

The Effects of Proactive Release Behaviors During Human-Robot Handovers

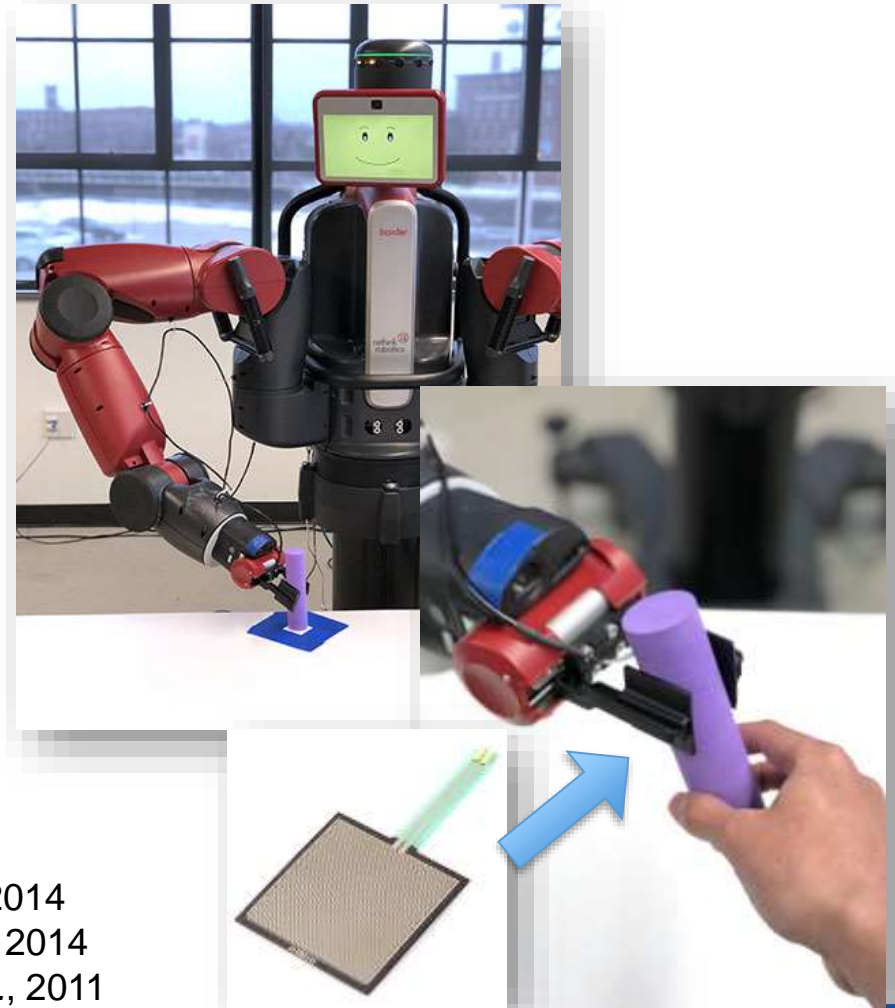
Zhao Han, Holly Yanco

University of Massachusetts Lowell



Robot to Human Handover

- Focus on release
- In all conditions:
 - Natural arm movement
 - Gazes at the object^{1,2}
 - Grasps the top part of the object³
 - Arm is extended as much as possible³



1. Moon *et al.*, 2014
2. Admoni *et al.*, 2014
3. Cakmak *et al.*, 2011

Robot to Human Handover

- Focus on release
- In all conditions:
 - Natural arm movement
 - Gazes at the object^{1,2}
 - Grasps the top part of the object³
 - Arm is extended as much as possible³

1. Moon *et al.*, 2014
2. Admoni *et al.*, 2014
3. Cakmak *et al.*, 2011



Motivation

- Three phases during a handover¹



- Transfer phase is vital
 - Failure has severe consequences
 - Dropped and broken², which may hurt people
 - Bad experience³
 - Least studied

1. Strabala *et al.*, 2013
2. Chan *et al.*, 2013
3. Cakmak *et al.*, 2011

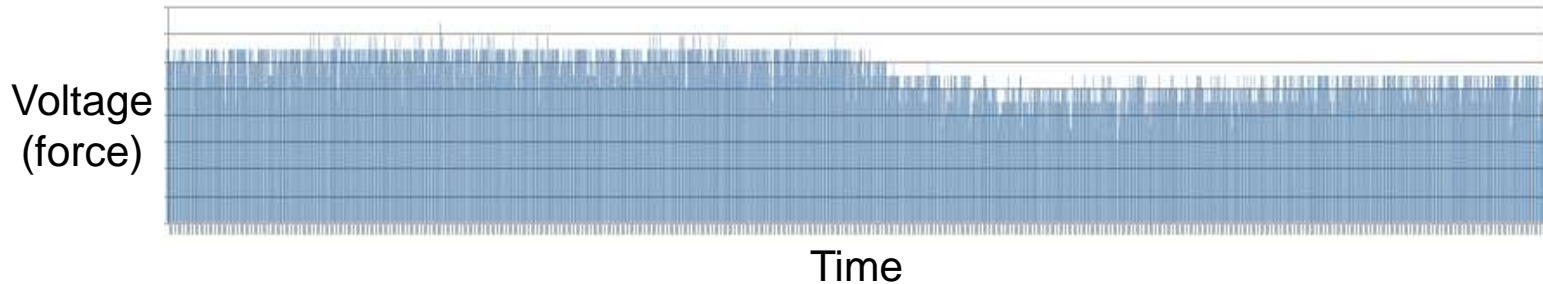
Three Release Behaviors

- **Rigid**
 - Release when arm is extended
 - By checking a force threshold
- **Passive**
 - Can be released after partial extension
 - By checking the same force threshold
- **Proactive**
 - Can be released after partial extension
 - By checking a force change pattern



Proactive Release

- Sample force pattern during a grasp



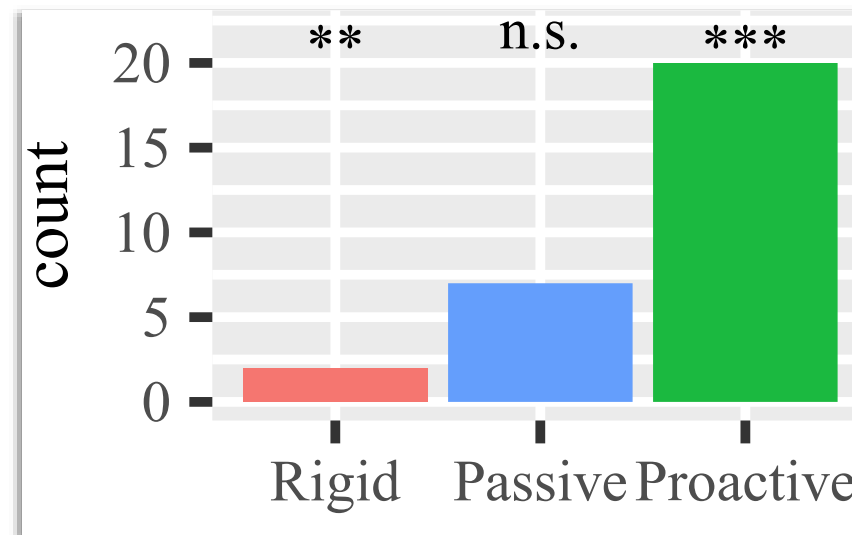
- Implementation: moving average
 - 90 windows of averaged data
 - 1 window: 180 voltage values
 - Release when 35% is decreasing

Methodology

- Within subjects
- Full counterbalancing
- 36 participants
 - 21 male, 15 female
 - Age ranged from 18 to 57 (M=29, SD=12)
- Data collection
 - Task completion time: logged
 - Additional timing: coding videos frame by frame
 - Subjective measures: Likert scale questionnaire

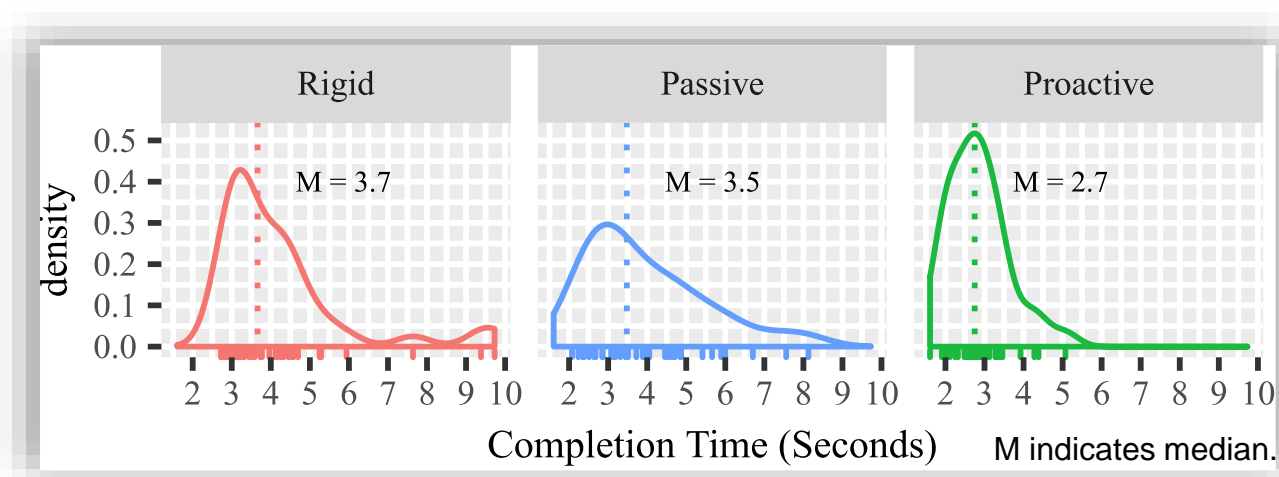
Preference

- Among 29 participants who explicitly stated a single preference, 20 participants preferred **proactive**.



Handover Efficiency

- Completion time (one second less in **proactive**)



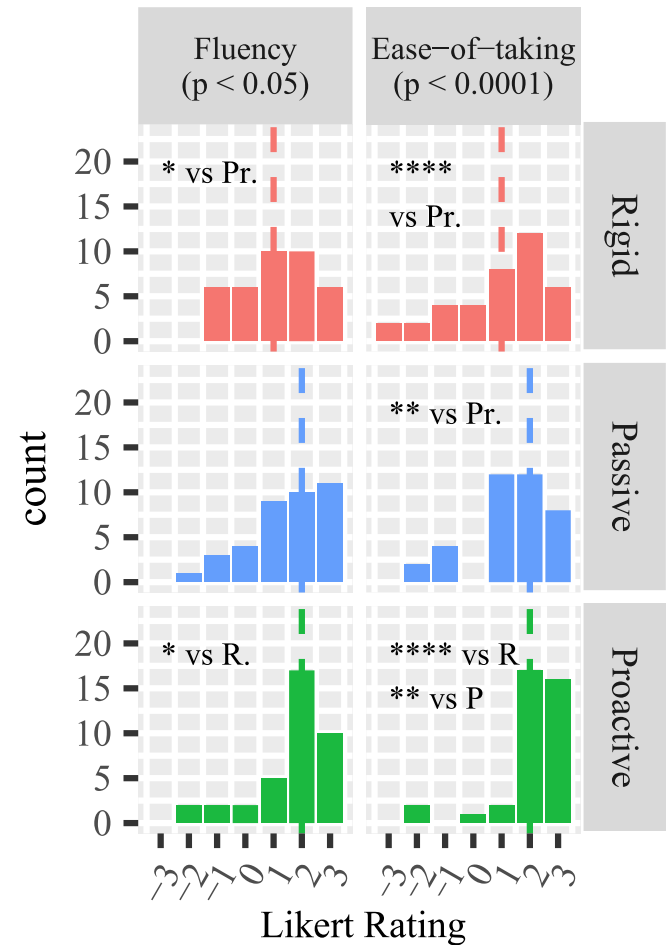
- Release duration

1.3 vs 1.2 vs 0.5 (seconds)

(**rigid** vs **passive** vs **proactive**)

Overall Experience Improved

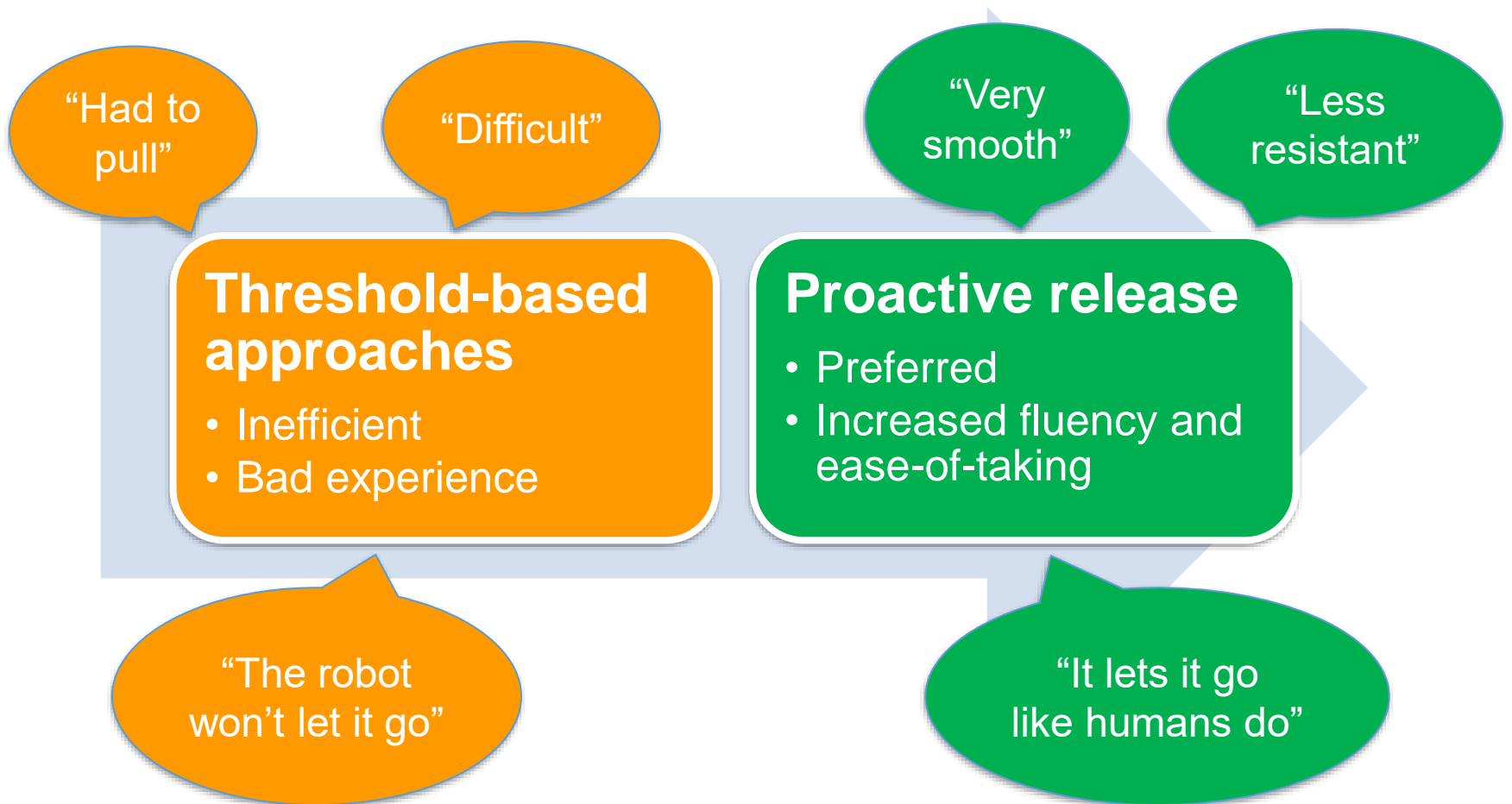
- Significant differences
 - Fluency (*)
 - Ease-of-taking (***)
- Trends
 - Trust ($p=0.05$)
 - Capability ($p=0.06$)
- No detectable difference
 - Discomfort



Why is Proactive Better?

- To take the object
 - People don't need to pull
 - They simply hold or touch
- People grasp differently in different trials
 - The fixed force threshold is not flexible
 - The decreasing pattern is still present

Takeaways



Thanks!

- **Zhao Han:** zhan@cs.uml.edu
- **UMass Lowell HRI Lab:** robotics.cs.uml.edu
- **Code:** github.com/uml-robotics/handover_moveit
- The Effects of Proactive Release Behaviors During Human-Robot Handovers