
Research question (max. 400 words)

Introduce the research question and explain clearly how it is embedded in the literature

In our daily life we often have to coordinate our actions with those of others. This requires us to infer our interaction partners' mental states, goals and potential actions, which then allows us to synchronize our actions with theirs, guaranteeing a smooth interaction process. It can be assumed that similar cognitive processes should be at work to achieve a successful human-robot interaction (HRI). Still, it is unclear whether humans are capable of forming a mental representation of robotic actions (also referred to as 'action corepresentation').

Several studies provide evidence that corepresentation only occurs during interaction with biological agents. However, more recent research discovered that individuals do show corepresentation of the actions of non-biological agents if they feature some human-like characteristics: Müller et al. [1] found that corepresentation can be elicited by a wooden interaction partner if people's perceptions about the animacy of that wooden character were manipulated. In a similar study, Stenzel and colleagues [2] showed that making participants believe that a robot's functional principles was based on a biological, human-like model was sufficient to induce corepresentation.

However, those studies manipulated people's beliefs about the human-likeness of the robot through explicit instructions, which is a quite artificial approach and not feasible when humans interact with robots in real-world settings. Hence, the question arises whether corepresentation can also be elicited by natural behavior of the robot expressed during the interaction process and if yes, which specific behaviors are suitable to implicitly evoke this effect. To investigate this question, it needs to be considered what characteristic behaviors humans show when they interact with another person. In social interaction emotional expressions play a crucial role as they provide cues which can be used by us to infer other people's mental states and then form a mental representation of their actions. Moreover, in HRI emotions have been found to increase believability of the robotic interaction partner. This suggests that a robot which displays emotional behavior during the interaction process might also appear more human-like than a non-emotional robot, and be more likely to implicitly trigger the same effect of corepresentation in human interaction partners as explicit instructions.

Formulate the research question as adequately as you can, possibly together with sub questions and hypotheses

Does the emotional expressiveness of the robot modulate the extent to which robotic actions are corepresented?

More concretely it is hypothesized that:

- 1) Participants in condition I (emotional robot) will show corepresentation of the robot's actions.
- 2) Participants in condition II (non-emotional robot) will not show corepresentation of the robot's actions.

Scientific and TIW relevance (max. 150 words)

Explain why your project fits the Innovation Sciences/ Human Technology Interaction domain (dealing with technology AND people) and how it connects or contributes to IS/HTI science.

In the present research we are trying to apply cognitive mechanisms which are at work during human-human interaction to improve HRI (HRI).

The contribution of the present study to HRI research is two-fold:

- *Content-wise*: If a person corepresents robotic actions, it can be inferred that this person's mental model of a robot resembles that of a human interaction partner, which facilitates interacting with the robot. As the occurrence of corepresentation requires a certain human-likeness of the robot, it is important to **identify those characteristics of robots that can lead to corepresentation**.
- *Methodological*: The experiments described above manipulated people's beliefs about the human-likeness of the robot through priming, using textual descriptions or video clips. We are taking a **more subtle, less artificial approach** by letting it display human-likeness through its behavior during the actual interaction process.

Method (max. 200 words)

Indicate HOW you are going to answer your research question. Describe for example what the (in)dependent variables are, what methodology you will use or develop. How are you going to collect your data? For example interviews, and if so, who are you going to interview and what for? How will you analyze your data?

psychological experiment (between-subject design, two experimental conditions):

Independent variable: **robot's emotional expressiveness**, manipulated during part I of the experiment, a gaming session where the participant plays Battleship against the Nao robot which either reacts emotionally to game events (through speech, gestures, eye-LED-patterns; condition I) or not (condition II).

Dependent variable: **corepresentation of robotic actions**, measured during part II of the experiment, the Social Simon Task [3]: Either a square or diamond is displayed on the left or right side of a screen to the participant and the robot who have to execute individual go/no-go tasks (participant responding to square, robot to diamond). This task does not require taking the other's action into account. However, reaction times (RT) appear to be slower when the target stimulus is paired with a spatial cue referring to the other person. This difference in RT between congruent (stimulus presented on participant's side of the screen) and incongruent trials (stimulus displayed on other side of the screen) which depends on the irrelevant presence of the co-player is understood as evidence for action corepresentation.

The effect of the robot's emotional expressiveness on action corepresentation is assessed by comparing the RT differences between congruent and incongruent trials for the two conditions.

References

Provide three references of scientific articles and/or books that underlie the research proposal. Make complete references (refer to: *Publication Manual of the American Psychological Association*, 6th ed. (Washington, DC: American Psychological Association, 2001).

- 1 Müller, B. C. N., Brass, M., Kühn, S., Tsai, C.-C., Nieuwboer, W., Dijksterhuis, A., & van Baaren, R. B. (2011). When Pinocchio acts like a human, a wooden hand becomes embodied. Action co-representation for non-biological agents. *Neuropsychologia*, 49(5), 1373–1377.
 - 2 Sebanz, N., Knoblich, G., & Prinz, W. (2005). How two share a task: corepresenting stimulus-response mappings. *Journal of Experimental Psychology: Human Perception and Performance*, 31(6), 1234.
 - 3 Stenzel, A., Chinellato, E., Bou, M. A. T., del Pobil, Á. P., Lappe, M., & Liepelt, R. (2012). When humanoid robots become human-like interaction partners: Corepresentation of robotic actions.
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