

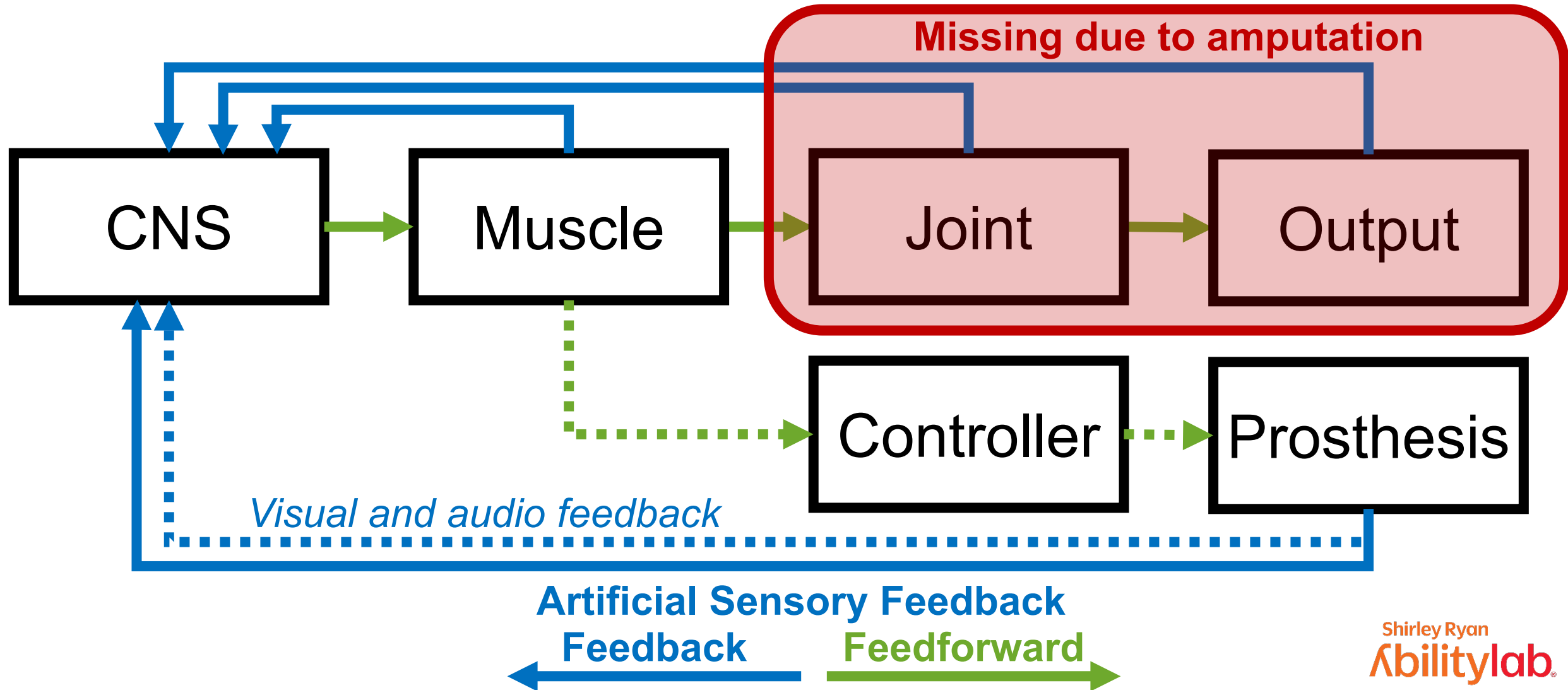
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VISUAL DISCRIMINATION OF BIOMIMETIC ARM SPEEDS

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MOTIVATION



SENSORY FEEDBACK

Prosthesis users rely heavily on vision as their main source of feedback

If sensory feedback too uncertain compared to vision, users continue relying primarily on vision

To best account for the effect of vision, we must understand visual uncertainty



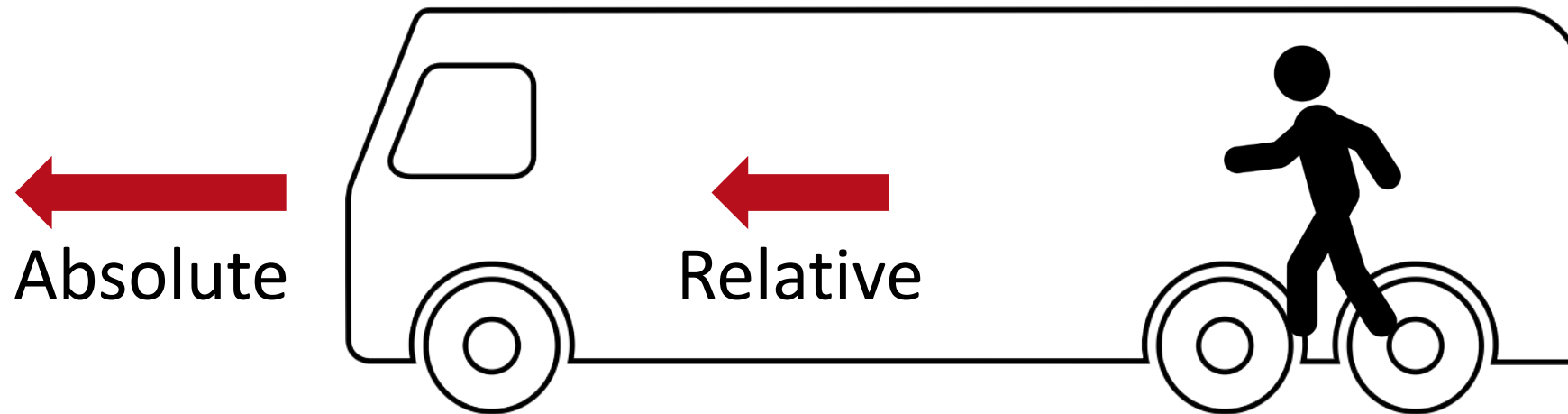
VISUAL UNCERTAINTY



Vision is more uncertain
about speed than
position

SPEED TYPE

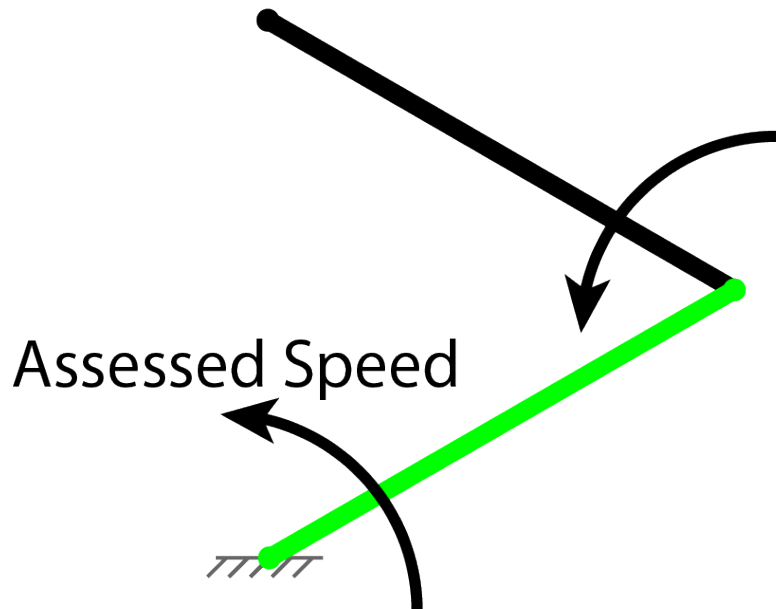
What *type* of speed is most uncertain?



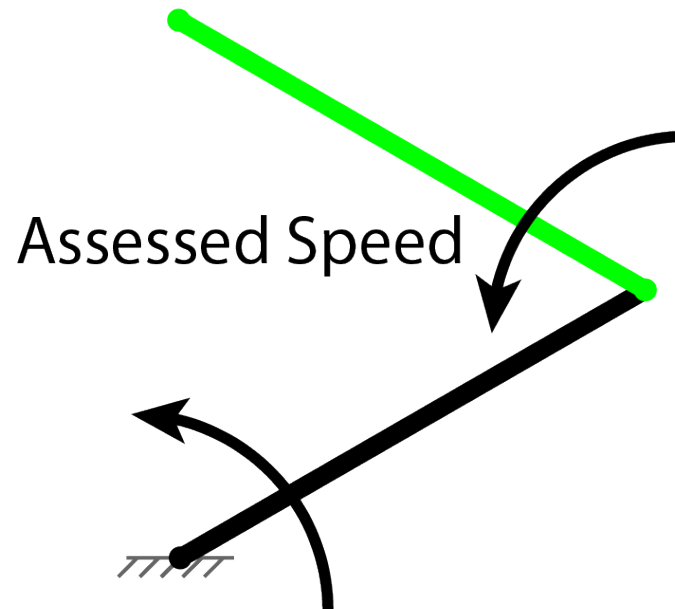
SPEED TYPE

What *type* of speed is most uncertain?

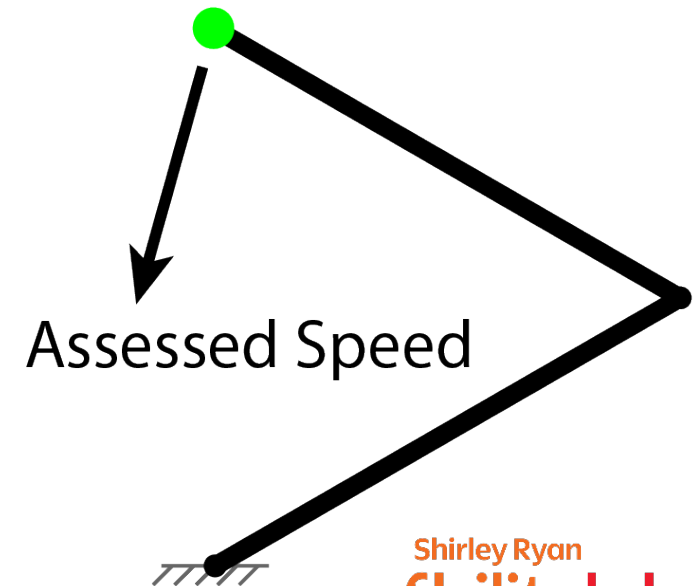
Absolute Speed



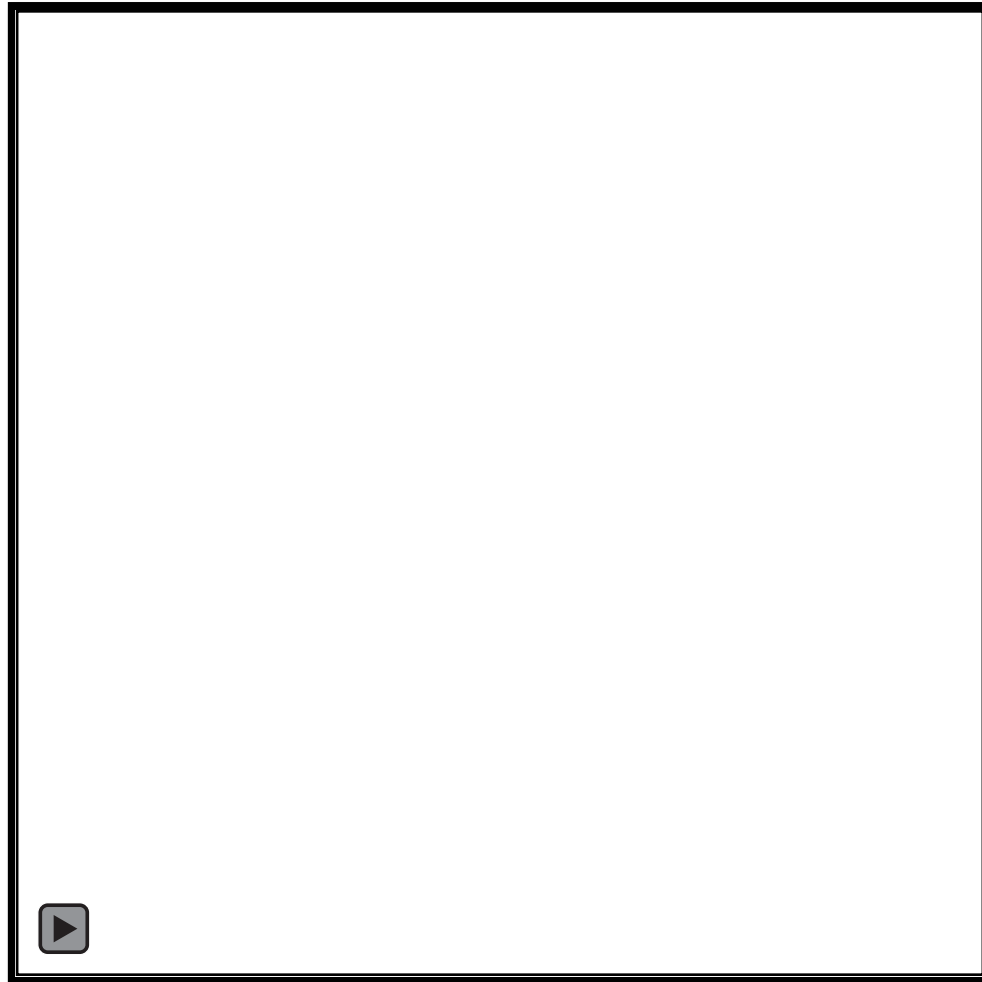
Joint Speed



Linear Speed



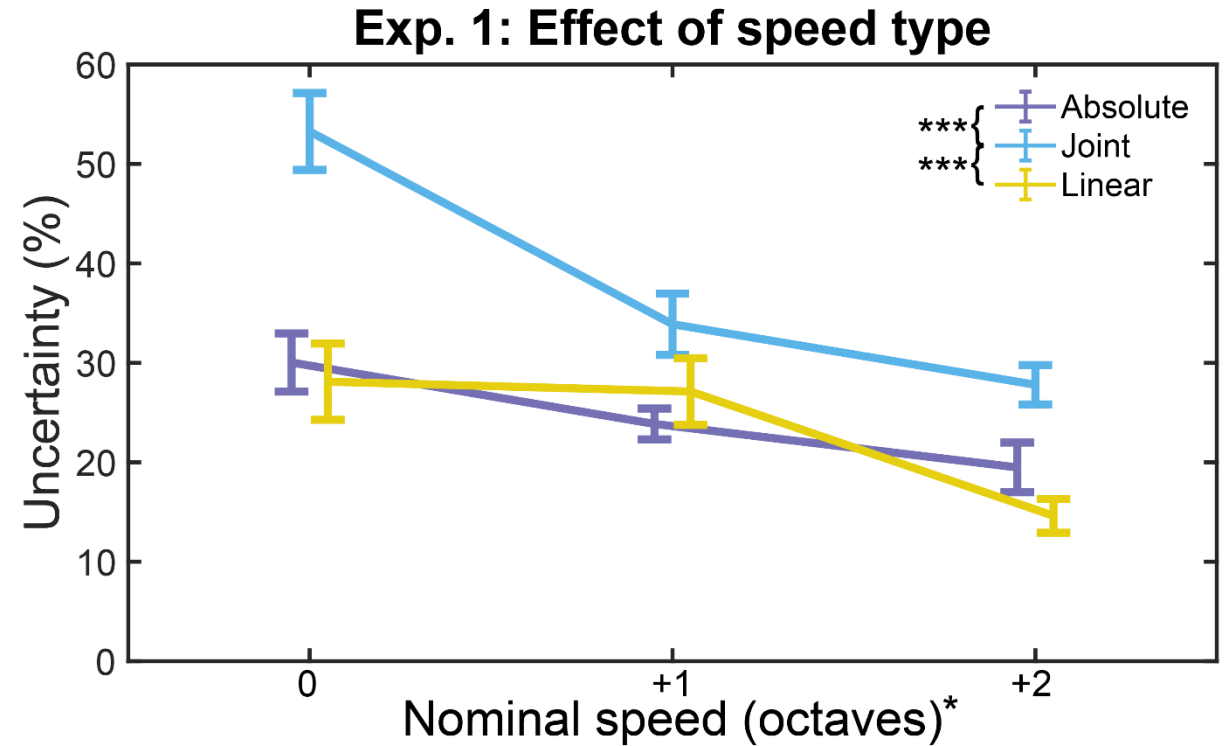
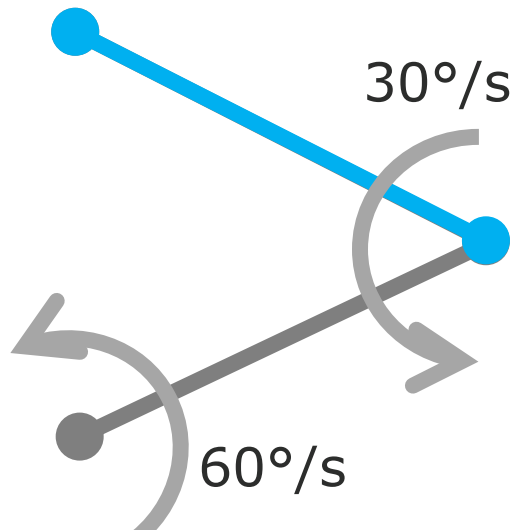
SPEED TYPE



SPEED TYPE

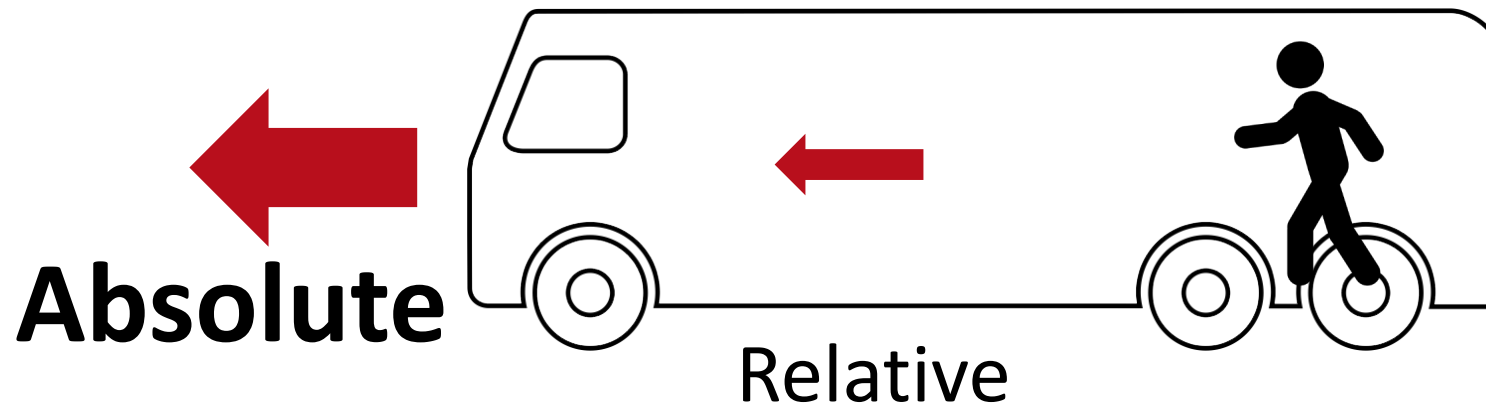
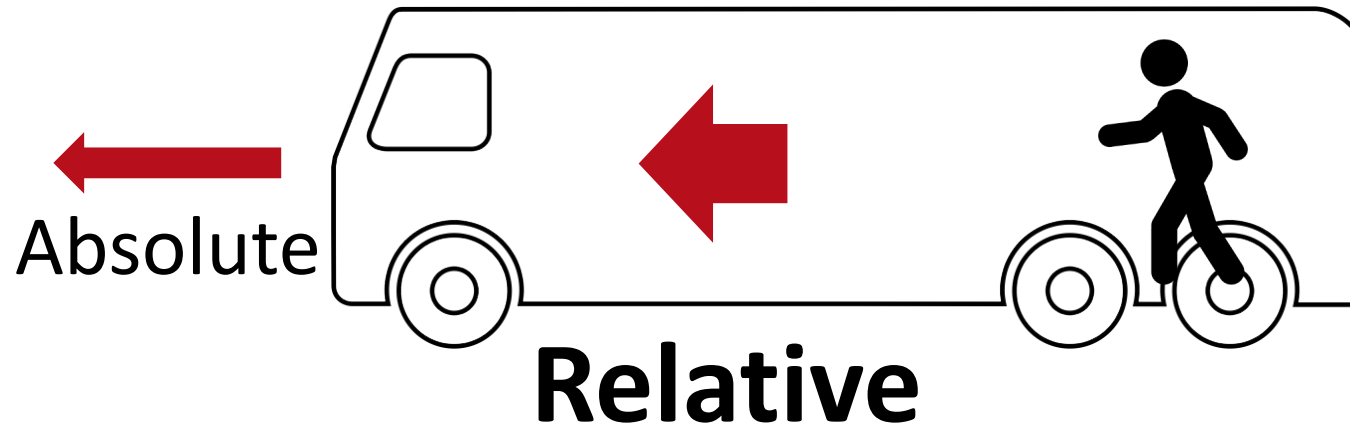
Egocentric and **Cartesian** speeds are perceived with low uncertainty

Joint speed uncertainty is highest with elbow moving slowly compared to shoulder:



REFERENCE FRAME SPEED

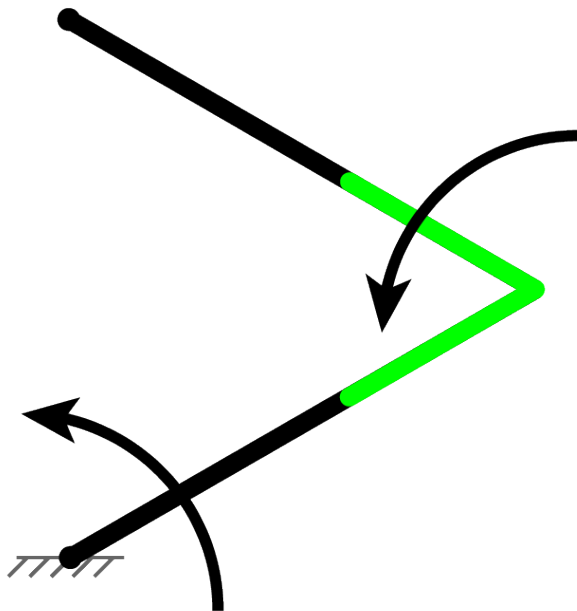
How does the *reference frame* affect uncertainty?



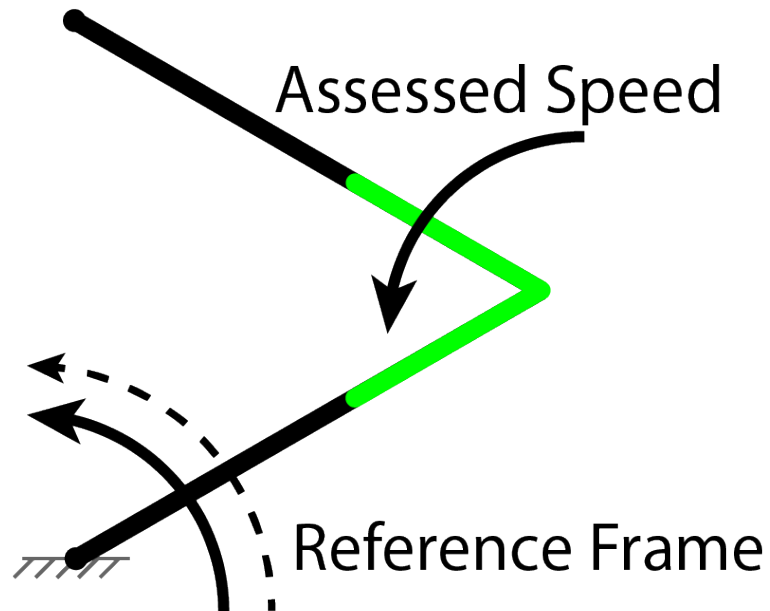
REFERENCE FRAME SPEED

How does the *reference frame* affect uncertainty?

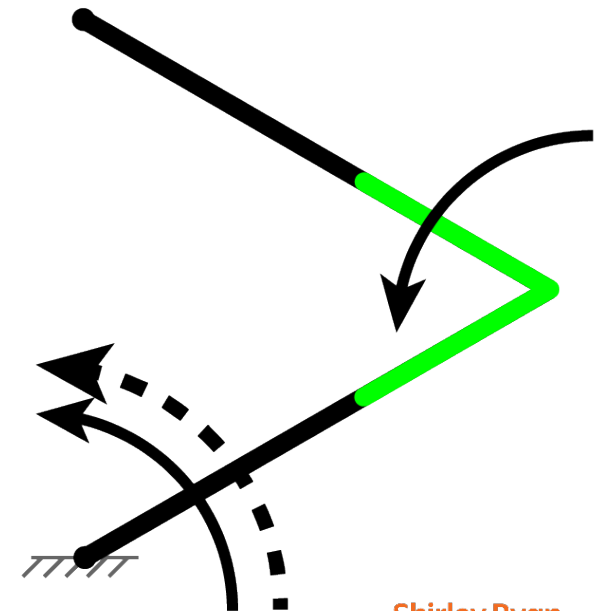
No Shift



Small Shift



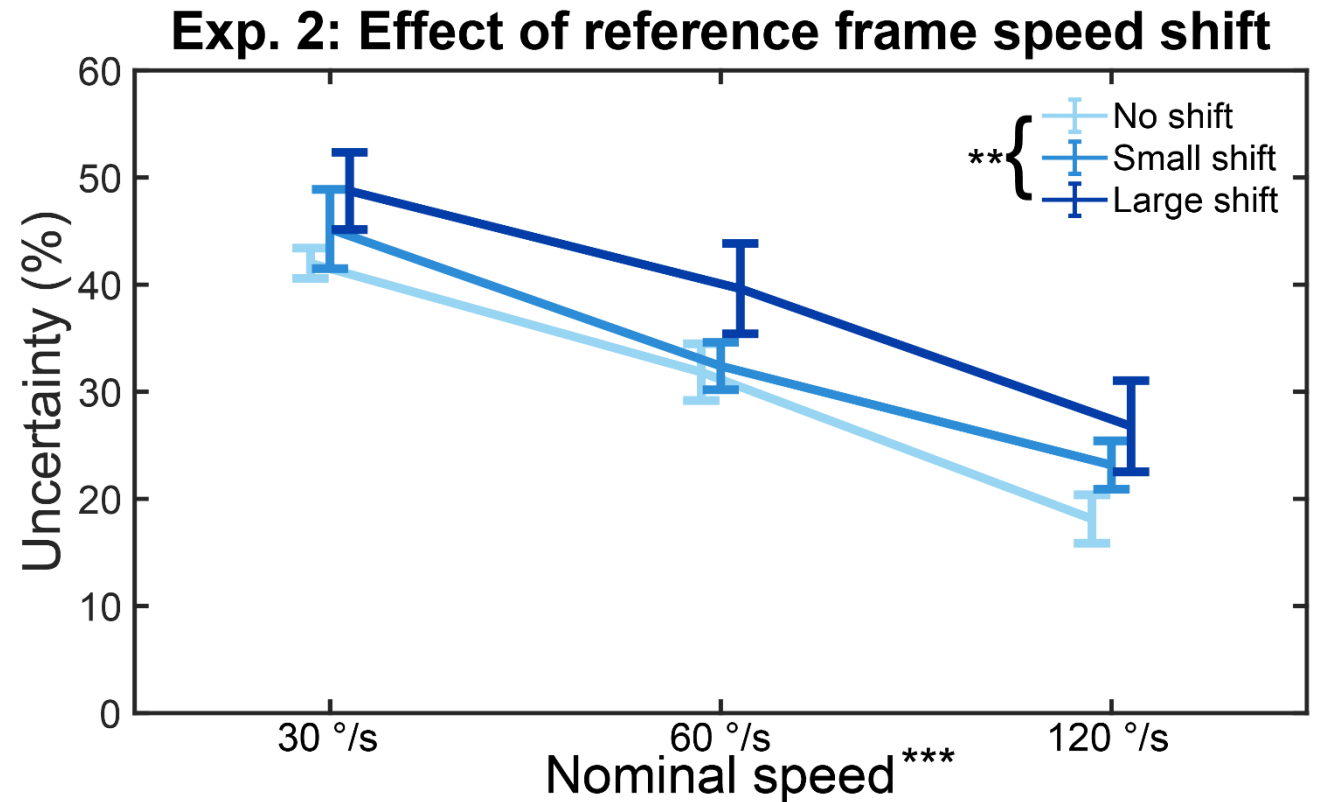
Large Shift



REFERENCE FRAME SPEED

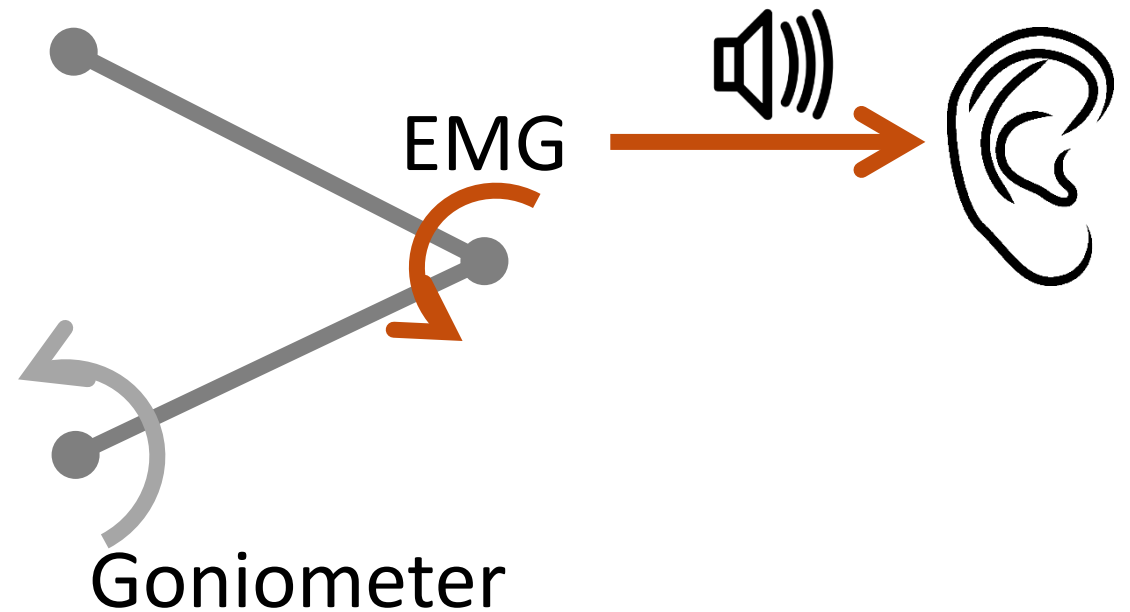
Uncertainty was highest with **large differences** in shoulder speed

Faster shoulder speed resulted in overestimation of elbow speed



SUMMARY

- Visual uncertainty is highest for **joint speed**
 - Especially as shoulder moves faster and at **different speeds**
- Therefore, providing sensory feedback based on joint speed should provide the greatest benefit to users
- We have developed a sensory feedback framework to provide audio cues based on joint speed, which will be tested in 2D and 3D virtual reaching tasks





THANK YOU