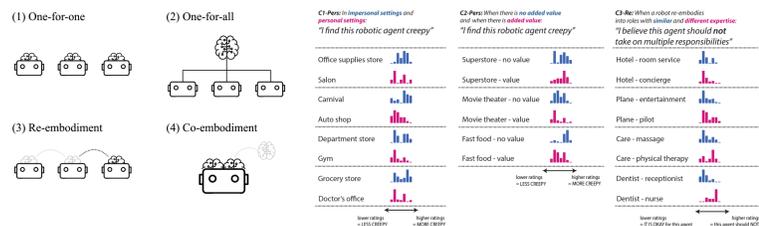


Human-Robot Collaboration with Distributed and Embodied Intelligence

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Challenge

Many barriers prevent people from accepting and effectively collaborating or interacting with robots. Our work broadly explores **service settings** where customers interact with robots and people's **homes** where family members interact with robots and agents. Our work particularly focuses on discovering when robots should and should NOT engage in behaviors that go beyond human capabilities, like **re-embodiment** (where a robot social presence jumps between different robot bodies) and **co-embodiment** (where two or more robot social presences reside in a single robot body).

Our research operationalizes theory from social psychology that describes optimal modes of social interaction. It also operationalizes theory from service science that describes best practices in terms of frontline service employees supporting customers. The work explores boundaries between work and home, robot competence and expertise, autonomy, privacy, trust, and acceptance of robotic technology.

Research Activities

1. Embodiment and Intelligence (Reig, HRI, 2019)
2. Re-embodiment and Co-embodiment (Luria, DIS, 2019)
3. Personal Interactions in Public Places (Reig, HRI, 2020)
4. Interpersonal Agents (Luria, CHI, 2020)
5. Personal and Collective Agent Ownership (Luria, DIS, 2020)
6. Customer Recognition and Re-embodiment (Reig, DIS, 2021)
7. Robots and Agents in Smart Homes (Reig, DIS, 2021)
8. Failure Recovery (Reig, HRI, 2021)
9. Agent Ownership (Luria, in progress)

We have completed 8 studies and are currently executing our ninth study. We used a variety of research methods including user enactments, laboratory studies, and more recently online studies that use storyboards or videos. The work mixes quantitative user ratings data and qualitative rationales for the ratings. This approach allows us to measure the strength of a participant's reaction and to gain some insight on the cause or trigger.

Societal Impact

Reduces barriers to the acceptance of robots in front stage services, where customers have face-to-face interactions.

Reduces barriers to the acceptance of robots in interpersonal spaces like people's homes, where issues of social hierarchy, possession of things and space, and ownership are more complicated.

Education and Outreach

Support for (2) students getting PhDs in HCI, (6) REU students learning how to conduct behavioral research and write scientific papers.

Presentations and discussions with robotic industry on the importance of thinking beyond human-to-human interaction as the ultimate goal of HRI for social robots.

Scientific Impact

- Advances the use of exploratory research methods (user enactments, speed dating, and online crowd studies) for addressing situations where we know we don't know how robots should behave (too unknown for hypotheses).
- Offers empirical evidence that people want robots to take on non-human capabilities like re-embodiment and customer recognition when this action provides immediate value for the user.
- Discovered roles requiring great expertise and high social status should always have a dedicated robot.
- Identified robot ownership as an under-investigated yet critical aspect of user acceptance.

Highlights

- People like robots that re-embodiment when they provide more efficient and streamlined service.
- People don't want robots to recognize them, especially in contexts where human workers would not. This can be lessened if the robot delivers personalized value.
- People object to re-embodiment that involves large

changes in expertise (airline check-in to co-pilot)

- Ownership has a huge impact on trust for robots that must access personal information. People want to know who the agent works for (affiliation).
- Collective ownership and personal ownership are complicated.
- People like to see robots recognize and recover when they make errors.

Quantifying Potential

Revealed important functional requirements and design guidance for robot developers, thereby increasing the likelihood of successful product deployments during the risky, initial phase of product introduction. These include:

- When to use dedicated robots vs. robots that utilize re-embodiment or co-embodiment
- Design characteristics for robots capable of re-embodiment
- Red lines for re-embodiment applications