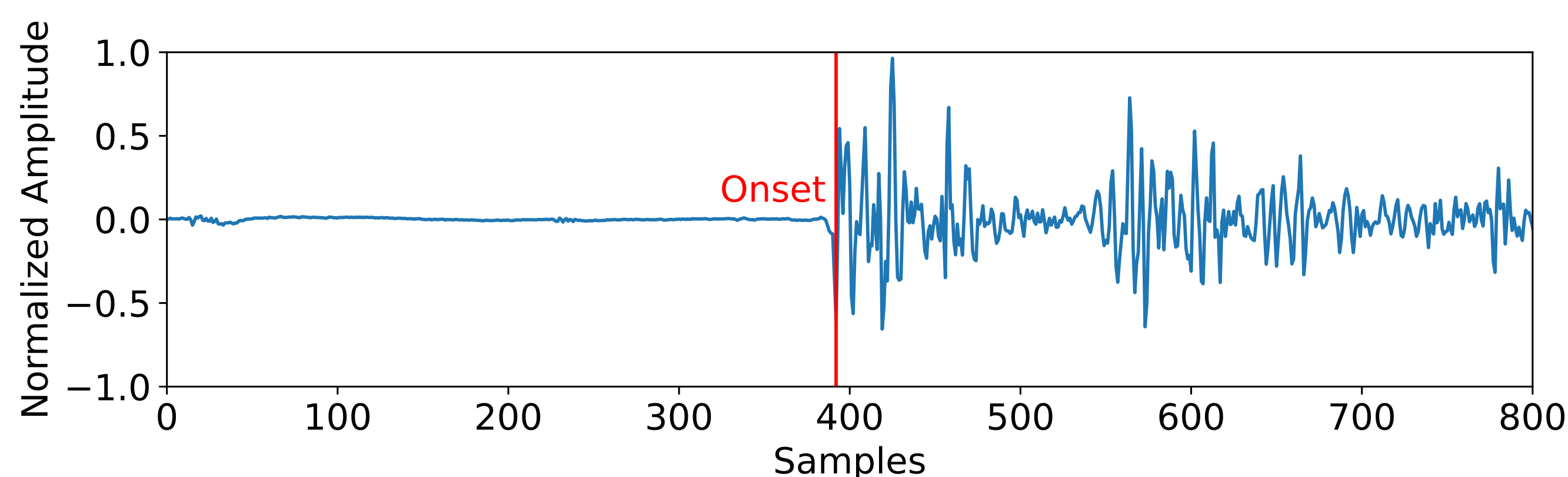
- Previous approaches need $h^e(t)$ and $h^p(t)$ to localize a listener, making them susceptible to environmental changes, e.g. rearranged furniture or fluctuations in air temperature between the estimates of $h^e(t)$ and $h^p(t)$

⇒ **Localization approach which does not require $h^e(t)$ is desirable**

2. Proposed Method

- **Estimate two RIRs, $h_1^p(t)$ and $h_2^p(t)$, in direct succession while the listener is present and compute $\Delta h(t) = h_1^p(t) - h_2^p(t)$**

- Since listeners exhibit subtle movements, e.g. breathing, while other elements in the room change much more gradually over time, $\Delta h(t)$ primarily reflects the listener's movements, producing a distinct onset:



- The onset time is proportional to the shortest path from the acoustic source, via the listener, to the microphone

⇒ **A listener can be localized by determining the direction of arrival and the time of the onset in $\Delta h(t)$, without requiring $h^e(t)$**

3. Dataset Acquisition and Evaluation

- Three participants were placed in two rooms, one at a time, at five positions, performing one of five conditions:

Condition 1: Standing while moving and facing the y-axis

Condition 2: Standing still, facing the y-axis

Condition 3: Standing still, facing the x-axis

Condition 4: Sitting while moving and facing the y-axis

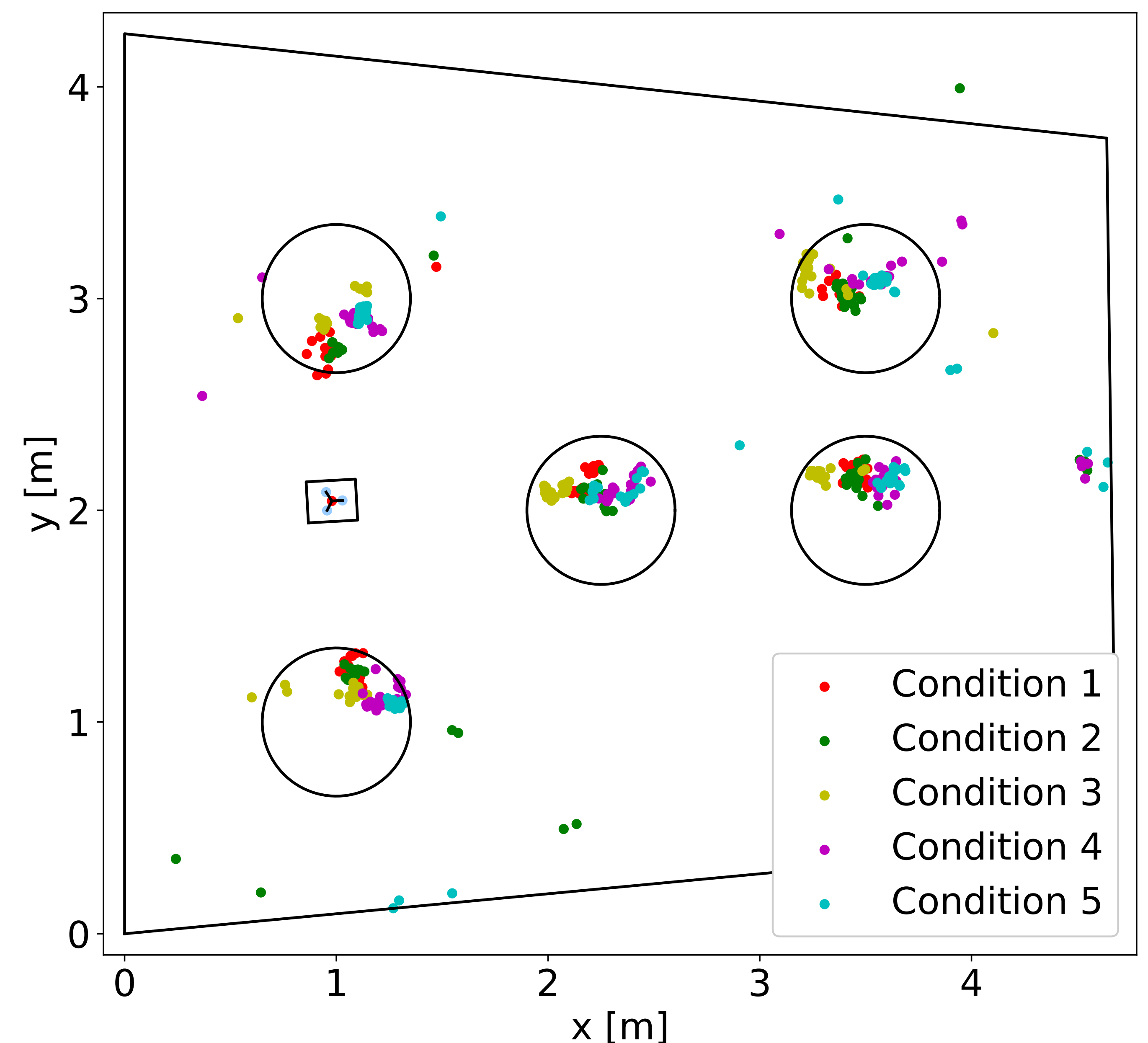
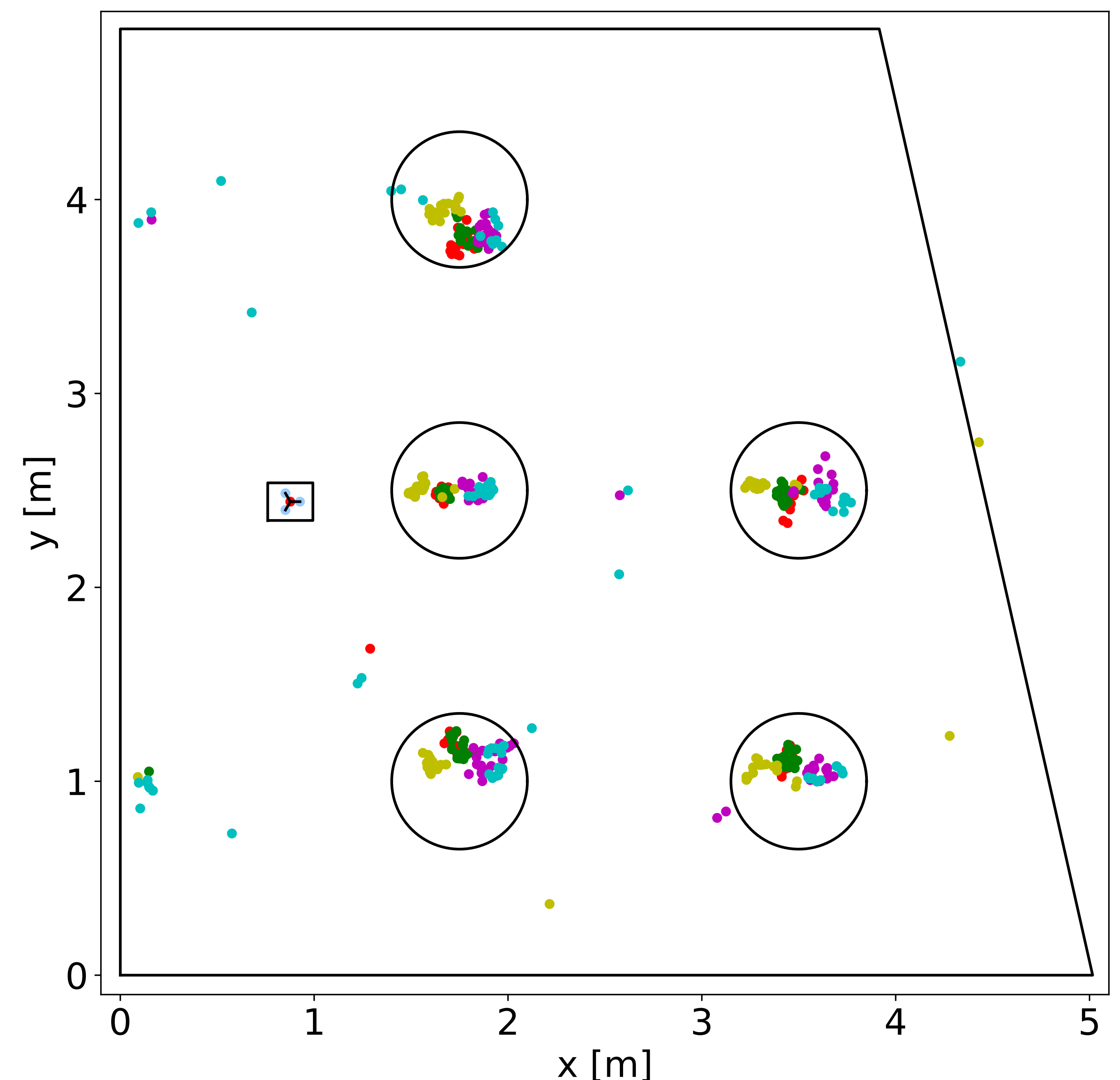
Condition 5: Sitting still, facing the y-axis

- A loudspeaker played four consecutive exponential sweeps in each situation, and the signals were captured by three microphones placed on top of the loudspeaker

- Localization was classified as successful if the position estimate falls within a circle of 35 cm radius around the ground truth

- **A total of 14400 RIRs with listeners present were evaluated**

4. Results in Two Different Rooms



Results across all listeners, listener positions and listener conditions

5. Conclusions

- We proposed a new method for localizing a silent listener in a room using successively captured RIRs
- **Our approach exploits subtle listener movements for localization and does not require the RIR without the listener present**
- In our experiments, **standing and seated listeners were localized within 35 cm accuracy in 93 % and 82 % of cases, respectively**