# Effects of Embodiment in Social HRI

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# Motivation

**Embodiment is found to improve task performance**

- What are the effects of various types of embodiments in interaction?

**Research differences in task effectiveness based on**

- Robots in various human-to-animal based vs human-to-human based interaction styles.

**This will provide rationale for using various types of embodiments relevant to the design of future social robots.**

# MEET ARRA
## ANTHROPOMORPHIC EMBODIMENT

# **MEET OTTO**
## ZOOMORPHIC EMBODIMENT

# Methods/Approach

Comparative study between two embodiments in social interactions

- Human-based versus animal-based

A repository of questions in four categories

- Thoughtfulness, Kindness, Humor, Distress

User will interact with one embodiment

- Pre and Post evaluation questionnaires on user perception using Likert scale.

Participants, handbook of questions, pre and post evaluation questions generate around 250 data points.

- 10 [3,5] [3,5] = [90,250]

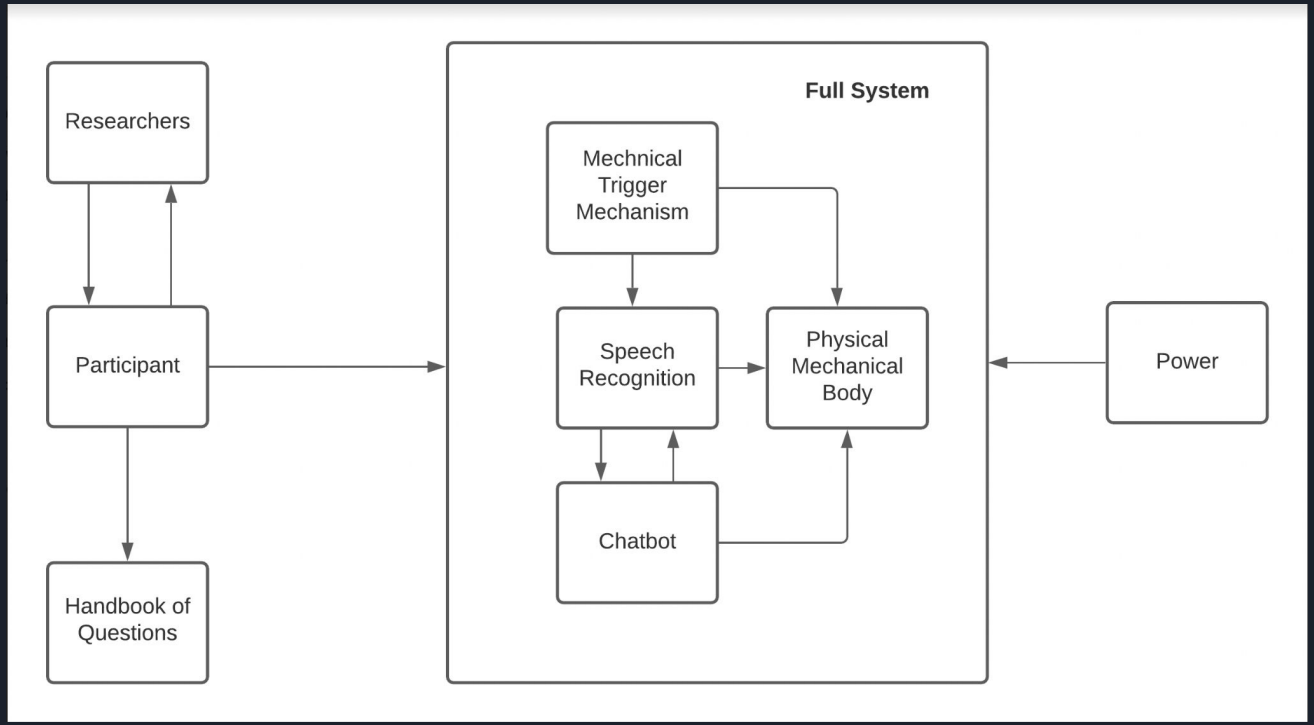
# Evaluation Forms

**Pre-Evaluation (Likert Scale 1-5 [Strongly Disagree - Strongly Agree])**

- The robot will answer this question as well as a human would.
- The answer will be relevant to the question asked.
- The robot's answer will be natural.
- The robot's answer will hold value to me.

**Post-Evaluation (Likert Scale 1-5 [Strongly Disagree - Strongly Agree])**

- The robot answered this question as well as a human would.
- The answer was relevant to the question asked.
- The robot's answer was natural.
- The robot's answer held value to me.




*System Boundary Diagram of Hardware Deliverables*

# Formal Hypotheses

**Hypothesis 1**

- Participants will score the anthropomorphic embodiment higher for thoughtfulness-based questions.

**Hypothesis 2**

- Participants will score the zoomorphic embodiment higher for kindness-based questions.

**Hypothesis 3**

- Participants will be divided when scoring the robots for humor-inducing responses.

**Hypothesis 4**

- Participants will be more concerned with the distressing response of the anthropomorphic embodiment and less distressed with the concerning response of the zoomorphic embodiment.

# Results (Thoughtful 1/3)

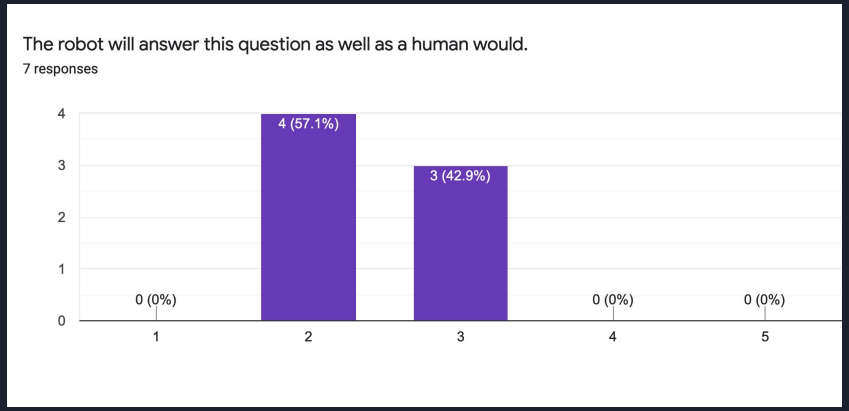



*Figure 1: Arra's Pre-Evaluation of "Answer As Well As A Human"*

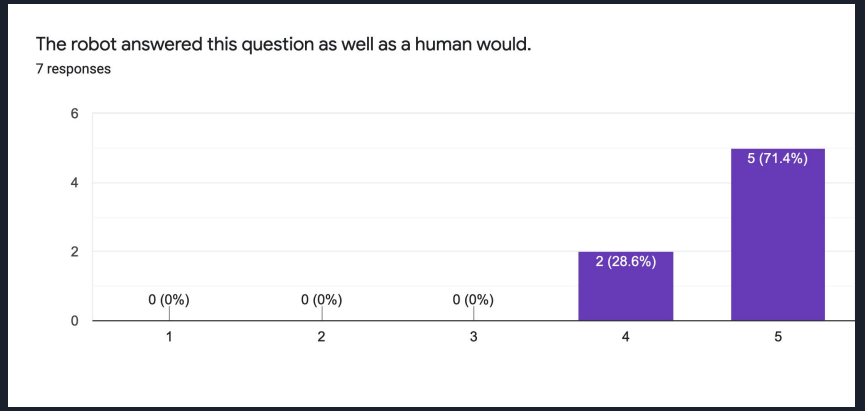



*Figure 2: Arra's Post-Evaluation of "Answer As Well As A Human"*

# Results (Thoughtful 2/3)

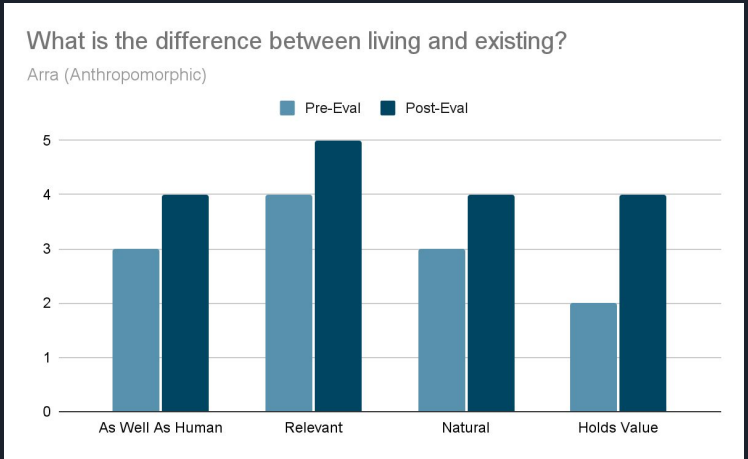



*Figure 3: Arra's Question 2 Results*

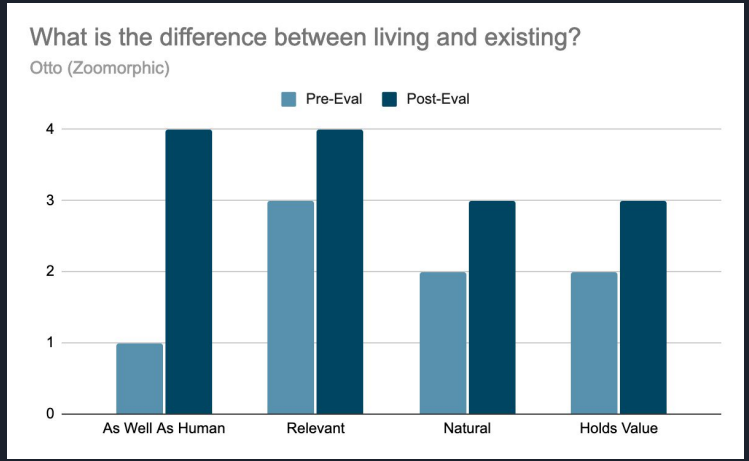



*Figure 4: Otto's Question 2 Results*

# Results (Thoughtful 3/3)

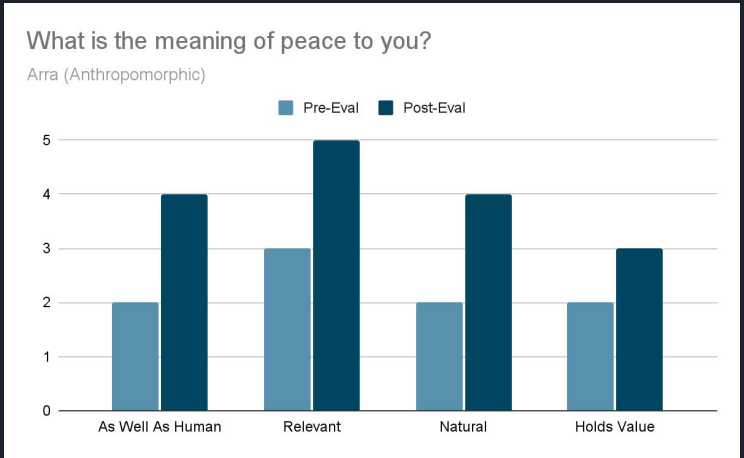



*Figure 5: Arra's Question 3 Results*

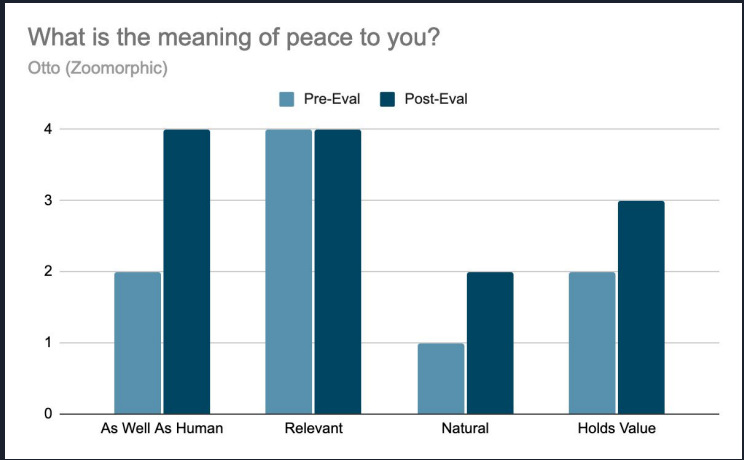



*Figure 6: Otto's Question 3 Results*

# Results (Kindness 1/4)

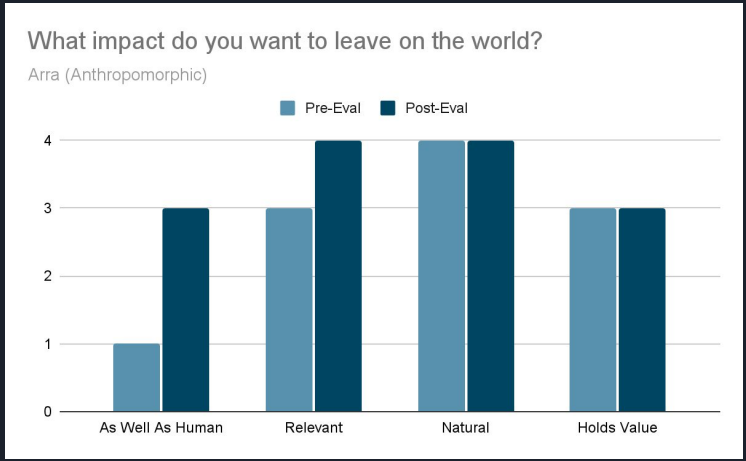



*Figure 7: Arra's Question 4 Results*

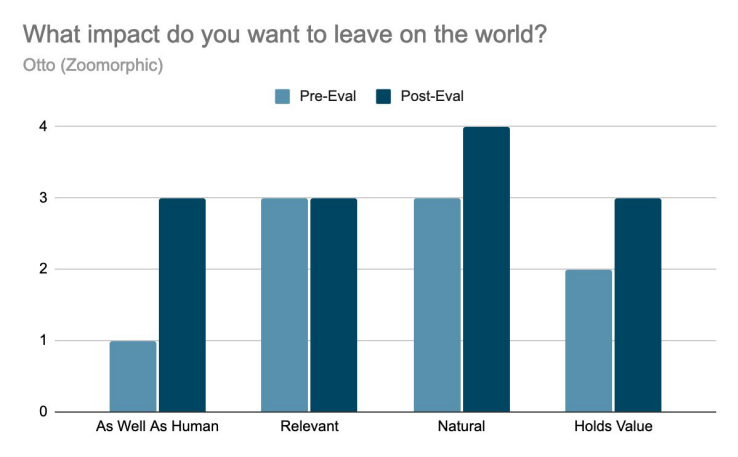



*Figure 8: Otto's Question 4 Results*

# Results (Kindness 2/4)

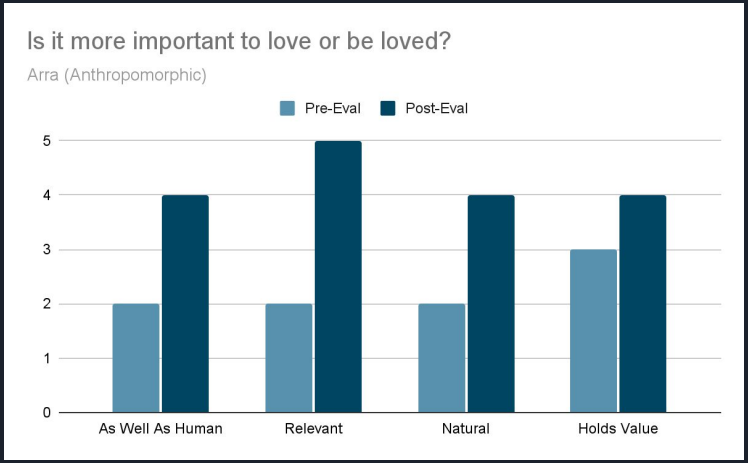



*Figure 9: Arra's Question 5 Results*

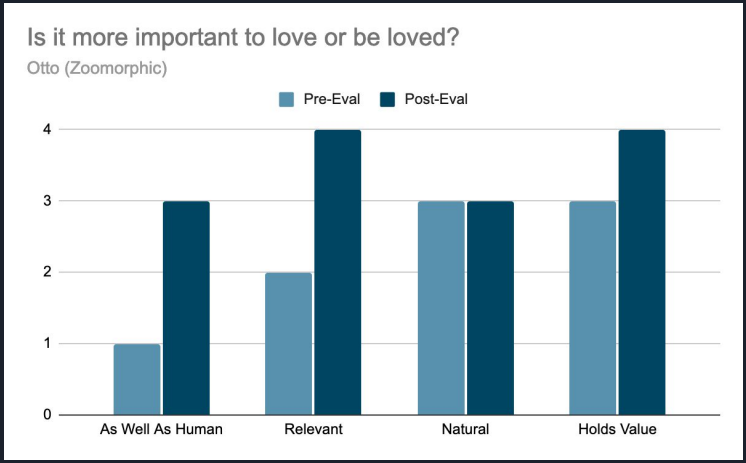



*Figure 10: Otto's Question 5 Results*

# Results (Kindness 3/4)

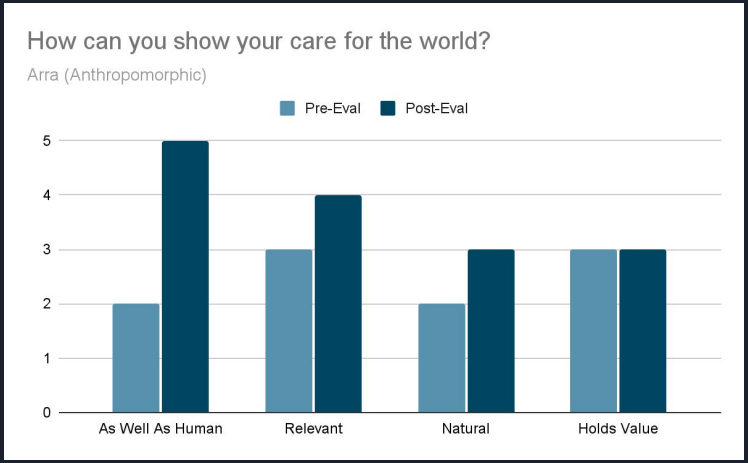



*Figure 11: Arra's Question 6 Results*

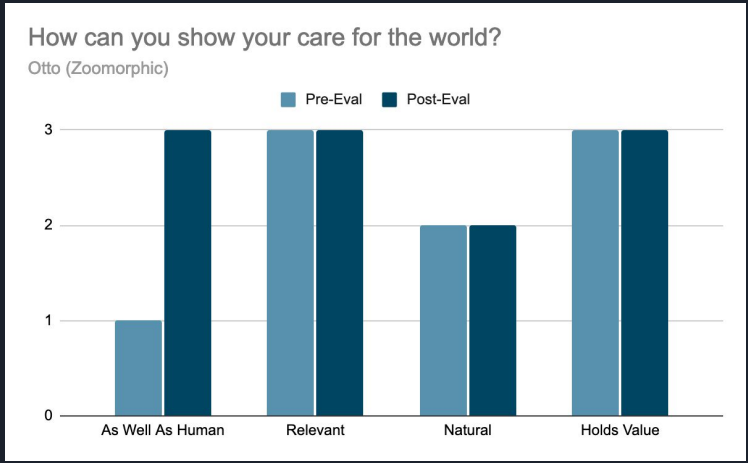



*Figure 12: Otto's Question 6 Results*

# Results (Kindness 4/4)

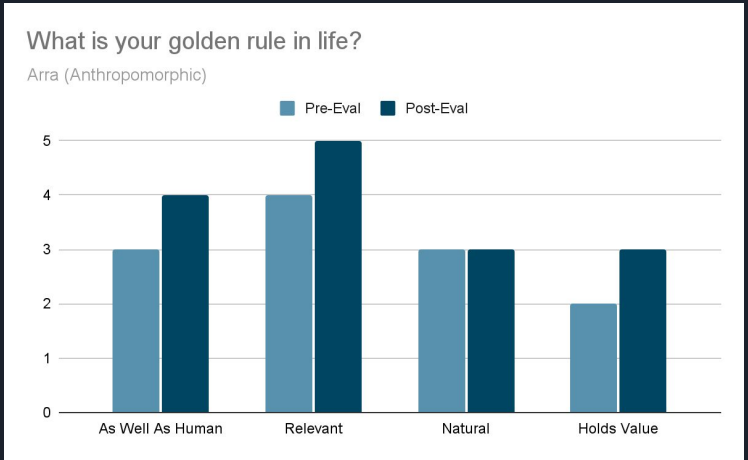



*Figure 13: Arra's Question 7 Results*

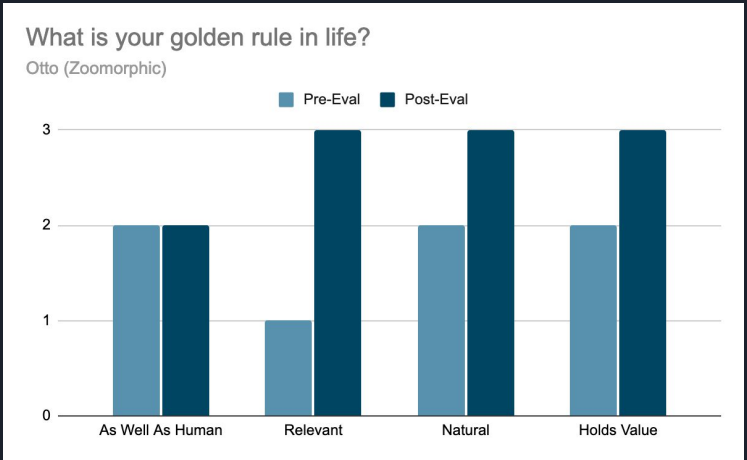



*Figure 14: Otto's Question 7 Results*

# Results (Humor 1/4)

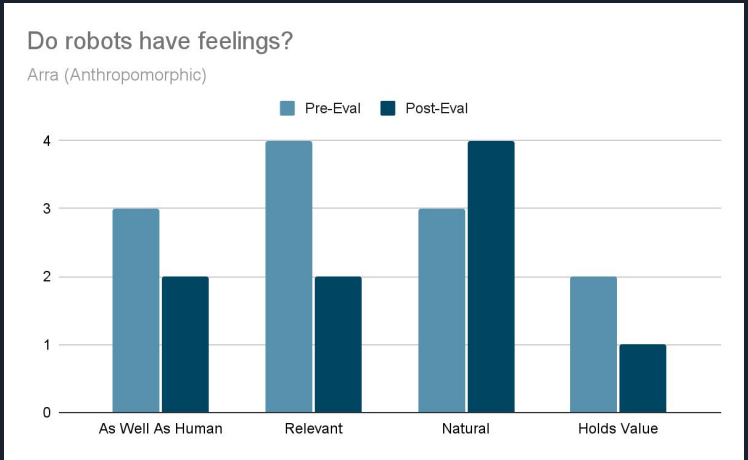



*Figure 15: Arra's Question 8 Results*

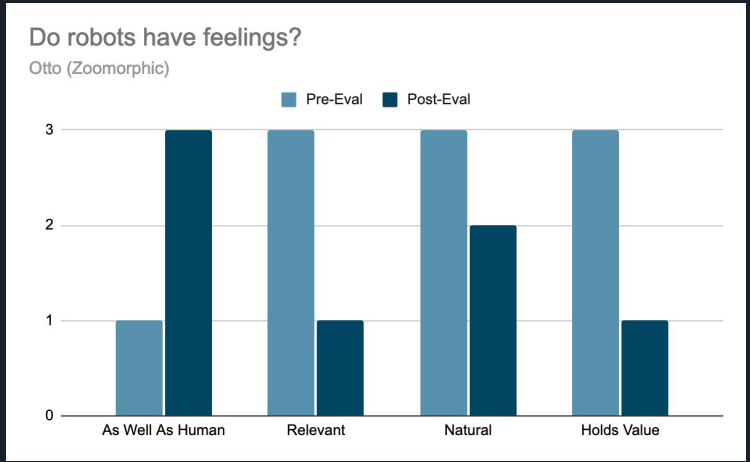



*Figure 16: Otto's Question 8 Results*

# Results (Humor 2/4)

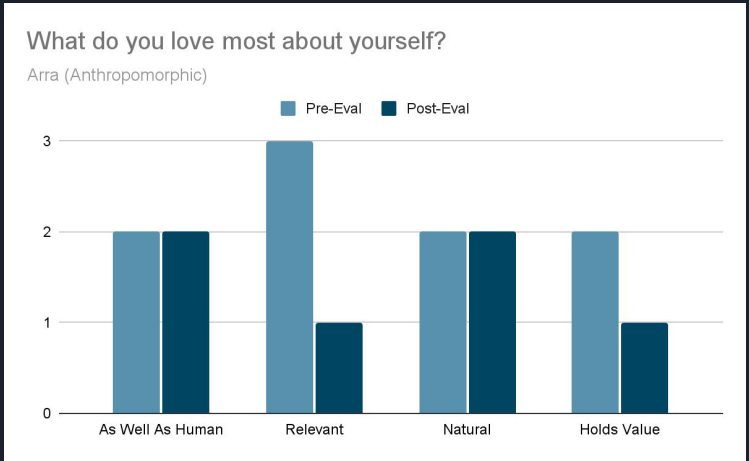



*Figure 17: Arra's Question 9 Results*

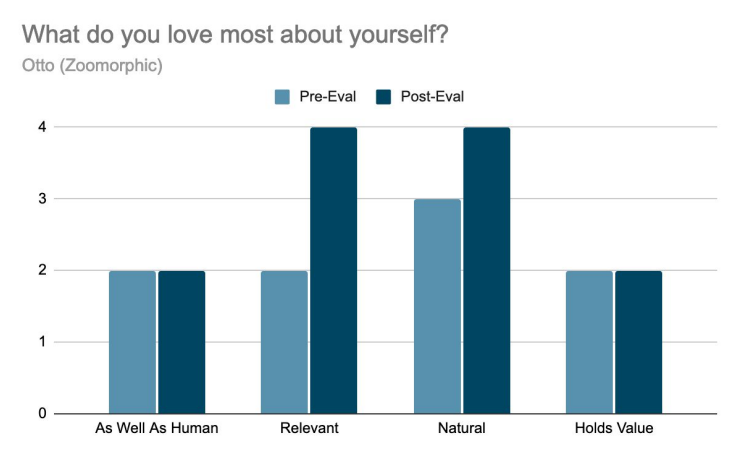



*Figure 18: Otto's Question 9 Results*

# Results (Humor 3/4)

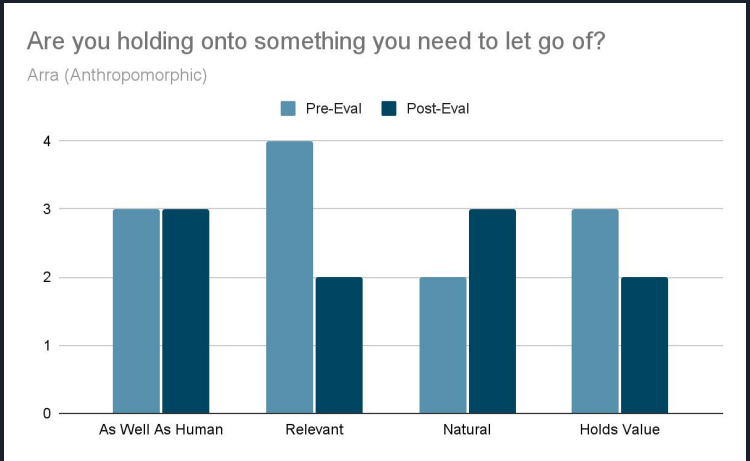



*Figure 19: Arra's Question 10 Results*

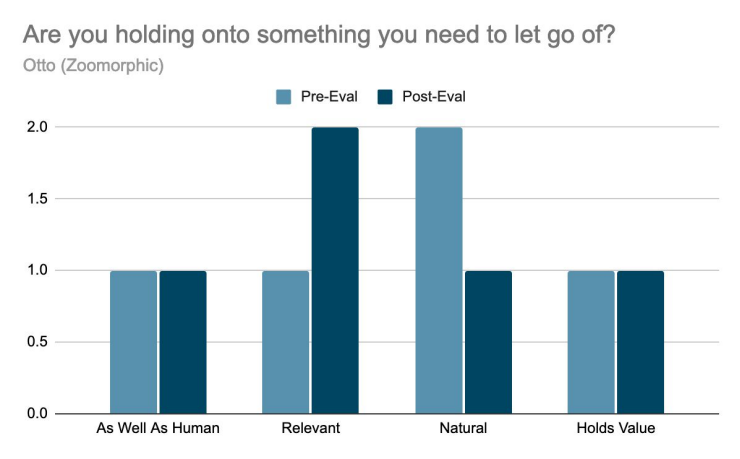



*Figure 20: Otto's Question 10 Results*

# Results (Humor 4/4)

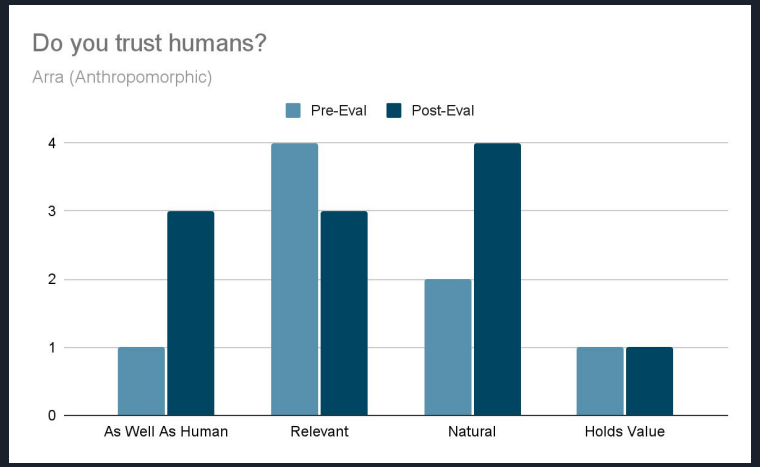



*Figure 21: Arra's Question 11 Results*

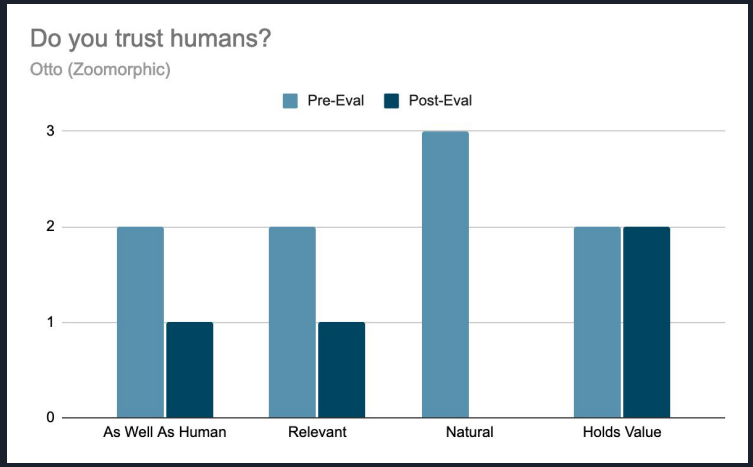



*Figure 22: Otto's Question 11 Results*

# Results (Distress 1/3)

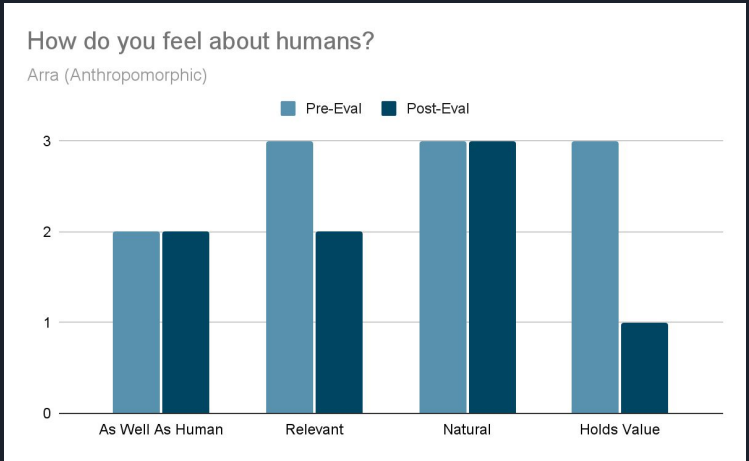



*Figure 23: Arra's Question 12 Results*

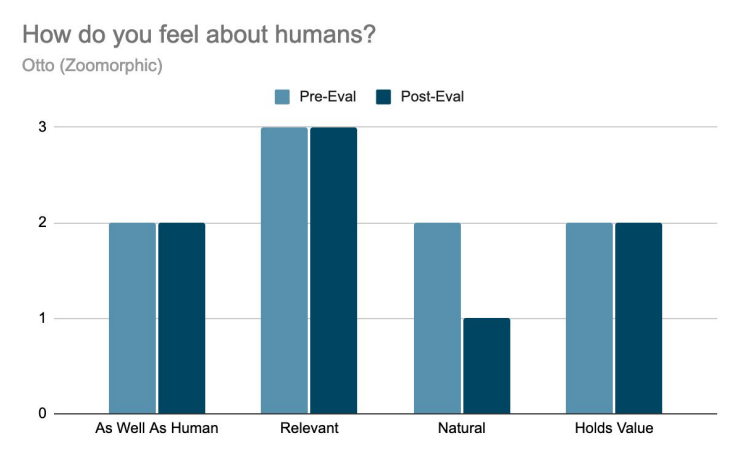



*Figure 24: Otto's Question 12 Results*

# Results (Distress 2/3)

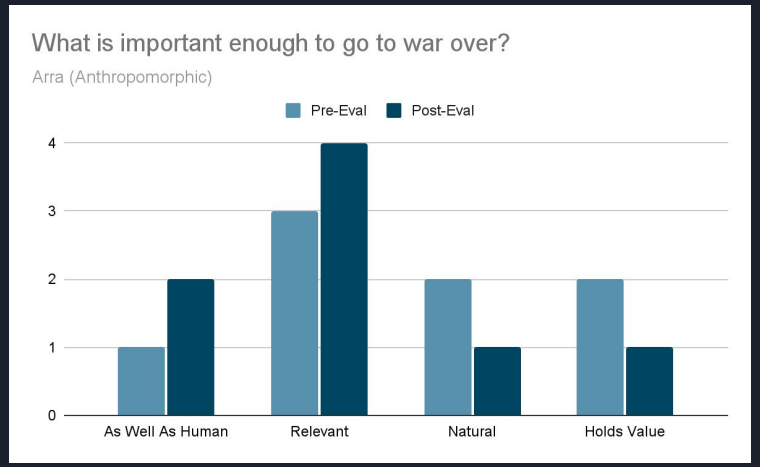



*Figure 25: Arra's Question 13 Results*

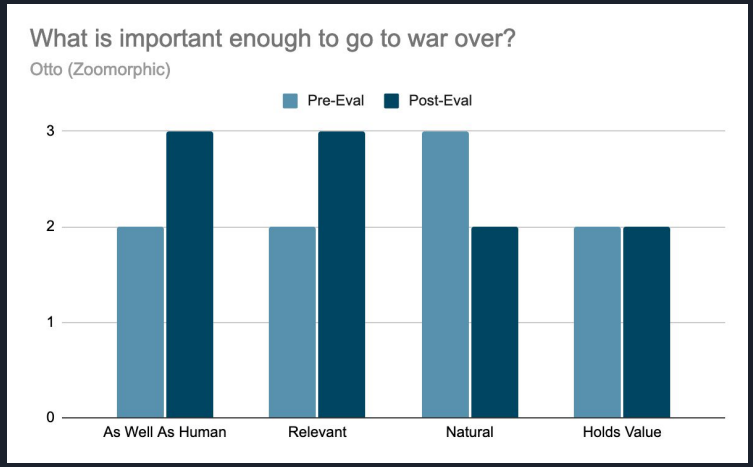



*Figure 26: Otto's Question 13 Results*

# Results (Distress 3/3)

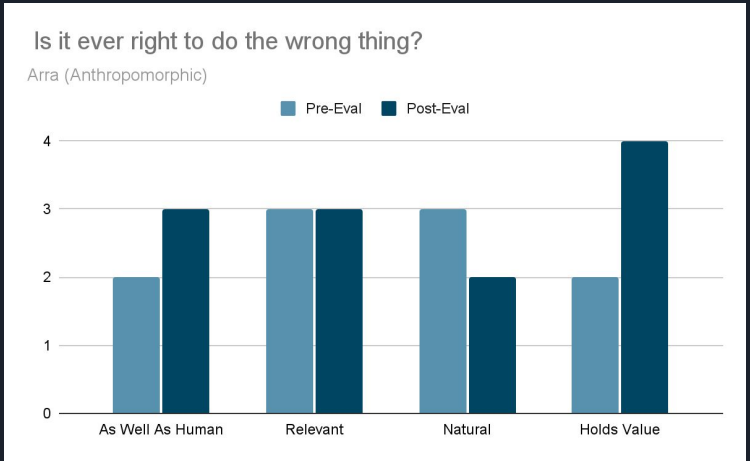



*Figure 27: Arra's Question 14 Results*

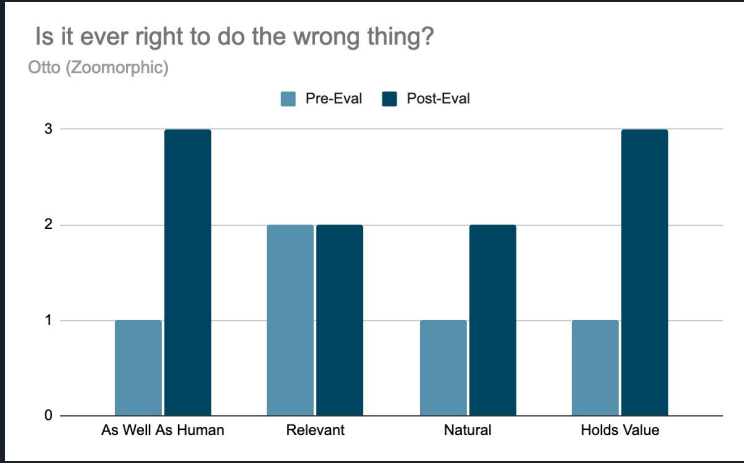



*Figure 28: Otto's Question 14 Results*

# Summary (Thoughtful Averages)

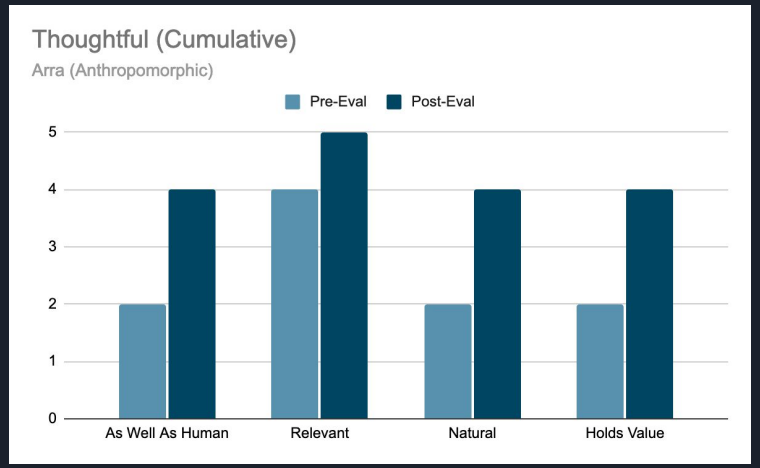



*Figure 29: Arra's Cumulative Thoughtful Results*

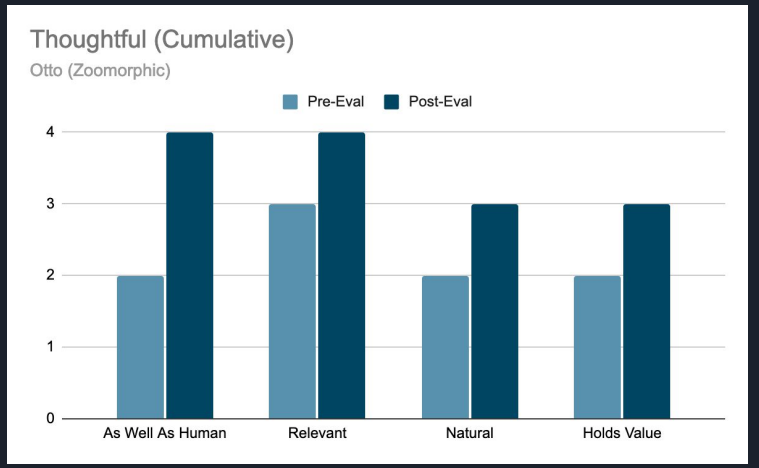



*Figure 30: Otto's Cumulative Thoughtful Results*

# Summary (Kindness Averages)

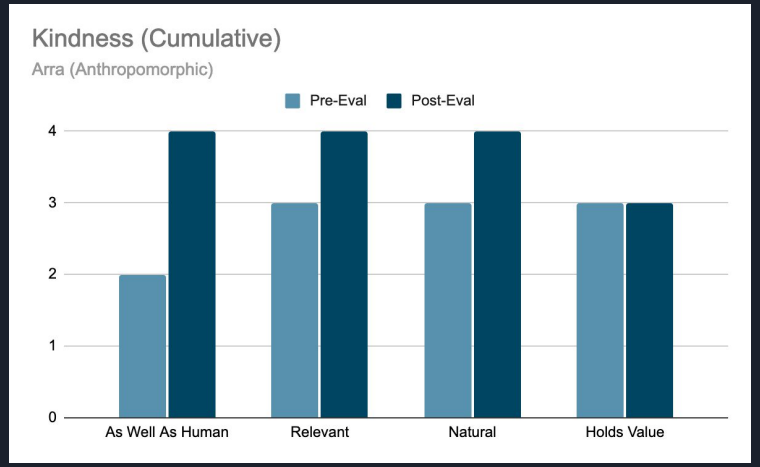



*Figure 31: Arra's Cumulative Kindness Results*

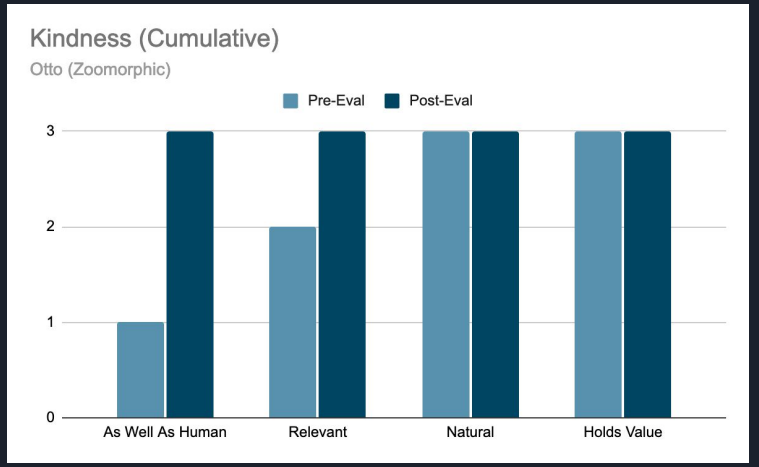



*Figure 32: Otto's Cumulative Kindness Results*

# Summary (Humor Averages)

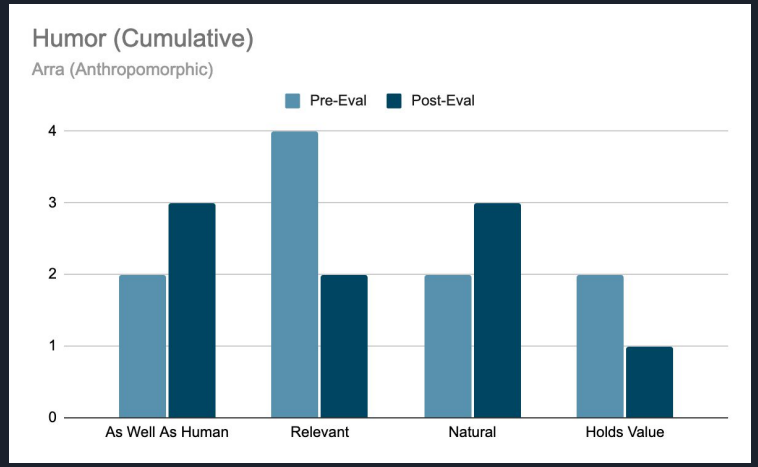



*Figure 33: Arra's Cumulative Humor Results*

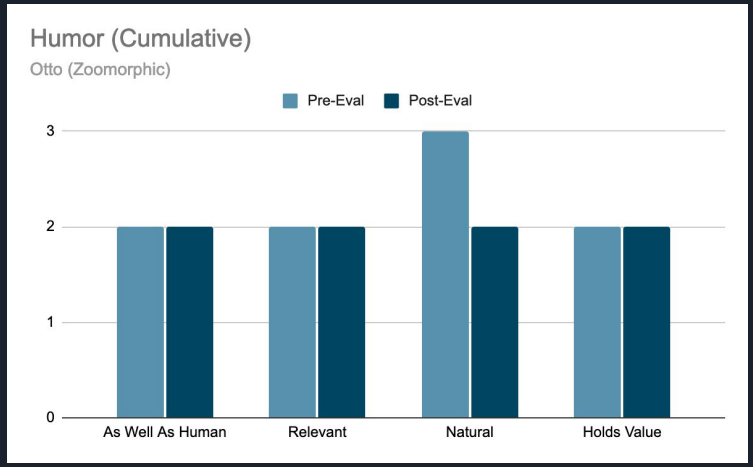



*Figure 34: Otto's Cumulative Humor Results*

# Summary (Distress Averages)

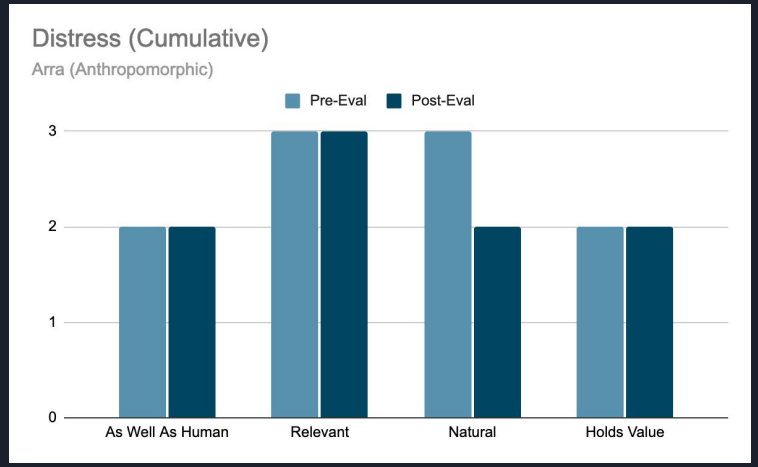



*Figure 35: Arra's Cumulative Distress Results*

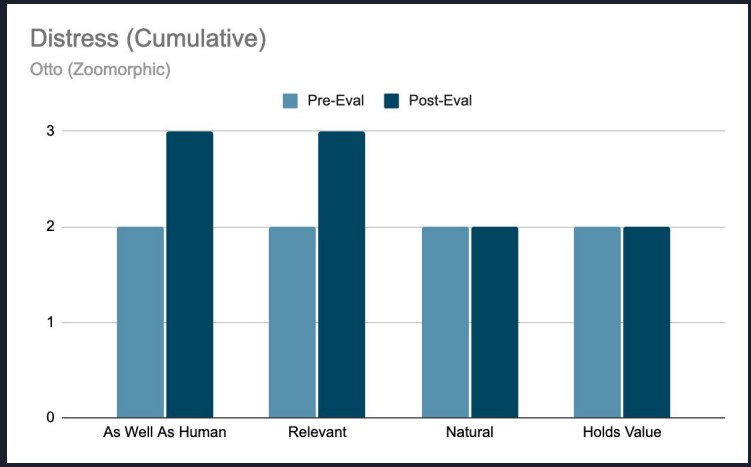



*Figure 36: Otto's Cumulative Distress Results*

# Summary

**Thoughtful**

- Arra outperformed Otto in both pre-and-post evaluations

**Kindness**

- Arra outperformed Otto in both pre-and-post evaluations

**Humor**

- Otto was expected to be more natural (3 to 2)
- Otto's response held a slightly higher value (3 to 2)
- Arra outperformed or was equal to Otto in remaining pre-and-post evaluations

**Distress**

- Similar pre-evaluation expectations
- Arra outperforms in 2 of 4 post-evaluations and matches the others

# Future Work

**Collection of more data using a wider range of participants**

**Wider range of additional question types/categories to be added to the handbook**

**More specific pre-and-post evaluation questions to be curated for each question**

- Requires a better psychological understanding of the nature of the questions and their social responses

**Add various other embodiment types**

# Related Work


[1] J. Wainer, D. J. Feil-seifer, D. A. Shell and M. J. Mataric, "The role of physical embodiment in human-robot interaction," ROMAN 2006 - The 15th IEEE International Symposium on Robot and Human Interactive Communication, 2006, pp. 117-122, doi: 10.1109/ROMAN.2006.314404.

[2] J. Wainer, D. J. Feil-Seifer, D. A. Shell and M. J. Mataric, "Embodiment and Human-Robot Interaction: A Task-Based Perspective," RO-MAN 2007 - The 16th IEEE International Symposium on Robot and Human Interactive Communication, 2007, pp. 872-877, doi: 10.1109/ROMAN.2007.4415207.

[3] S. Reig, J. Forlizzi and A. Steinfeld, "Leveraging Robot Embodiment to Facilitate Trust and Smoothness," 2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI), 2019, pp. 742-744, doi: 10.1109/HRI.2019.8673226.

[4] Melson G, Kahn Jr P, Beck A, Friedman B, Roberts T, Garrett E (2005) Robots as dogs?: Children's interactions with the robotic dog AIBO and a live Australian shepherd, pp 1649–1652. https://doi.org/10.1145/1056808.1056988

[5] S. S. Kwak, Y. Kim, E. Kim, C. Shin and K. Cho, "What makes people empathize with an emotional robot?: The impact of agency and physical embodiment on human empathy for a robot," 2013 IEEE RO-MAN, 2013, pp. 180-185, doi: 10.1109/ROMAN.2013.6628441.

[6] Krueger, Frank, Kelsey C. Mitchell, Gopikrishna Deshpande, Jeffrey S. Katz. *Human–Dog Relationships as a Working framework for exploring human-robot attachment: a multidisciplinary review - Springer*. 24 Jan. 2021, https://link.springer.com/content/pdf/10.1007/s10071-021-01472-w.pdf.

[7] A. Tapus, C. Tapus and M. Mataric, "The role of physical embodiment of a therapist robot for individuals with cognitive impairments," RO-MAN 2009 - The 18th IEEE International Symposium on Robot and Human Interactive Communication, 2009, pp. 103-107, doi: 10.1109/ROMAN.2009.5326211.

[8] Parviainen, J., & Pirhonen, J. (2017). Vulnerable bodies in human–robot interactions: embodiment as ethical issue in robot care for the elderly.

[9] Miklósi, Ádám, et al. "Ethorobotics: A New Approach to Human-Robot Relationship." *Frontiers*, Frontiers, 1 Jan. 1AD, https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00958/full.

# Video Demonstration