



A Naturalistic Laboratory Setup for Real-World HRI Studies

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ABSTRACT

We present our novel naturalistic laboratory setup that facilitates the presentation of real-world live-action stimuli by physically present actors in a controlled manner. Participants observe live-action stimuli through a screen, which is surrounded by curtains, akin to a theatre experience, and promptly evaluate them when the screen turns to its opaque mode. Additionally, we introduce key components of the setup, including curtains, an actor PC, a security camera, and a bell, and the insights we gained during the task development. This innovative setup holds promise for advancing real-world investigations in Human-Robot Interaction.

CCS CONCEPTS

• **Human-centered computing** → **Laboratory experiments.**

KEYWORDS

social robotics, naturalistic experiments, real-world stimuli, ecological validity, Wizard of Oz experiments

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1 MOTIVATION

In the context of human-robot interaction (HRI), a significant amount of discussion revolves around the perception of robots, particularly those designed for social interaction. Although social robots are engineered to engage with various entities, including humans and

other robots, their integration into individuals' lives and the establishment of relationships are not assured. The way humans perceive these robots significantly shapes the subsequent relationship. For instance, attributing mental states such as emotions or feelings to a robot can evoke a protective instinct, reducing the likelihood of causing harm to these entities. Similarly, beliefs in a robot's capacity for moral decision-making or reasoning can foster trust and an expectation of virtuous behavior. Consequently, a thorough exploration of the mind perception induced by social robots is essential to advancing our understanding of HRI dynamics [13].

Waytz et al. [14] explored the causes and consequences of mind perception, considering perspectives from both the perceiver and the perceived. While prior research often focused on robot properties, such as appearance and capabilities, evidence highlights that attributions of mental capacity increase when robots exhibit social [3, 12] behavior. Given the influence of real-life context on human observation, there is a need for mind perception studies involving robots in live actions. While action videos or images are viable alternatives, the observed rise in mental attributions in the presence of physical robots [8, 12] suggests the importance of expanding studies to assess robots in real-time interactions.

Conducting fully uncontrolled field studies with real robots poses challenges given current technological constraints. Nevertheless, the Wizard of Oz (WoZ) experimental methodology [7], where participants interact with a robot under the illusion of autonomy while a human experimenter controls it, proves beneficial for simulating autonomous behavior and presenting controlled stimuli. Responding to the recurring and increasing demand for more naturalistic studies to enhance ecological and external validity, we address this need by introducing a naturalistic laboratory setup. This setup facilitates the presentation of real-world stimuli and captures real-time behavioral data, including response time and mouse tracking metrics, as participants evaluate Agency and Experience—two prominent dimensions in the mind perception process [4]. We share the insights we got while designing the present task and setup as well as conducting real-time experiments with this setup, with the HRI community.

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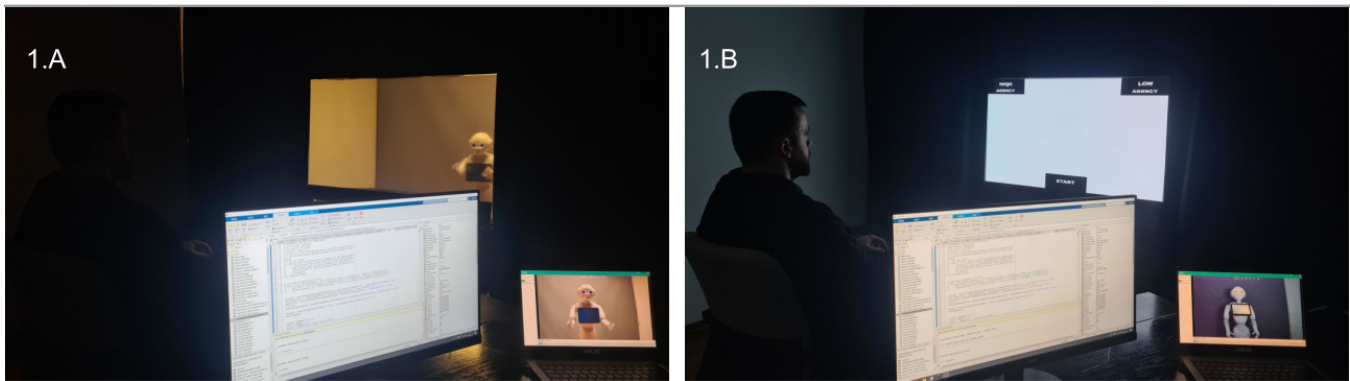


Figure 1: The setup in operation. 1.A: The participant observes the robot actor and its actions in the screen's see-through mode. 1.B: The participant evaluates the stimulus by clicking on the upper right or left corners of the screen in its opaque mode.

2 OVERVIEW

The present video starts by mentioning alternative methods for testing mind perception induced by social robots. The first method involves interviews, capturing qualitative data through open-ended questions. This approach is particularly valuable in the early stages of investigations for generating exploratory insights and, later, for comparing controlled test results with real-life responses. The second scenario illustrates a widely used methodology in HRI: surveys and self-reports. While self-reports offer valid assessments of social cognition, they come with well-known limitations [13]. Implicit measurements are crucial when exploring complex cognitive processes like mind perception, contributing to the consolidation of findings obtained from explicit measurements.

The video proceeds to showcase the adapted Single-Category version [6] of the original Implicit Association Task (IAT) [5]. These tasks measure participants' associations by their pacing during the matching of *target stimuli* (displayed in the center of the screen) with *attribute stimuli* (located in the upper right and left corners of the screen), interpreted as indicators of strong or weak associations. In the video, for the first task, participants evaluated concepts related to robots and humans. However, recognizing individual variabilities in mental representations, we advocate using images of robots and humans as target stimuli. Subsequently, the participants view images depicting human and robot actors engaged in various actions to examine the influence of action nature on participant judgments. In the last computerized scenario, the participants watch the short action videos of a human and a robot, and they attribute *High* or *Low Agency* or *Experience* depending on the capacity level they attribute based on the action and the agent they watched.

The final scenario, preceding the introduction of our task, illustrates an imaginary task where participants observe live actions performed by actors and subsequently make evaluations on a computer screen. This demonstration highlights potential challenges for participants, including difficulties in simultaneously tracking actions and the computer screen, navigating changing positions to observe actions, encountering issues when returning to the computer screen, and experiencing distraction and overwhelm due to the diversity of micro-tasks within a "single" implicit task.

The explicit tasks, like interviews or questionnaires, easily adapt to real-life settings as they do not require strict control over stimuli. However, implicit tasks, such as ours, aim to collect behavioral data (e.g., response times, mouse trajectories) to interpret cognitive processes, such as mind perception in our case. Accuracy in data collection over precisely controlled stimuli is crucial. Our setup not only allows the presentation of live-action stimuli by actors but it also facilitates real-time behavioral data collection on the same screen. The use of a special OLED screen eliminates modulation changes or distractions. Without this screen, live actors and actions could be presented directly; however, separate modalities would be needed for participant instructions, preventing mouse tracking and increasing the confounds during response time calculation.

3 METHOD

3.1 Components

OLED screen: The 55" OLED screen is a crucial component in our setup, as it enables the presentation of real-world stimuli and the elicitation of real-time behavioral data using the same visual modality. Through the manipulation of room lighting and adjustments to the background color on our participant display screen, we achieve a seamless transition between transparency and opacity. When we turn off all room lights and set the screen background to white, we ensure 100% opacity. Conversely, by only turning on the LED lights on the ceiling and setting the screen background to black, we create a transparent (see-through mode) display. This functionality allows us to present instructions and prompts in opaque mode, while the see-through mode enables the controlled presentation of live actions of actors.

Curtain System: The room is divided by heavy black-out curtains into participant and actor areas. The participant area comprises the participant table, response device, and an experimenter table with the experiment PC and a separate laptop for security camera display. The actor area features a cabinet for the actors to wait for their turns, a laptop for the human actor to follow the block and actor orders and the action orders in her blocks, and a security camera facilitating communication between the human actor and experimenter.



Figure 2: The participant area displays the participant observing the human actor through the OLED screen and the experimenter monitoring the process.

3.2 Proposed Setup in Operation

In a sample session, participants sit facing the OLED screen in a darkened room, with actors positioned inside the actor cabinet. The participants are instructed that one human and one robot actor are waiting behind the curtains, and they will perform live when during the study. The experimenter informs the participants that they will see the actors and the backstage at the end of the experiment, akin to a theatre play. The tasks begin with instructions displayed on the opaque screen. During live-action presentations, the screen turns transparent for six seconds, matching the action duration. Subsequently, the screen shifts to white, signaling participants to evaluate stimuli by clicking on one of the choices presented on the upper right and left corners of the screen. Participants observe the same eight actions (four communicative and four noncommunicative) in each of the four blocks: two Agency, two Experience, two with human, and two with the robot actor. The block order is counterbalanced among participants, controlled by the human actor and experimenter. After each block, the neutral background music starts, accompanied by a cue, like "It is Pepper's turn, change places," sent to the actor's PC. The human actor signals readiness to the experimenter with a waving gesture. Once the backstage transition is confirmed smooth, the experimenter initiates the next block. This design ensures participants can focus on the background music without being distracted by actor changes.

In case of issues from the actor's side, the human actor signals the experimenter with a gesture, while a bell ring by the experimenter indicates delays due to experimenter-side problems, such as connection issues. Manual control between blocks and communication behind curtains ensures smooth experiment execution despite potential issues. Participants are kept unaware of procedural details, the security camera's presence, or assistance from the human actor during changes to maintain neutrality regarding the robot actor's autonomy. Further technical details, including materials and connections, can be found in our previous work [10]. We introduced the Real-World Implicit Association Test (RW-IAT) we designed using this setup, providing detailed documentation and sample data analyses in a recent work [11].

4 CONTRIBUTION

Despite still being a laboratory setup, our design allows presenting live-action stimuli performed by live actors. We preserve the highly controlled nature of the experiments while enhancing the ecological validity, which is referred to as Level 4 of naturalism based on the taxonomy introduced in [2]. We collected a huge amount of data from four generations of participants, including the elderly [9]. We believe our setup allows modifications for future studies using real-world stimuli whether dynamic or static by a robot, human or animal, whether interactive or single-sided, in a setup resembling a theatre [1]. The materials we incorporated such as the security camera, LED lights, curtains, and even the bell could also inspire other Wizard of Oz studies and real-world investigations in HRI.

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REFERENCES

- [1] Kim Baraka. 2023. Why robotics labs should look more like theatres. In *Connected World: Insights from 100 Academics on How to Build Better Connections*, Ivar Vermeulen (Ed.). VU Press.
- [2] S. Fan, O. Dal Monte, and S.W.C. Chang. 2021. Levels of naturalism in social neuroscience research. *iScience*, 24 (7), 102702.
- [3] Marlena R. Fraune, Benjamin C. Oisted, Catherine E. Sembrowski, Kathryn A. Gates, Margaret M. Krupp, and Selma Šabanović. 2020. Effects of robot-human versus robot-robot behavior and entitativity on anthropomorphism and willingness to interact. *Computers in Human Behavior* 105 (2020), 106220. <https://doi.org/10.1016/j.chb.2019.106220>
- [4] Heather M. Gray, Kurt Gray, and Daniel M. Wegner. 2007. Dimensions of Mind Perception. *Science* 315, 5812 (2007), 619–619. <https://doi.org/10.1126/science.1134475> arXiv:<https://www.science.org/doi/pdf/10.1126/science.1134475>
- [5] Anthony G. Greenwald, Debbie E. McGhee, and Jordan L.K. Schwartz. 1998. Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology* 74, 6 (1998), 1464.
- [6] Andrew Karpinski and Ross B. Steinman. 2006. The Single Category Implicit Association Test as a measure of implicit social cognition. *Journal of Personality and Social Psychology* 91, 1 (2006), 16–32.
- [7] John F. Kelley. 1984. An iterative design methodology for user-friendly natural language office information applications. *ACM Transactions on Information Systems (TOIS)* 2, 1 (1984), 26–41.
- [8] Jamy Li. 2015. The benefit of being physically present: A survey of experimental works comparing copresent robots, telepresent robots and virtual agents. *International Journal of Human-Computer Studies* 77 (2015), 23–37.
- [9] Tuğçe Nur Pekçetin, Cengiz Acarturk, and Burcu A. Urgan. 2024. Investigating Mind Perception in HRI through Real-Time Implicit and Explicit Measurements. In *Companion of the 2024 ACM/IEEE International Conference on Human-Robot Interaction*. <https://doi.org/10.1145/3610978.3638366>
- [10] Tuğçe Nur Pekçetin, Şeyda Evsen, Serkan Pekçetin, Cengiz Acarturk, and Burcu A. Urgan. 2023. A Naturalistic Setup for Presenting Real People and Live Actions in Experimental Psychology and Cognitive Neuroscience Studies. *JoVE (Journal of Visualized Experiments)* 198 (2023), e65436.
- [11] Tuğçe Nur Pekçetin, Şeyda Evsen, Serkan Pekçetin, Cengiz Acarturk, and Burcu A. Urgan. 2024. Real-World Implicit Association Task for Studying Mind Perception: Insights for Social Robotics. In *Companion of the 2024 ACM/IEEE International Conference on Human-Robot Interaction*. <https://doi.org/10.1145/3610978.3640706>
- [12] Ilona Straub. 2016. "It looks like a human!" The interrelation of social presence, interaction and agency ascription: a case study about the effects of an android robot on social agency ascription. *AI & Society* 31 (2016), 553–571.
- [13] Sam Thellman, Maartje de Graaf, and Tom Ziemke. 2022. Mental State Attribution to Robots: A Systematic Review of Conceptions, Methods, and Findings. 11, 4 (2022). <https://doi.org/10.1145/3526112>
- [14] Adam Waytz, Kurt Gray, Nicholas Epley, and Daniel M. Wegner. 2010. Causes and consequences of mind perception. *Trends in Cognitive Sciences* 14, 8 (2010), 383–388. <https://doi.org/10.1016/j.tics.2010.05.006>