

Expressive motion aids seamless interaction

Expressive motion: a robot's ability to communicate mental state, social context, and task state via body movements.

Humans naturally pick up on the body language of others and are then able to infer their internal states. If robots could use human-readable motion to express their "inner states":

- People could be able to detect when a robot is lost, concerned about a collision, or needs to recalculate its path.
- People could bond more with robots, find their motion more humanlike and therefore easier to interpret, or have a favorite robot based on its personality.

We adapt expressive motion from theater

The present study focuses on the temporal characteristics of a robot's path. We use the CoBot platform, pictured below.

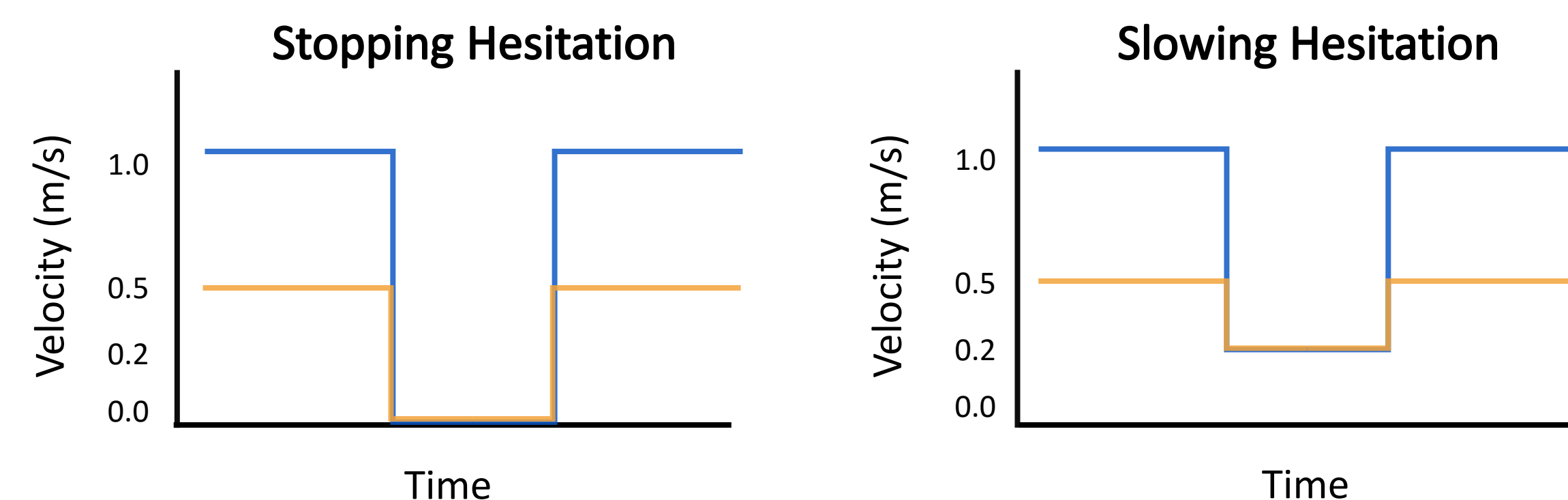


Figure 1. Participant views CoBot's motion during pilot study.

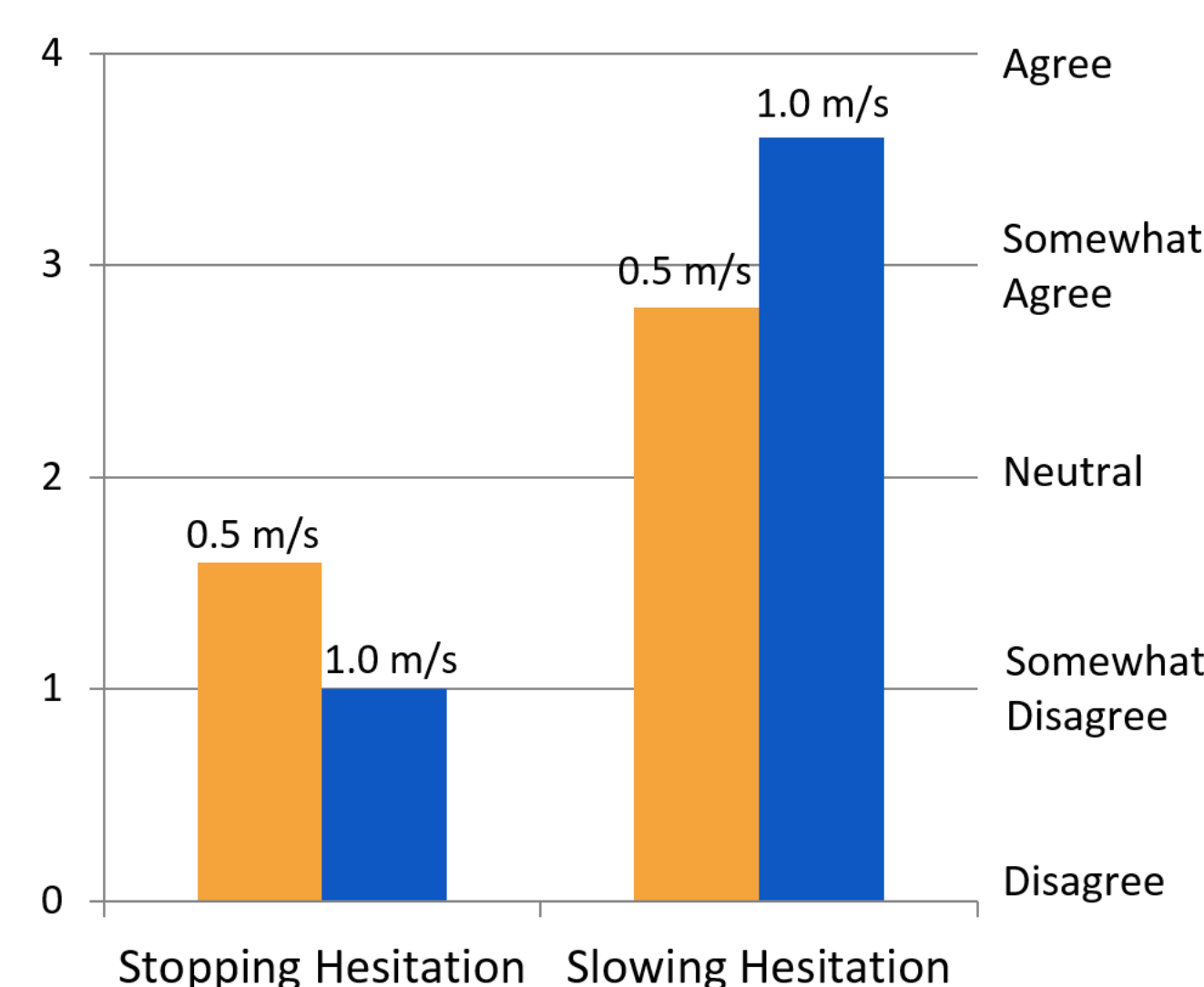
Our implementation is inspired by the Time Effort of the Laban Effort system. The Laban Effort system is used in theater to define and reproduce human motion. Each Effort has two poles:

Effort Vector	Fighting Polarity	Inducing Polarity
Time: attitude toward time	Sudden (abrupt)	Sustained (gradual)
Weight: force or apparent inertia	Strong (powerful)	Light (delicate)
Space: attitude toward target	Direct (single-focus)	Indirect (multi-focus)
Flow: sense of restriction	Bound (constrained)	Free (unconstrained)

Slowing and stopping hesitations tell different stories



Participants rated slowing hesitation more "tentative, unsure, wavering"



Participants described hesitations in an interview:

"Full stop was less unsure—it meant to do that—compared to when it just slowed down."

"Slow down could be a decision-making moment, the robot hesitates to take in its environment."

"The slowing down was more along the lines of timid. The stopping motion was more surprise, 'oh sh*t!'"

Participants viewed paths with varied temporal features

Participants watched the CoBot approach an object of attention ten times. Each approach path had different temporal features. The paths included:

Constant Velocity	Hesitation	Acceleration
0.2 m/s	$V_{max} = 1.0$ m/s, stopping	Accelerate to 1.0 m/s
0.5 m/s	$V_{max} = 0.5$ m/s, stopping	Decelerate to 0.2 m/s
0.75 m/s	$V_{max} = 1.0$ m/s, slowing	
1.0 m/s	$V_{max} = 0.5$ m/s, slowing	

Participants were given a tablet and completed a survey with 6 questions about the robot's motion and attitude after each path and then were interviewed after all paths had been viewed.

Future: Combine hesitations with proxemics

Our pilot results indicate that people have strong reactions to hesitations. In future work, we will explore the impact of varied spatial distance, hesitation duration, and type of relational object in combination with slowing and stopping hesitations.



Figure 2. Setup for pending study. The CoBot on the left hesitates as the other rotates toward it.

Type of hesitation: We will continue to explore the impacts of slowing and stopping hesitations.

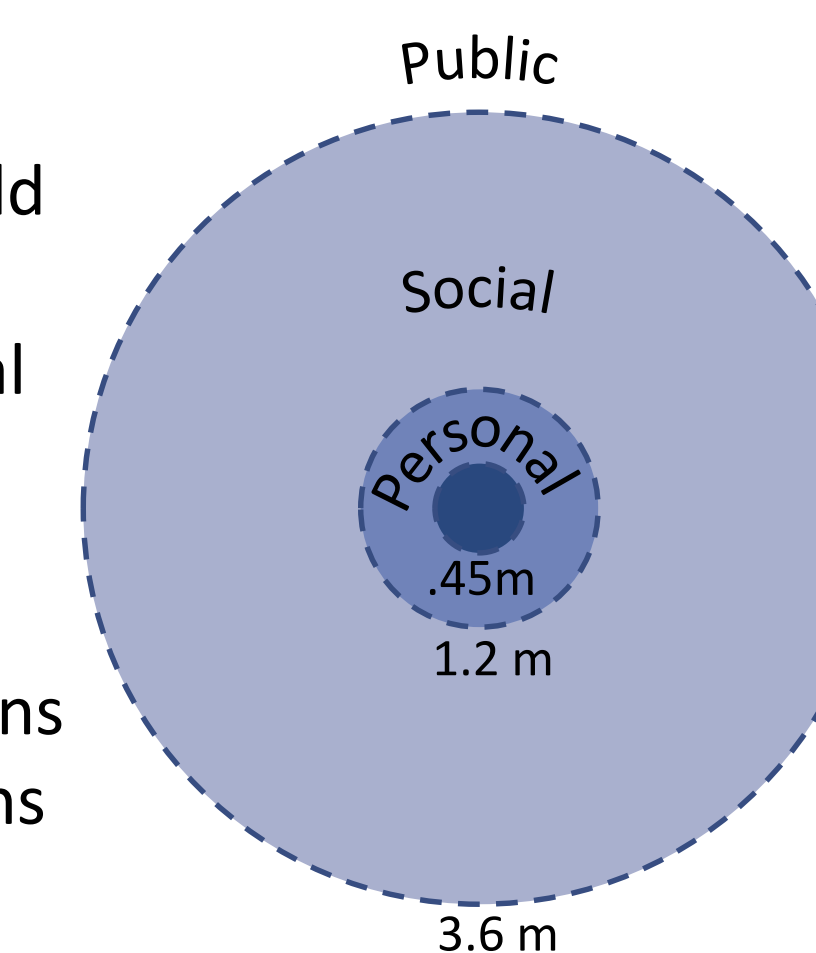
Spatial distance: Proxemics is a field that enumerates normal social distances. We plan to explore social and asocial zones.

Hesitation duration: We will implement brief and long hesitations based on the duration of hesitations acted out by people.

Relational object: A second CoBot, which the first approaches, will either be stationary or will rotate from facing the wall to facing the first CoBot as the first hesitates (see image above).

Hypotheses:

- Hesitations will be interpreted as a reaction to the second CoBot in the public zone when the second CoBot rotates and in either case when hesitation occurs in the social zone.
- Sudden hesitations will prompt attributions of surprise while sustained hesitations will prompt attributes of tentativeness.
- People will attribute more expressiveness to brief hesitations as compared to long ones.



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References

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2. E. T. Hall, *The Hidden Dimension*, Doubleday, NY, (1966)

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