Neural Signatures of Trust in Human-Robot Collaboration: A Tale of Two Use-Cases

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Background

At present
- Manufacturing encompasses 12% of US economy
- Traditional assembly lines are either manual or completely automated

HRC allows for
- Improved team fluency with complementary skill set
- New possible interaction modes and collaboration

Challenges
- Improved teaming requires human factors considerations, such as trust
- Operator safety is critical as robots are not 100% reliable

Strictly separated robot workspace

Part of the workspace is shared

Workspaces are full shared

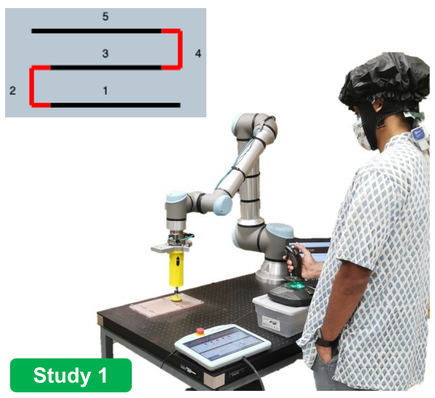
Level of Human Robot Collaboration

Methods

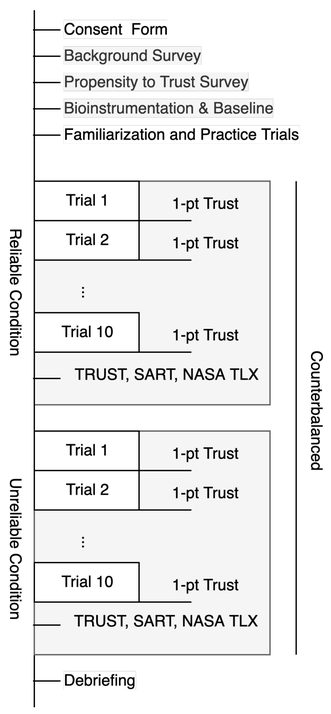
Participants
- Sixteen (age 25.12 ± 3.31 years) and thirty-eight (age 25.37 ± 5.7 years) subjects in study 1 and 2
- Both the studies were approved by the local IRB (IRB2020-0097DCR and IRB2020-0432F)

Experimental Task 1
- S-shaped metal surface polishing task
- 3-axis end effector control using joystick
- Autonomous takeover during turns

Perturbations include
- Reduction in speed
- Loss of surface contact
- Joystick command stops
- Straight turn by automatic control



Experimental protocol

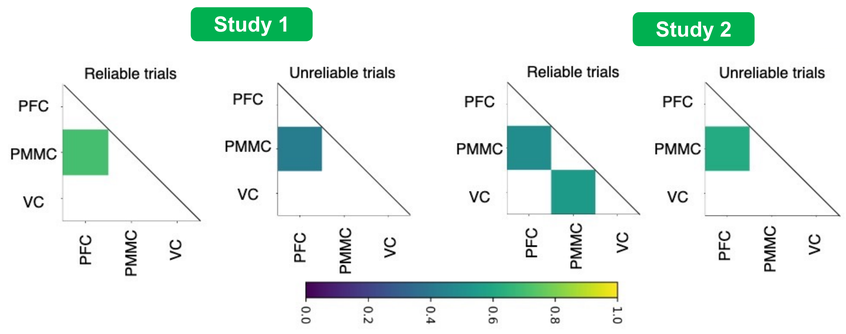


Experimental Task 2
- Planetary gear assembly task
- The robot delivers parts in sequence of assembly

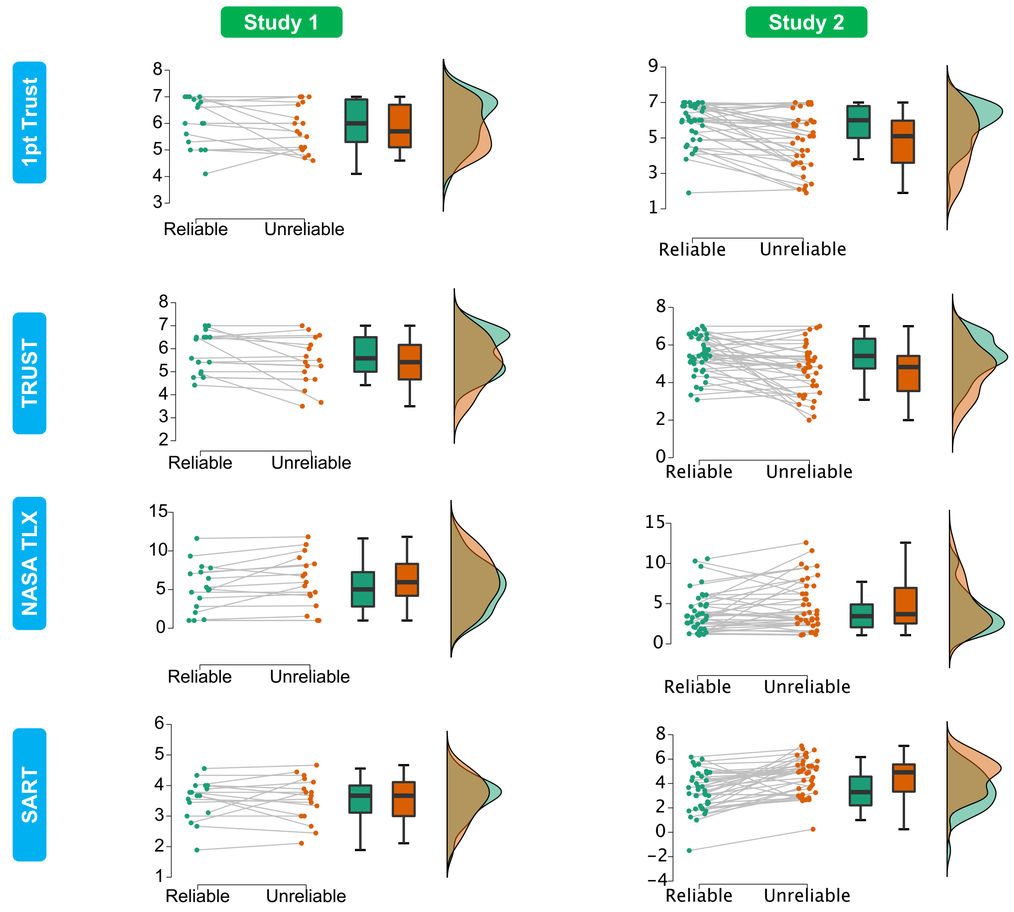
Perturbations include
- Sudden change in speed
- Wrong delivery sequence
- Invasion of human space

Results

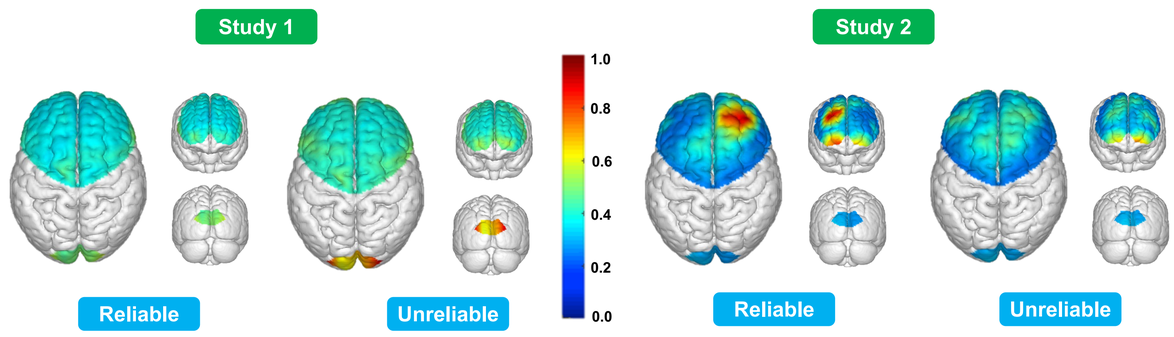
Functional connectivity



Subjective Responses



Brain Activations



Heart Rate Variability

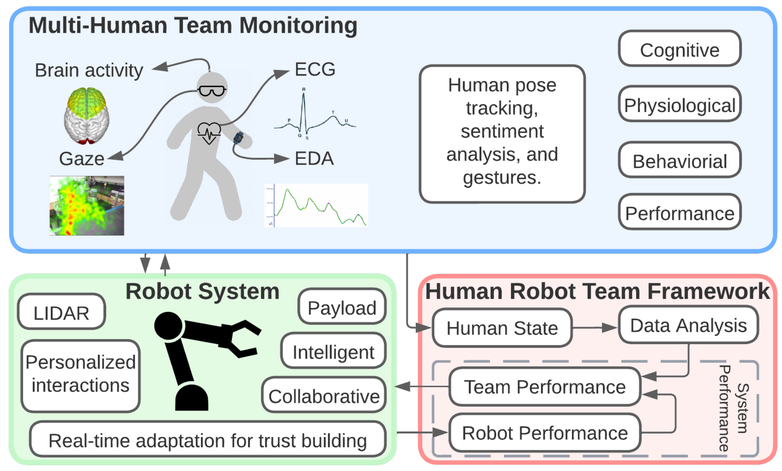
Study 1
- $RMMSD_{reliable} < RMMSD_{unreliable}$
- $HF_{reliable} < Hf_{unreliable}$
- $LF_{reliable} < Lf_{unreliable}$
- Mean $HR_{reliable}$ > Mean $HR_{unreliable}$

Study 2
- No significant difference was observed in study 2

Key takeaways

- Subjective response were similar in both the studies
- Perturbations in robot trajectory was able to induce distrust in the robot
- Different neural mechanisms were active due to the inherent task difference
- Subjective responses belies the internal state of the human. They did not change with change in neural activity.
- HRV can only resolve trusting attitudes in relatively static tasks.

Future work: closed loop robot adaptation



Acknowledgements

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References and online resources