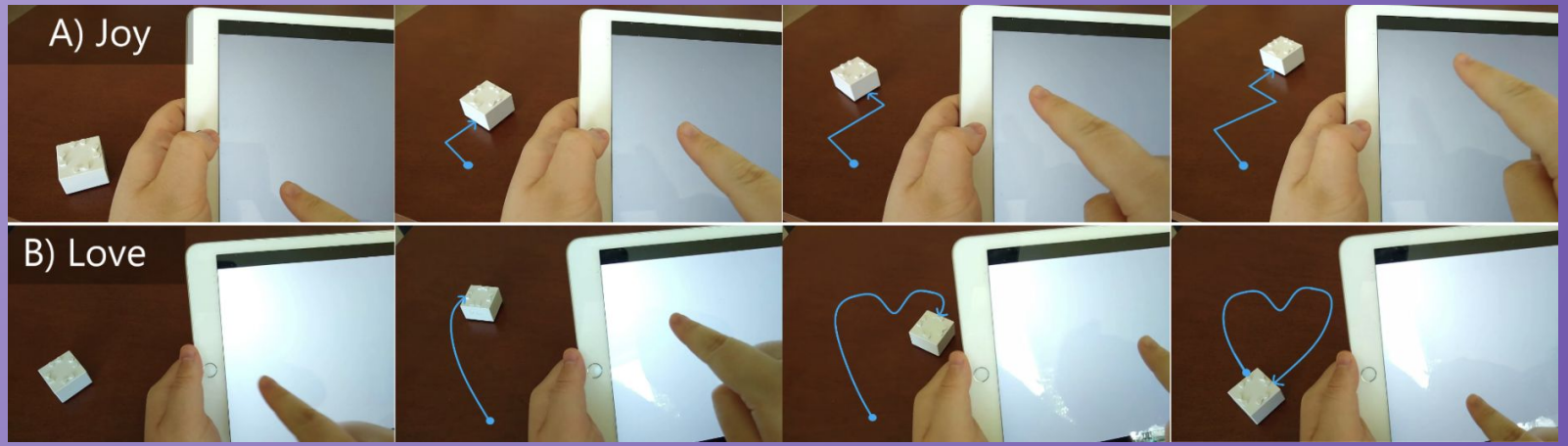
Emotion in Motion: Exploring User-Defined Emotional Perception in Non-Anthropomorphic Robots



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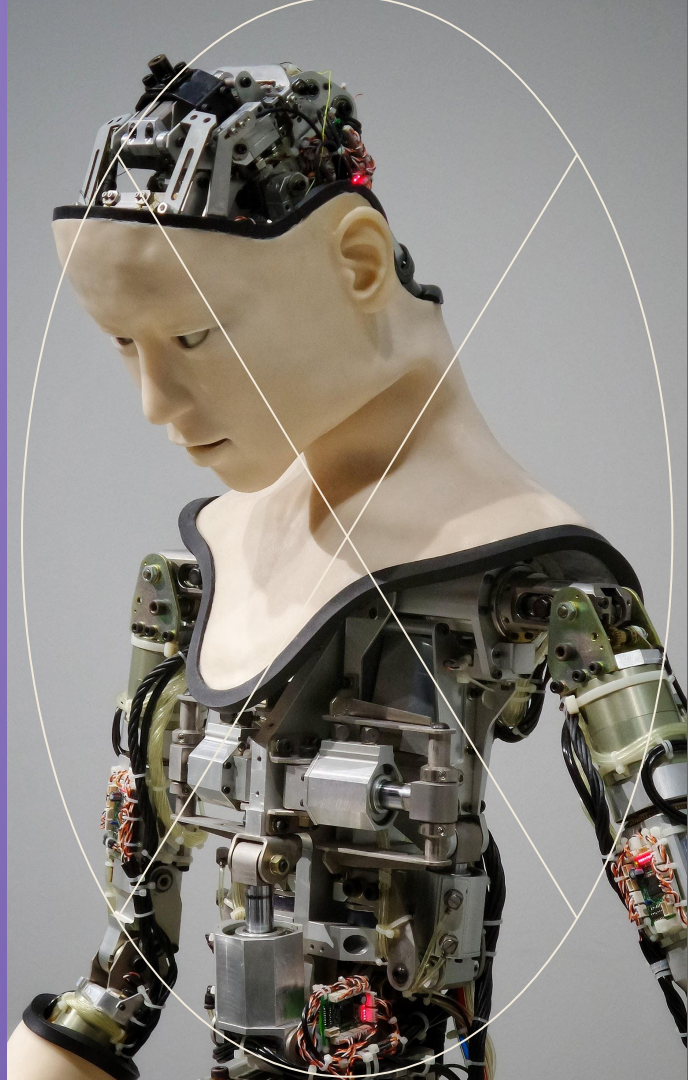
Overview

1. Contribution/Novelty
2. Related Work
3. Methodology
4. Demo Video
5. Results
6. Discussion
7. Limitations and Future Work

Contributions/Novelty

- Better understanding on the perception of non-anthropomorphic robots express emotions
- As this is an elicitation study, better understanding of general user preference for how non-anthropomorphic robots should express emotions.



Related Work

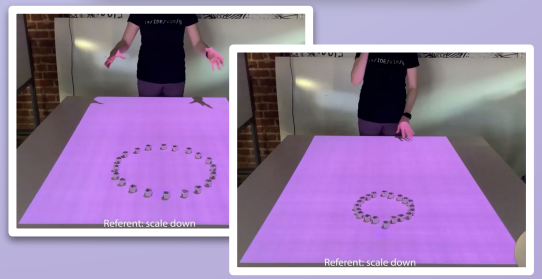
User-Defined Swarm Robot control (2020)

Covers the challenges of human control over robot swarms and the need for user-defined interaction methods.

Non-anthropomorphic, elicitation study.

Diff: Gesture control vs robot motion

Lawrence H. Kim, Daniel S. Drew, Veronika Domova, and Sean Follmer. 2020. User-defined Swarm Robot Control. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20). Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3313831.3376814.



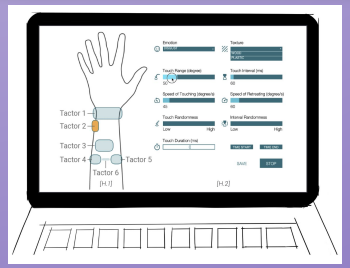
EmotiTactor: Exploring How Designers Approach Emotional Robotic Touch

Developed a platform for designers to program emotional haptic cues.

Non-anthropomorphic, elicitation study.

Diff: Haptic feedback vs robot motion

Ran Zhou, Harpreet Sareen, Yufei Zhang, and Daniel Leithinger. 2022. EmotiTactor: Exploring How Designers Approach Emotional Robotic Touch. In Designing Interactive Systems Conference (DIS '22). Association for Computing Machinery, New York, NY, USA, 1330–1344. https://doi.org/10.1145/3532106.3533487



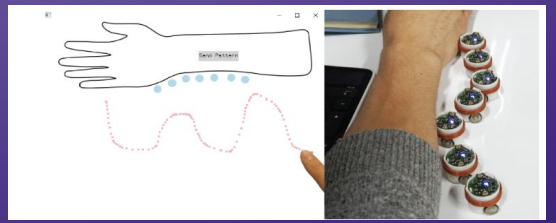
SwarmHaptics: Haptic Display with Swarm Robots (2019)

Elicitation study on how users can communicate with swarm robots using touch

Non-anthropomorphic, elicitation study.

Diff: Swarm robot vs single robot

Lawrence H. Kim and Sean Follmer. 2019. SwarmHaptics: Haptic Display with Swarm Robots. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (CHI '19). Association for Computing Machinery, New York, NY, USA, Paper 688, 1–13.https://doi.org/10.1145/3290605.3300918.



Study Procedure

Preparation

- Study Explanation
- Exploration Period

8 emotions in randomized order:

Motion Design Period

VideoTape Final Motion
Also collect metric data of Toio

Self -Reflection Questionnaire

Exit Questionnaire
Overall experience

Self-reflection Questionnaire

- ❏ “I understand <*emotion*> very well

  ○ Strongly Disagree ○ Disagree ○ Neutral ○ Agree ○ Strongly Agree

- ❏ “I am confident that the Toio can convey <*emotion*> via the movement that I designed”

  ○ Strongly Disagree ○ Disagree ○ Neutral ○ Agree ○ Strongly Agree

- ❏ “The robot's movement aligned well with my ideas for how to convey <*emotion*>”

  ○ Strongly Disagree ○ Disagree ○ Neutral ○ Agree ○ Strongly Agree

- ❏ “How would you describe the types of movements you used for <*emotion*>?”
  Short answer

Exit Questionnaire

- ❏ “Overall, how satisfied are you with the robot's ability to convey emotions?”

  ○ Strongly Disagree ○ Disagree ○ Neutral ○ Agree ○ Strongly Agree

- ❏ “Which emotion(s) did the robot portray most effectively?”

  ☐ Joy ☐ Fear ☐ Sadness ☐ Anger
  ☐ Trust ☐ Surprise ☐ Disgust ☐ Anticipation

- ❏ “Which emotion(s) did the robot portray least effectively?”

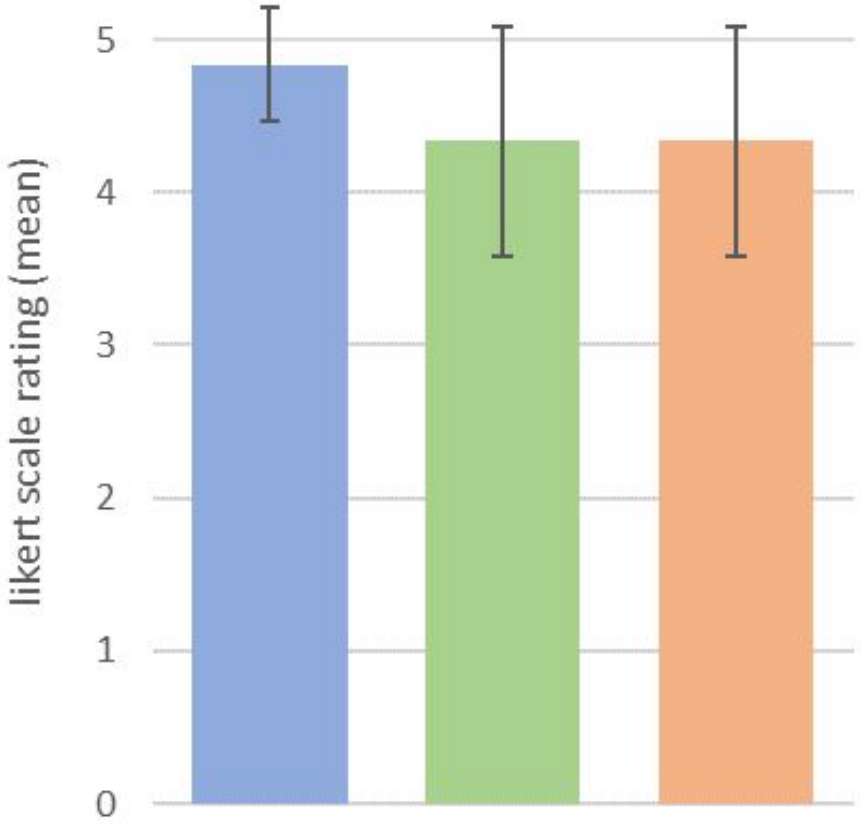
  ☐ Joy ☐ Fear ☐ Sadness ☐ Anger
  ☐ Trust ☐ Surprise ☐ Disgust ☐ Anticipation

- ❏ “Do you have any additional comments or feedback about your experience with the robot's emotion portrayal?”
  Short answer

Results

Anger

	I understand anger very well.
	I am confident that the Toio can convey anger via the movement that I designed.
	The robot's movement aligned well with my ideas for how to convey anger.



Anger

Quantitative:

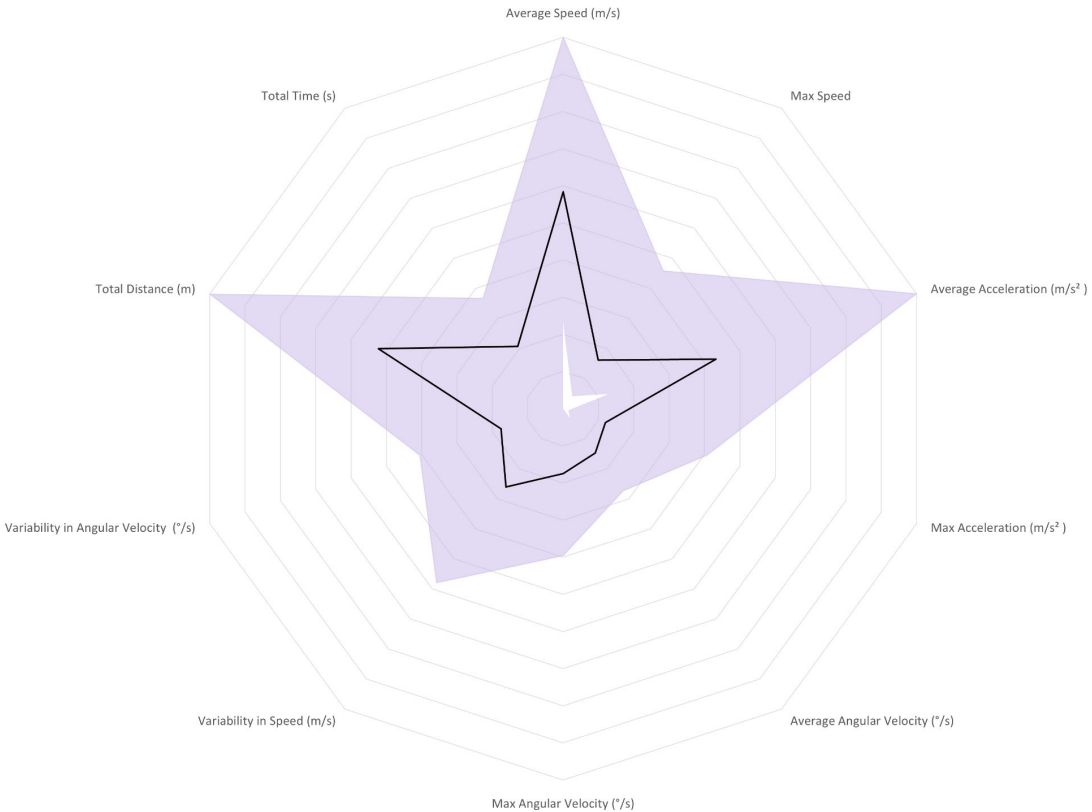
High average speed and acceleration

Low angular velocity

Covered a large distance in a short period of time

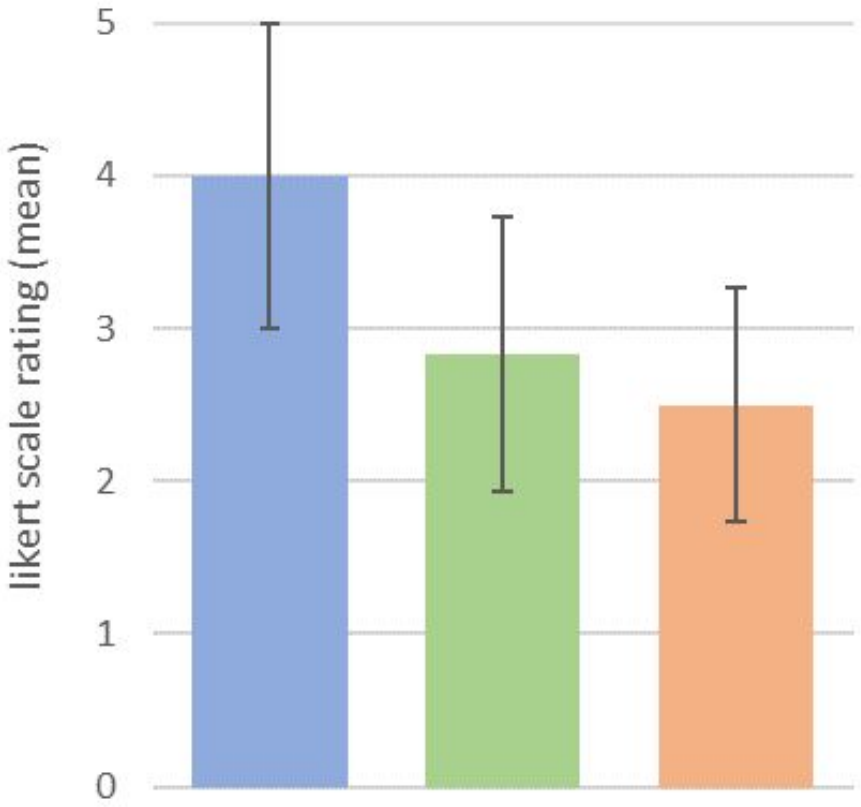
Qualitative:

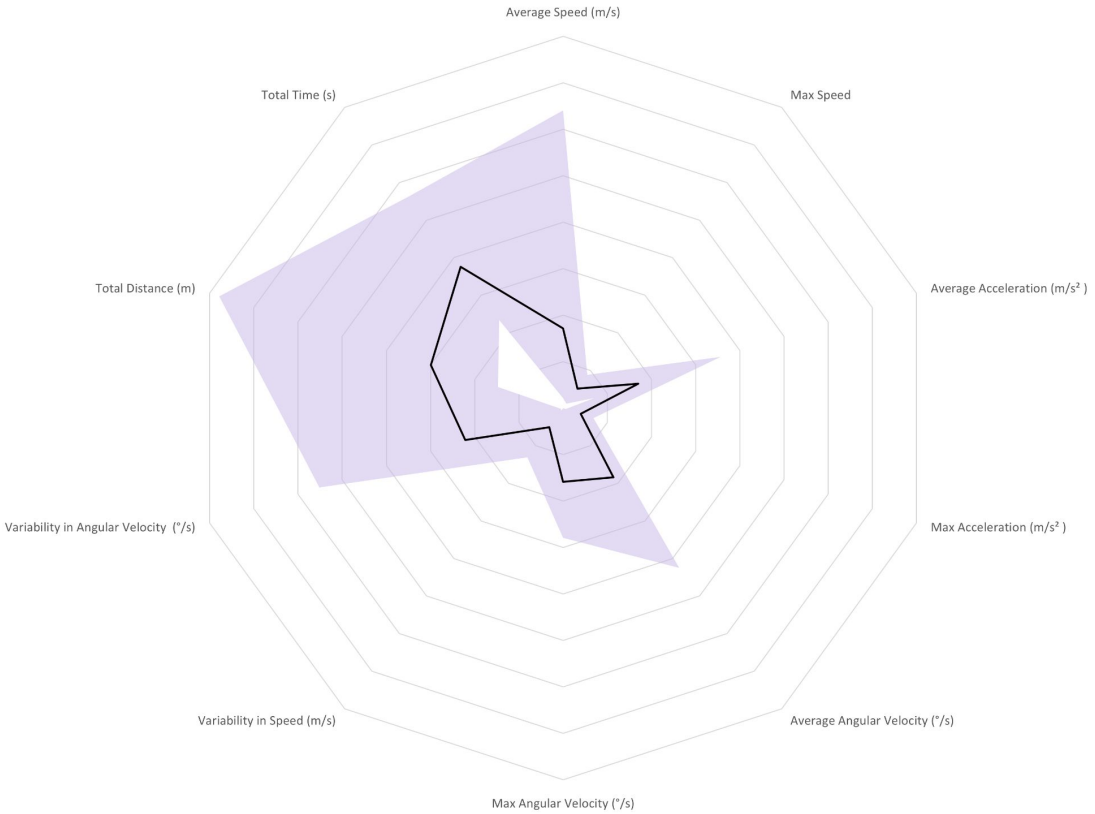
Sudden fast (Shaky", "back and forth", "zig zag", "attacking") movements towards participant/camera



Anticipation

	I understand anticipation very well.
	I am confident that the Toio can convey anticipation via the movement that I designed.
	The robot's movement aligned well with my ideas for how to convey anticipation.





Anticipation

Quantitative:

Low variability in speed

High variability in angular velocity

Low max speed

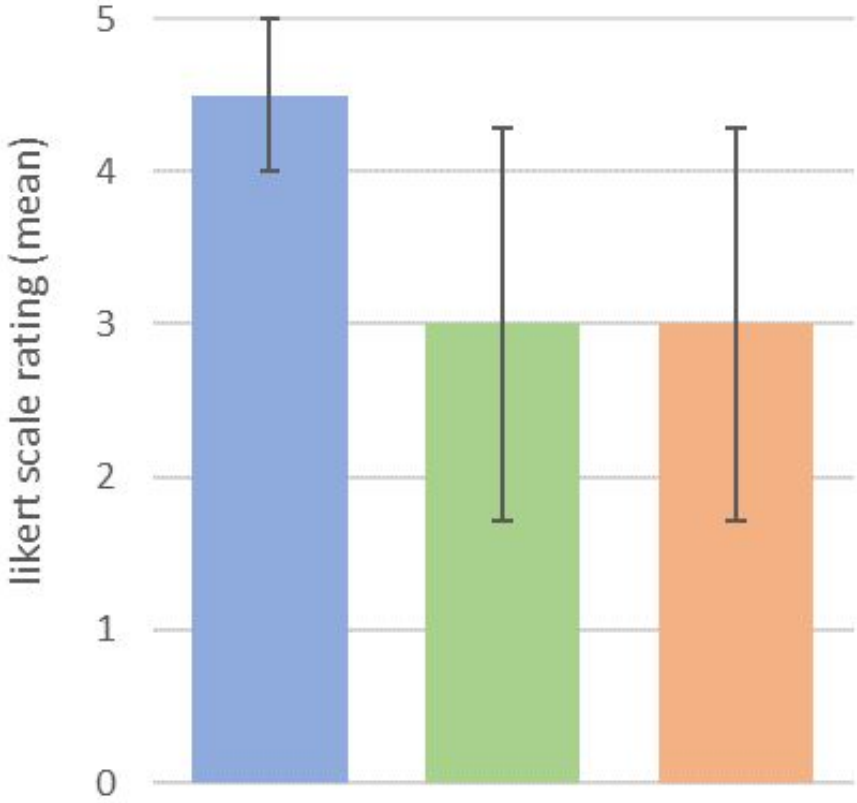
Qualitative:

Back and forth or circular movement

Different participants associated anticipation with different speeds

Disgust

	I understand disgust very well.
	I am confident that the Toio can convey disgust via the movement that I designed.
	The robot's movement aligned well with my ideas for how to convey disgust.



Disgust

Quantitative:

High max speed and acceleration

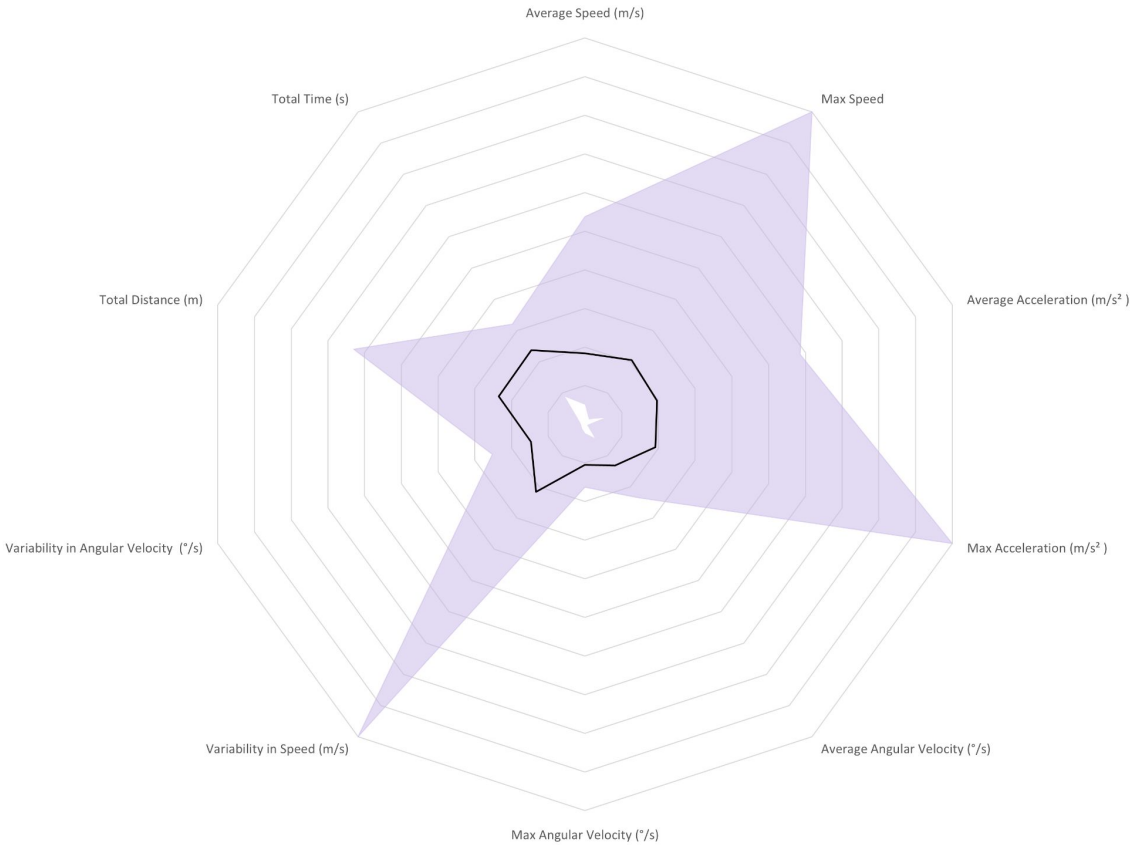
High variability in speed

Large differences between max mean

Qualitative:

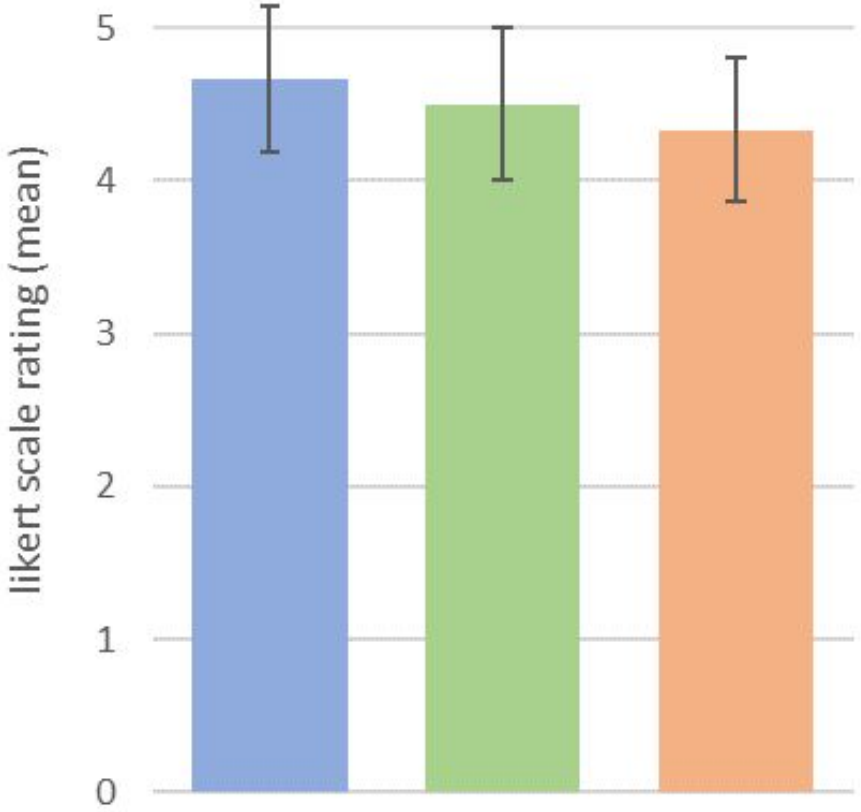
Movement away from participant/camera

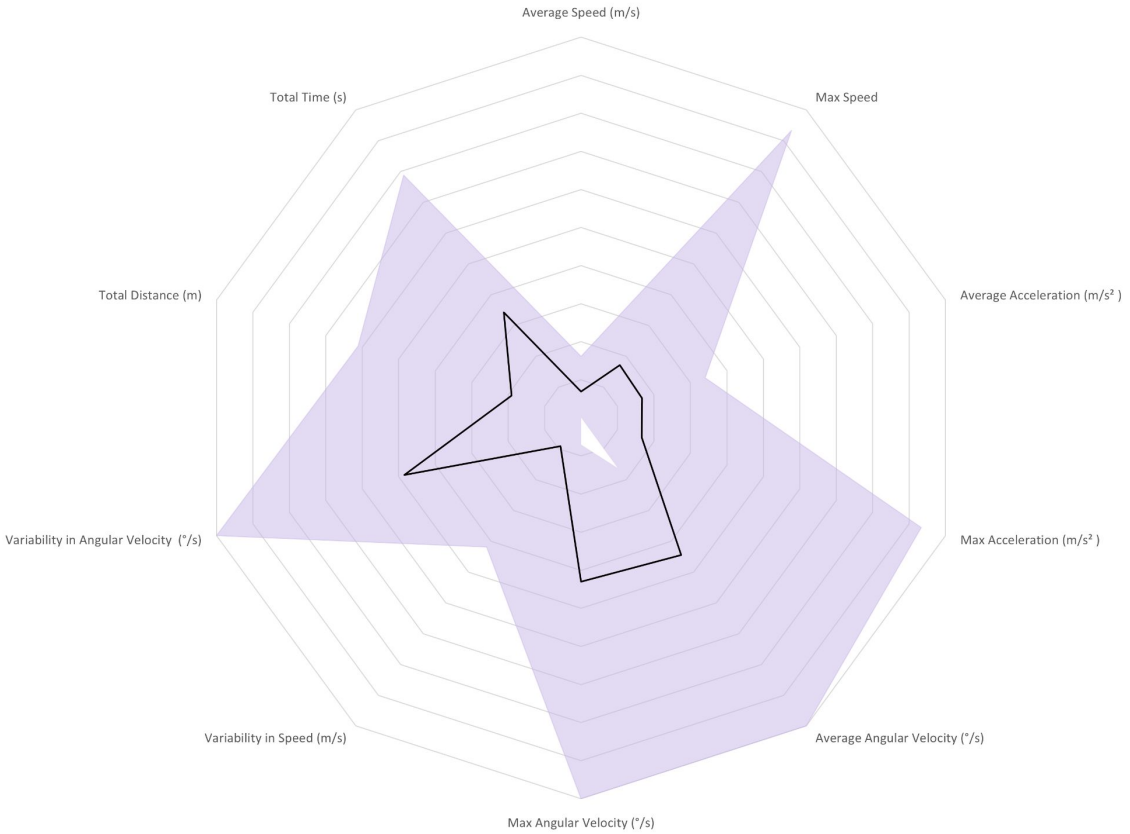
Some participants combined approaching and moving away



Fear

	I understand fear very well.
	I am confident that the Toio can convey fear via the movement that I designed.
	The robot's movement aligned well with my ideas for how to convey fear.





Fear

Quantitative:

High angular velocity

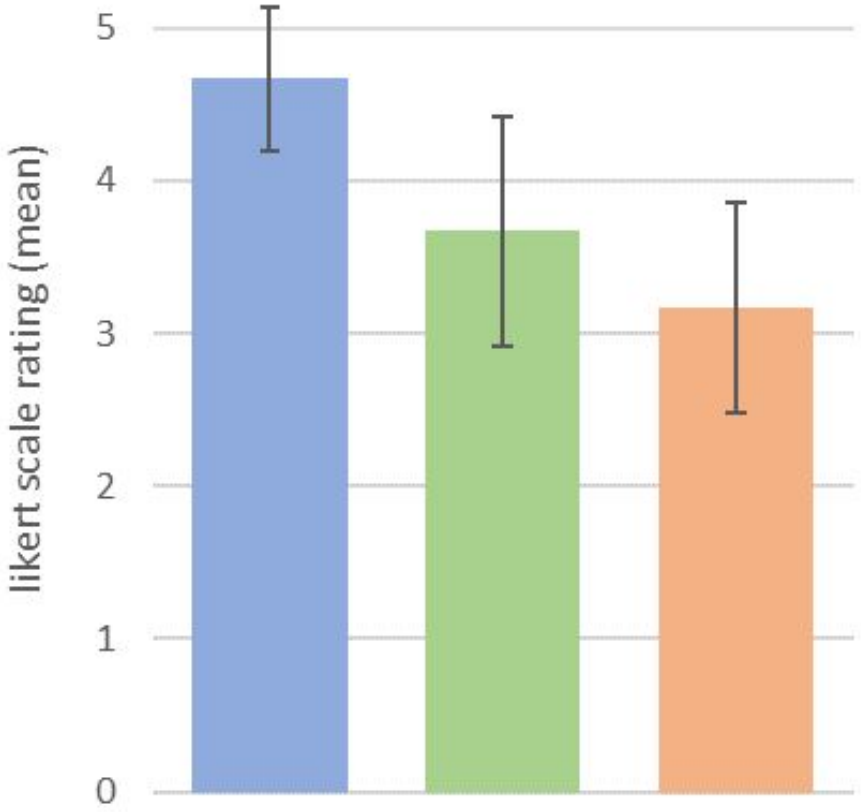
Larger differences between max and mean for acceleration and speed

Qualitative:

Shaking and trembling movements away from the participant/camera

Joy

	I understand joy very well.
	I am confident that the Toio can convey joy via the movement that I designed.
	The robot's movement aligned well with my ideas for how to convey joy.



Joy

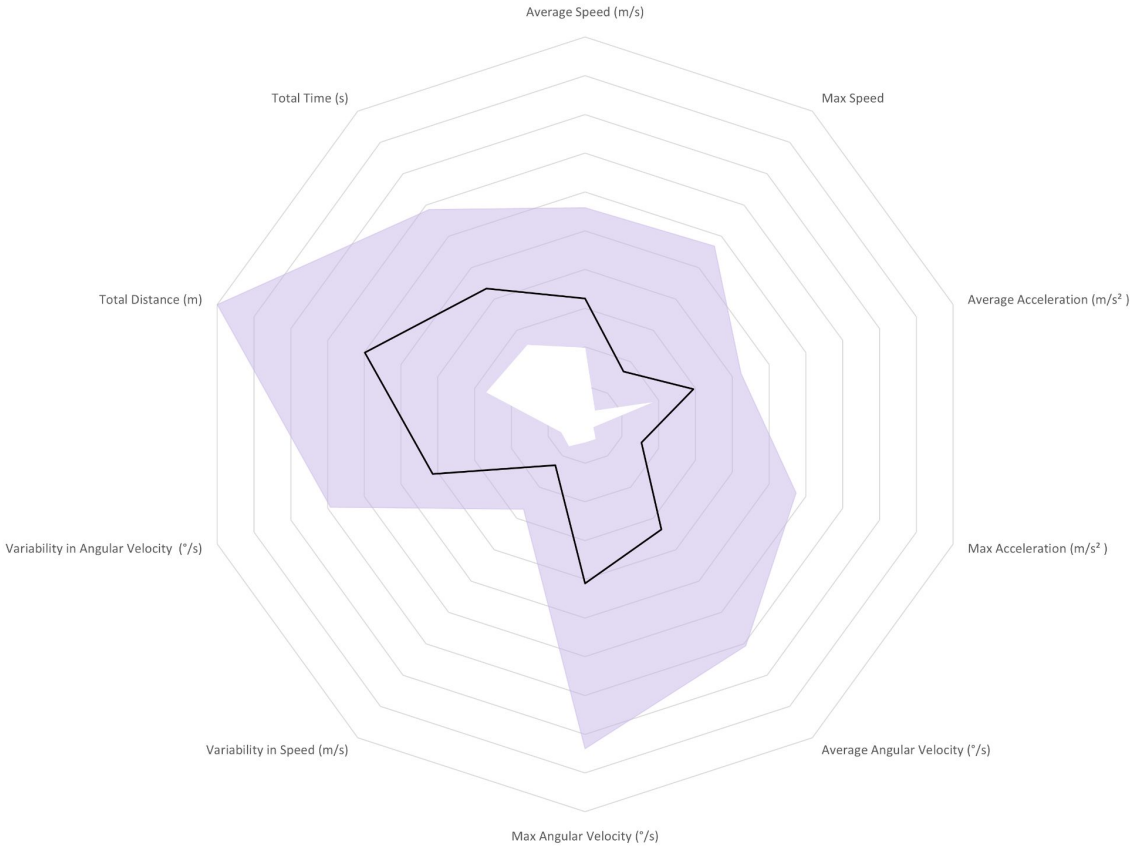
Quantitative:

High max angular velocity

More consistent results between the mean and max values

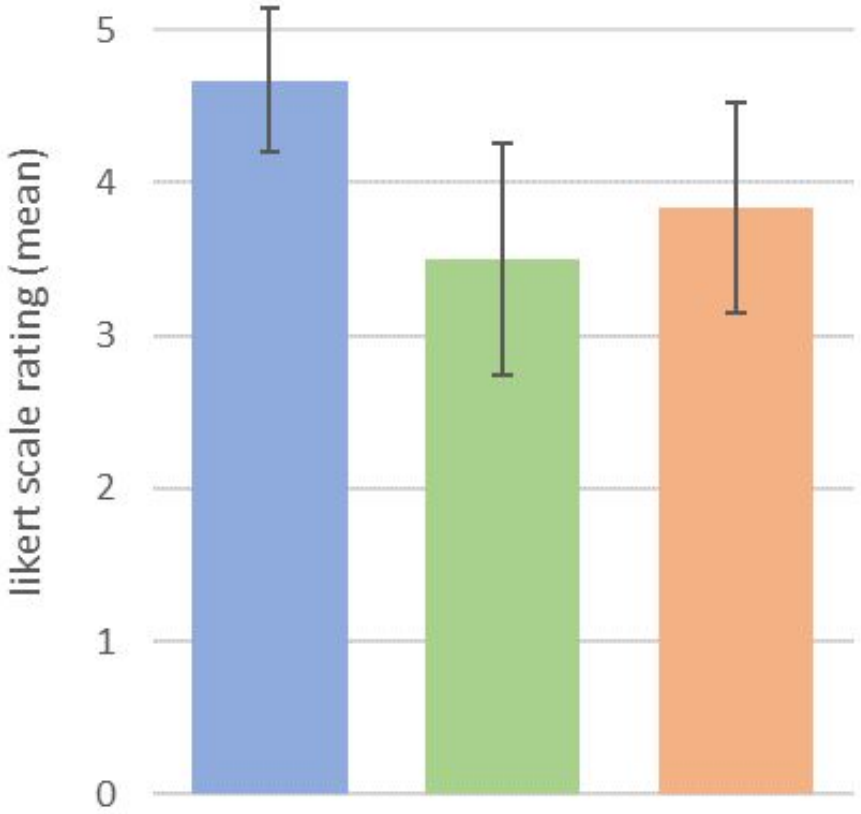
Qualitative:

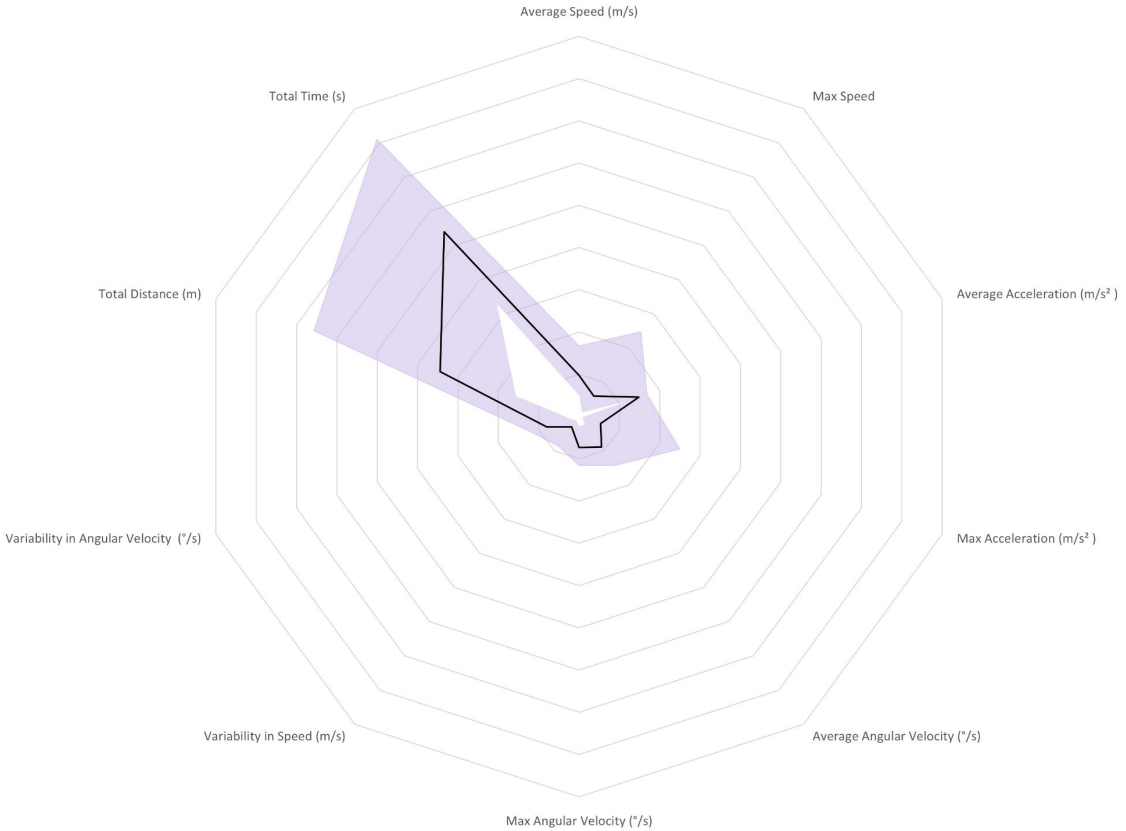
Fast movements often described with dance-related words (“twirling, “circular”, “zigzag”)



Sadness

	I understand sadness very well.
	I am confident that the Toio can convey sadness via the movement that I designed.
	The robot's movement aligned well with my ideas for how to convey sadness.





Sadness

Quantitative:

High distance and time but low speed and acceleration on both measures

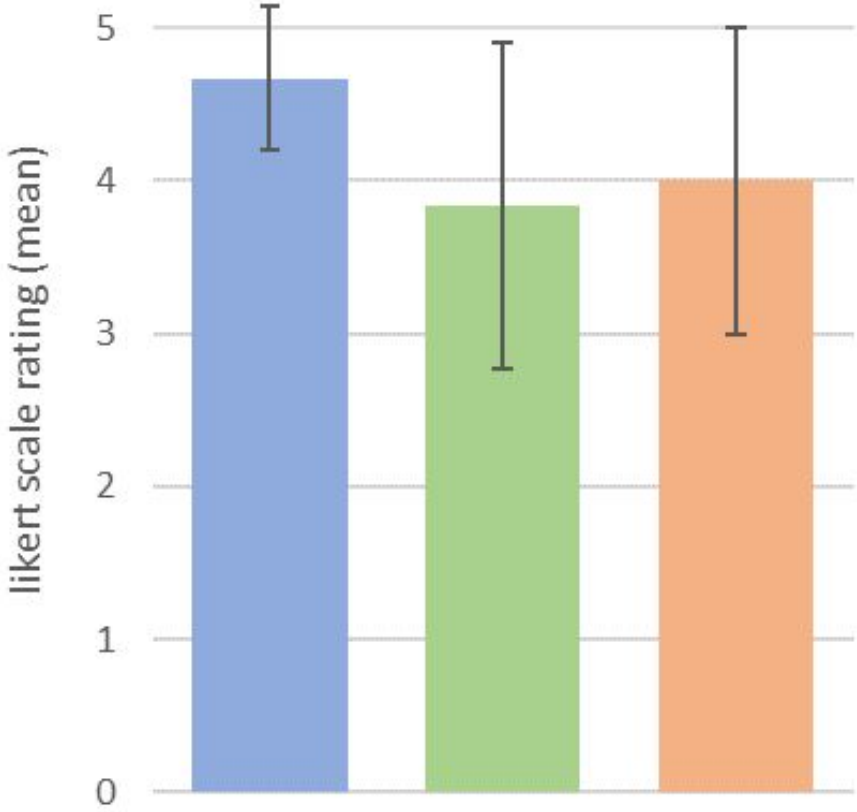
Range between minimum and maximum values is small

Qualitative:

Slow movements, swaying side-to-side away from the participant/camera

Surprise

	I understand surprise very well.
	I am confident that the Toio can convey surprise via the movement that I designed.
	The robot's movement aligned well with my ideas for how to convey surprise.



Surprise

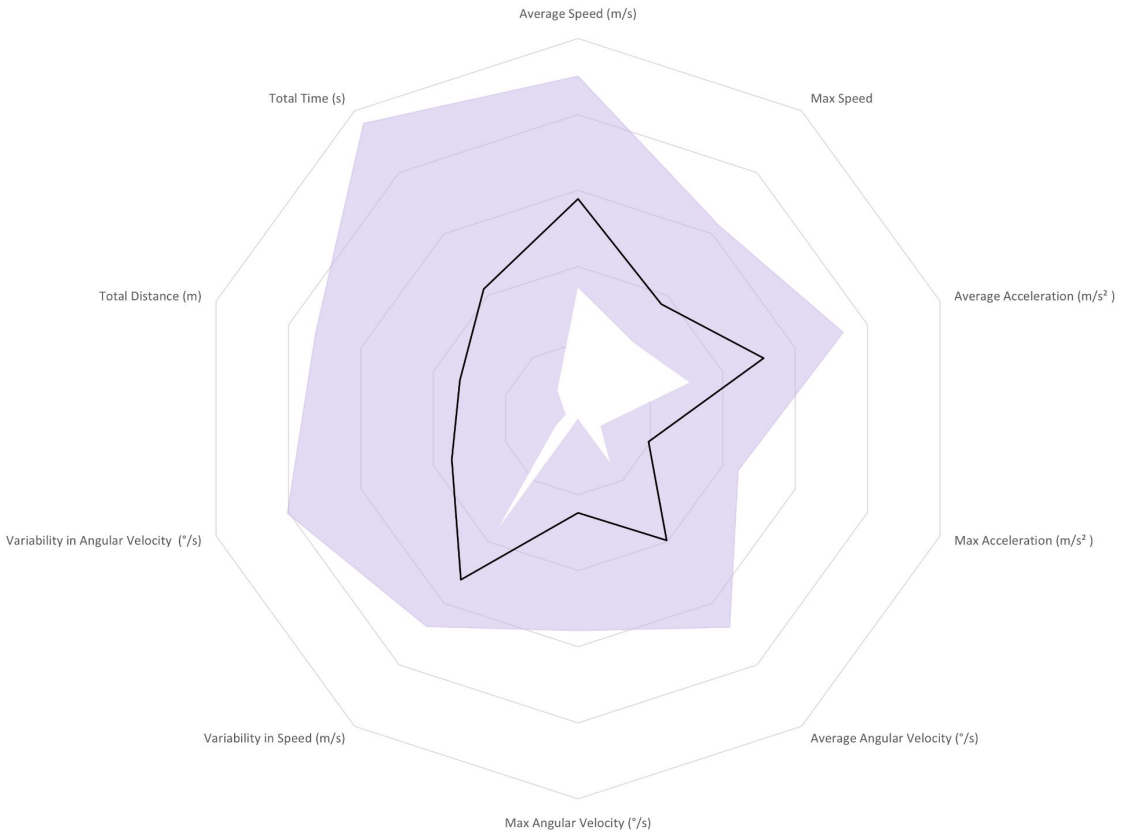
Quantitative:

Consistently high variability in speed

Larger minimums for average speed and acceleration

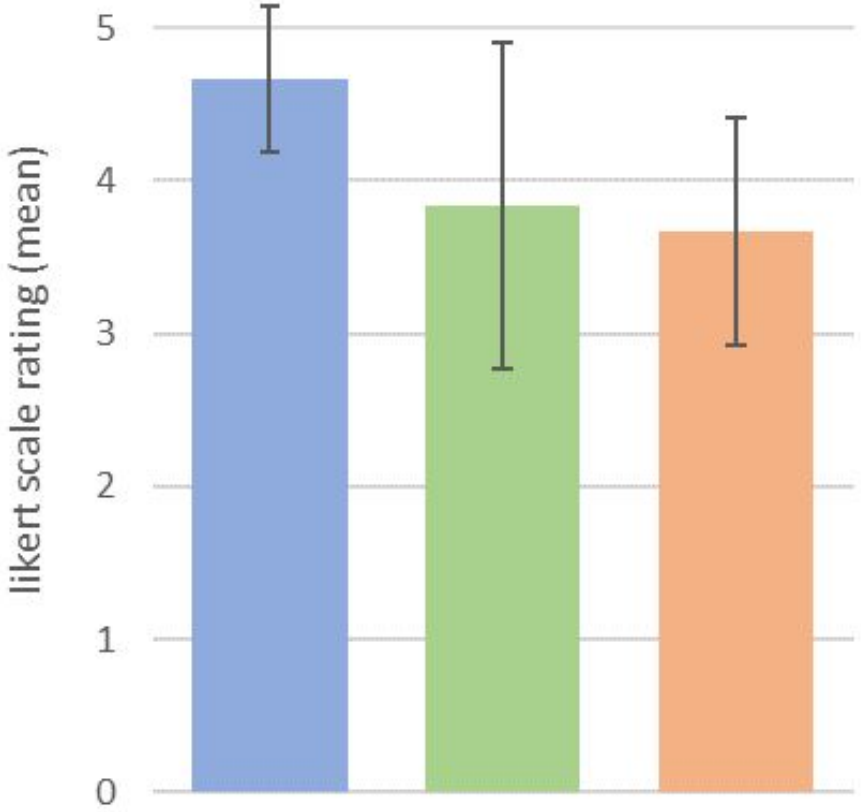
Qualitative:

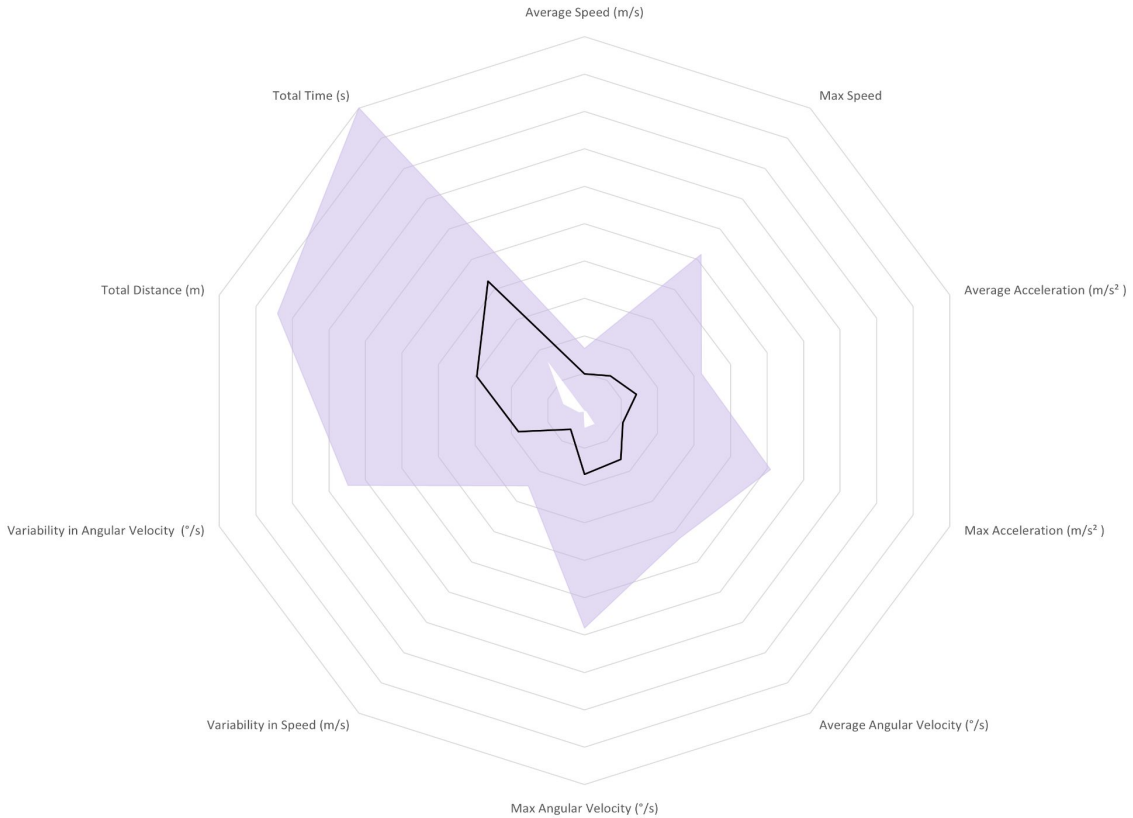
Short (“jerky”, “side-to-side”) burst of movement away from the participant/camera



Trust

	I understand trust very well.
	I am confident that the Toio can convey trust via the movement that I designed.
	The robot's movement aligned well with my ideas for how to convey trust.





Trust

Quantitative:

Low average speed

Distance covered and time

Qualitative:

Slow movements towards the participant/camera often close to or directly touching the participant's hand.

Emotion Taxonomy

Joy Fast movements often described with dance-related words (“twirling, “circular”, “zigzag”)	**Trust** Slow movements towards the participant/camera often close to or directly touching the participant’s hand.	**Fear** Shaking and trembling movements away from the participant/camera
Surprise Short (“jerky”, “side-to-side”) burst of movement away from the participant/camera	**Emotion in Motion**	**Sadness** Slow movements, swaying side-to-side away from the participant/camera
Disgust Movement away from participant/camera Some participants combined approaching and moving away	**Anger** Sudden fast (Shaky”, “back and forth”, “zig zag”, “attacking”) movements towards participant/camera	**Anticipation** Back and forth or circular movement Different participants associated anticipation with different speeds

Figure 1: Which emotion(s) did the robot portray **most** effectively?

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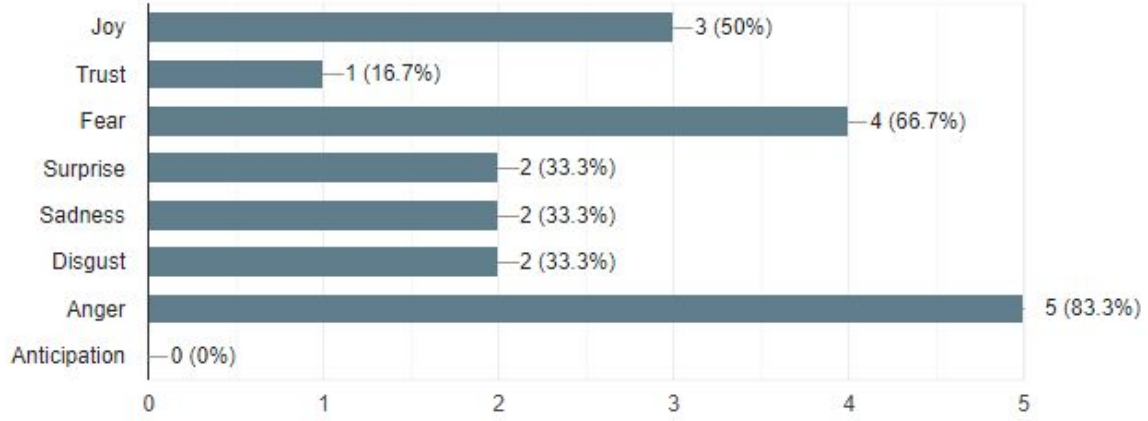
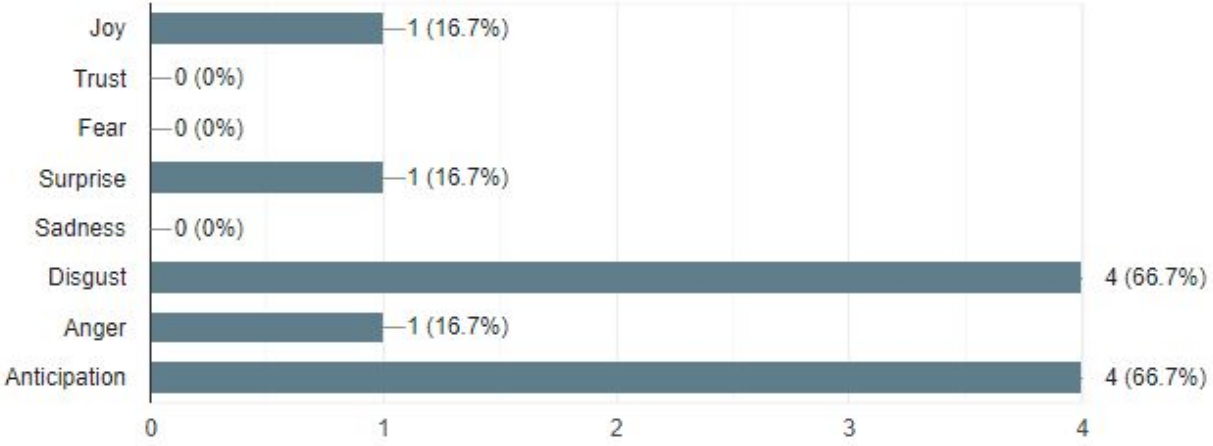
Figure 2: Which emotion(s) did the robot portray **least** effectively?





Discussion

- Most participants said Anger was portrayed the most effectively to model
  - Robot attacking an object (participant's hand, camera etc)
- Least effectively portrayed was Disgust and Anticipation
  - Anticipation can be context dependent (slow and fast)
- Participants used physical proximity from themselves/camera to provide context to the emotion
  - User Defined Swarm Robot Control had a similar hypothesis and found a significant effect
  - Possible area of exploration in our study
- Participants found the Toio to have very limited emotional expression capabilities
  - Wanted more communication modalities (e.g., a head, sound) and 3D movements (e.g., jumping for joy and surprise)

Limitations

- LImited number of participants (Six in total)
- Simple form of robot and limited 2D movement (affects generalizability)
- Our study did not account for cultural differences
- Sampling bias (Participants were mostly recruited from class)
- Researcher bias (researchers should ideally not be participants in their own research)

Future Work

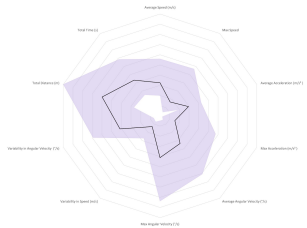
- Conduct a replication study with a larger sample size and a more diverse range of participants
- Conduct a study with multiple robots
- Utilize a dimensional model to portray the emotions conveyed by the Toio rather than a categorical model
- Would participants model emotions differently if they could model it via manual control vs. remote control?

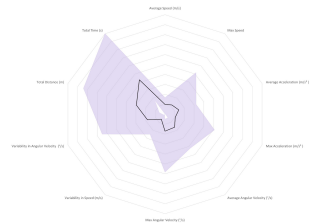
Thank You!

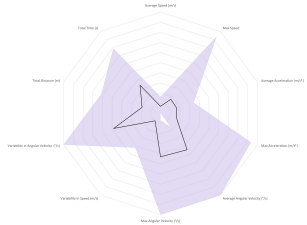
Questions?

Trust

Joy

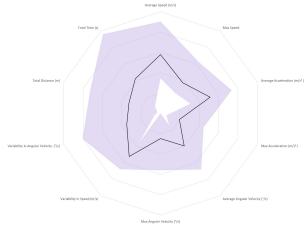




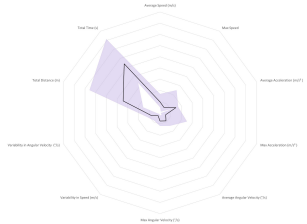


Fear

Surprise

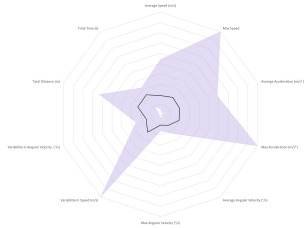


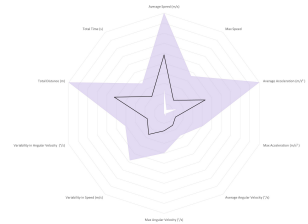
Emotion in Motion

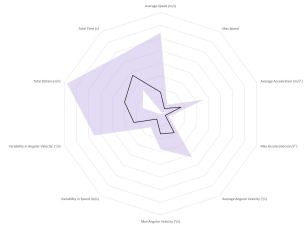


Sadness

Disgust







Anticipation

Anger