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### How Degrees of Freedom Affects Sense of Agency

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## Abstract

- Can the rubber-hand illusion be extended to a moving robotic arm in different degrees of freedom (DOF), inducing sense of ownership & agency over the arm?
- Hypothesis:  
DOF closer to what humans possess will result in a stronger sense of ownership and agency

## Introduction

### Rubber Hand Illusion

- Creates false sense of ownership over rubber hand—as though part of participant's body
- Synchronous tactile stimuli concurrently applied to rubber hand & participant's hand
  - Rubber hand placed in front of participant
  - Participant's arm hidden from view
- After a short period of time, spatial mismatches between visual and somatic experience is created (Costantini & Haggard 2007).

### Intentional Binding

- Time between action & outcome perceived as shorter when participant has sense of agency over action (Moore & Haggard 2010)



2. Robotic Arm (WidowX) used for the Experiment



1. Rubber Hand Illusion

## Methods

1. Place participant's arm as in rubber hand illusion
2. Tactile stimuli through squeezing ball using index and thumb—grab of robot arm follows
3. Proprioception is performed using accelerometer & motion tracking system
4. Measure Intentional binding for participant's sense of agency over the robotic arm
5. Questionnaire verifies participant's sense of agency measured by Intentional binding

### Conditions

- **Control:** 1 DOF (squeezing only)
- **Trial 2:** 3 DOF (+wrist pitch/roll)
- **Trial 3:** 4 DOF (+elbow pitch)
- **Trial 4:** 6 DOF (+shoulder pitch/roll)

## Goals

- See how sense of agency and ownership over the robotic arm is affected by movements in different degrees of freedom
- Follow up study to see is how having more degrees of freedom in movement than what humans possess affects participant's sense of ownership and agency