

Quantifying Coordination in Multiple DOF Movement
and
Its Application to Evaluating 6 DOF Input Devices

Shumin Zhai

IBM Almaden Research Center

Paul Milgram

University of Toronto

6 DOF Input Control

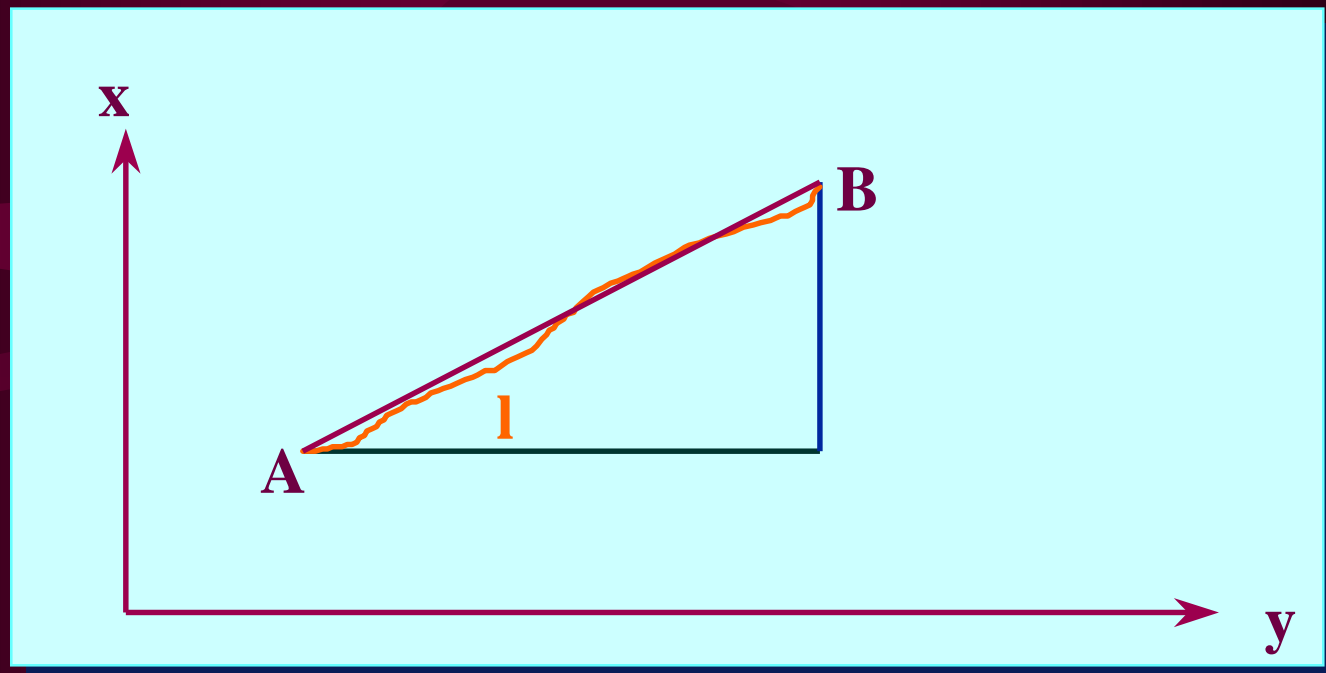
- Basic questions remain to be (scientifically) answered!
 - Can users simultaneously control all 6 degrees of freedom (too much to do)?
 - Can one 6 DOF device be substituted with multiple lower DOF devices?
 - Can one “coordinate” all 6 DOF?

Measuring Multiple DOF Coordination

- Simultaneity: the percentage simultaneous activation of multiple DOF.
 - does not account for the magnitude of the control actions in each DOF.
- Time-on-Target (TOT), Ellson (1947)
- Correlation (Senders et al, 1955)
 - Both TOT and correlation fail at perfect trials

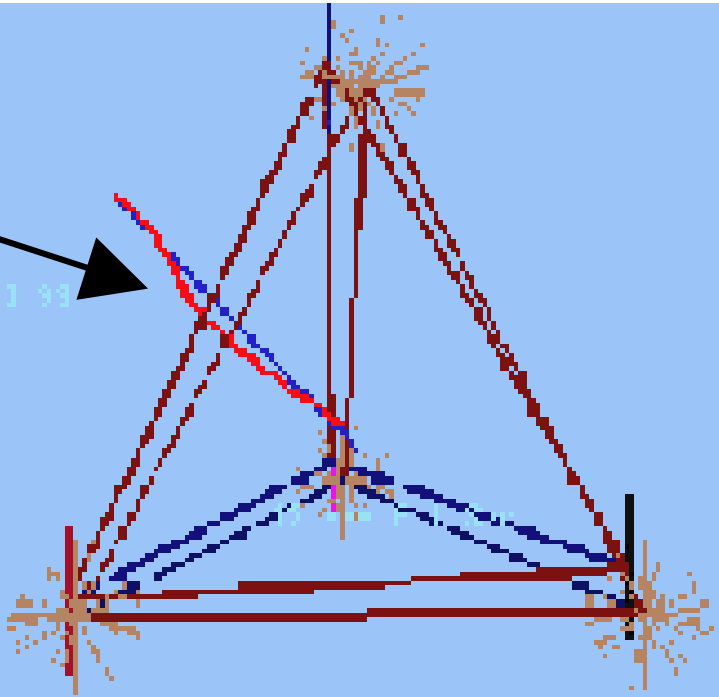
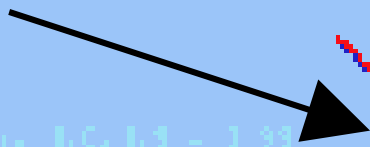
Efficiency as Coordination Measure

- 2 DOF example

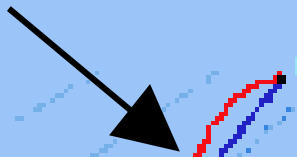


$$\text{Coordination measure} = (|I| - |AB|) / |AB|$$

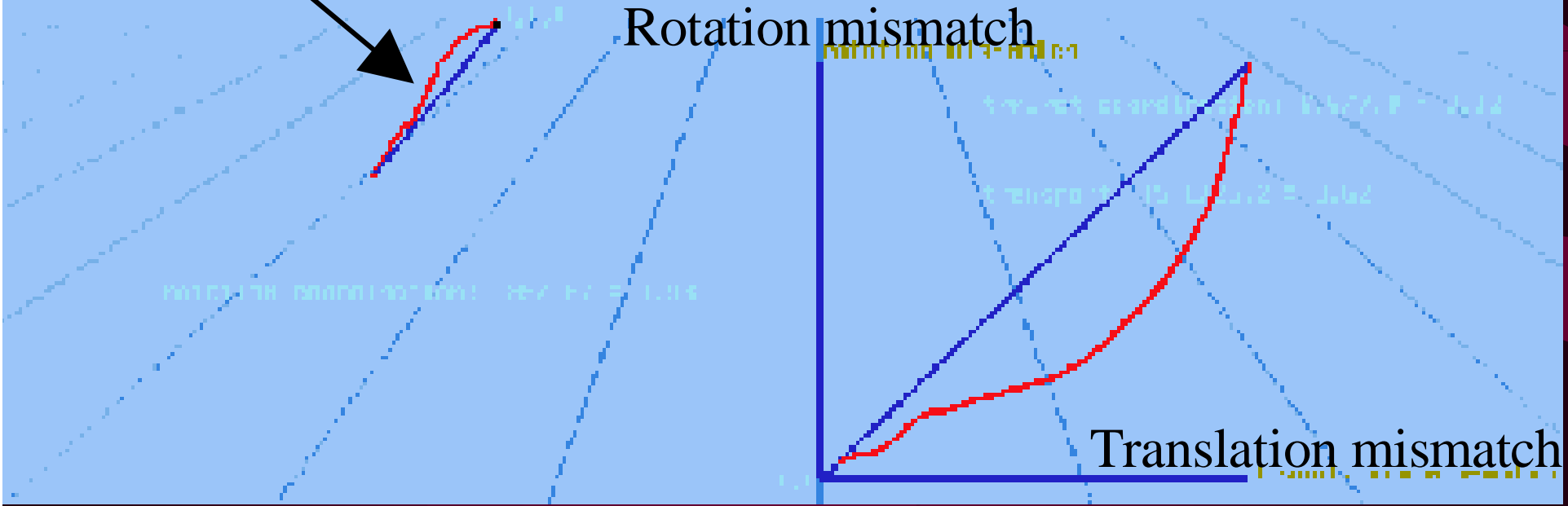
Translation path



Rotation path

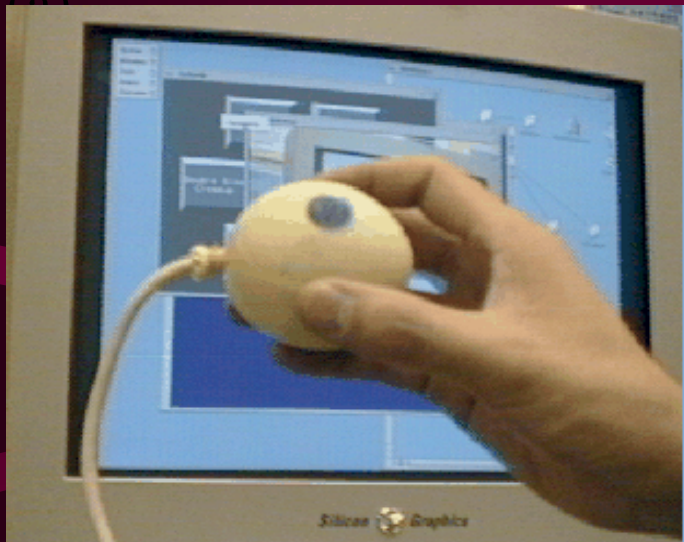


Magnitude of
Rotation mismatch

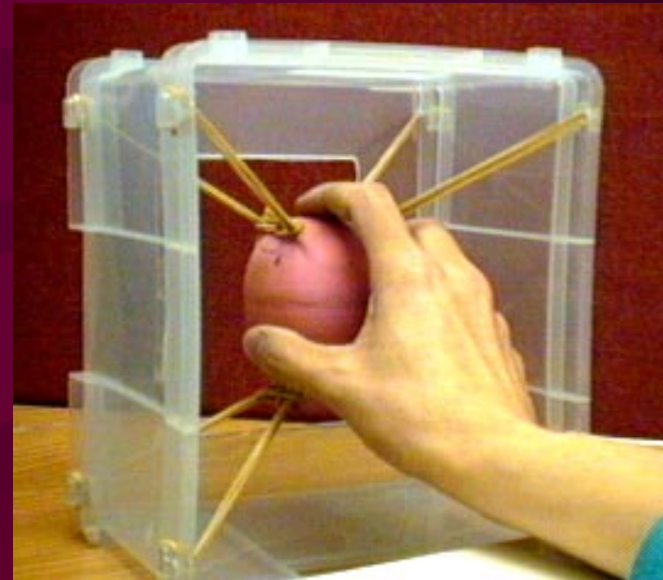


Translation mismatch

Evaluating Two Classes of 6DOF Devices



Fingerball:
free moving
position control

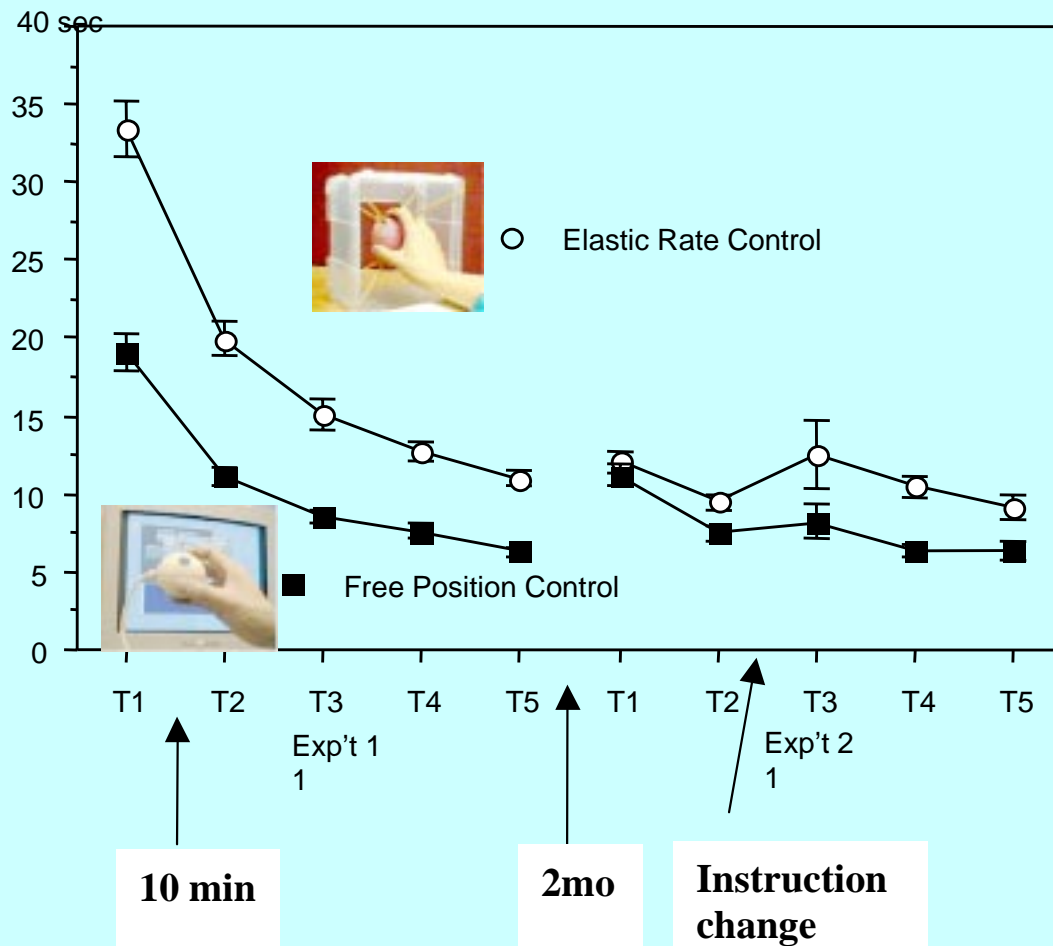


EGG:
elastic, desktop
rate control

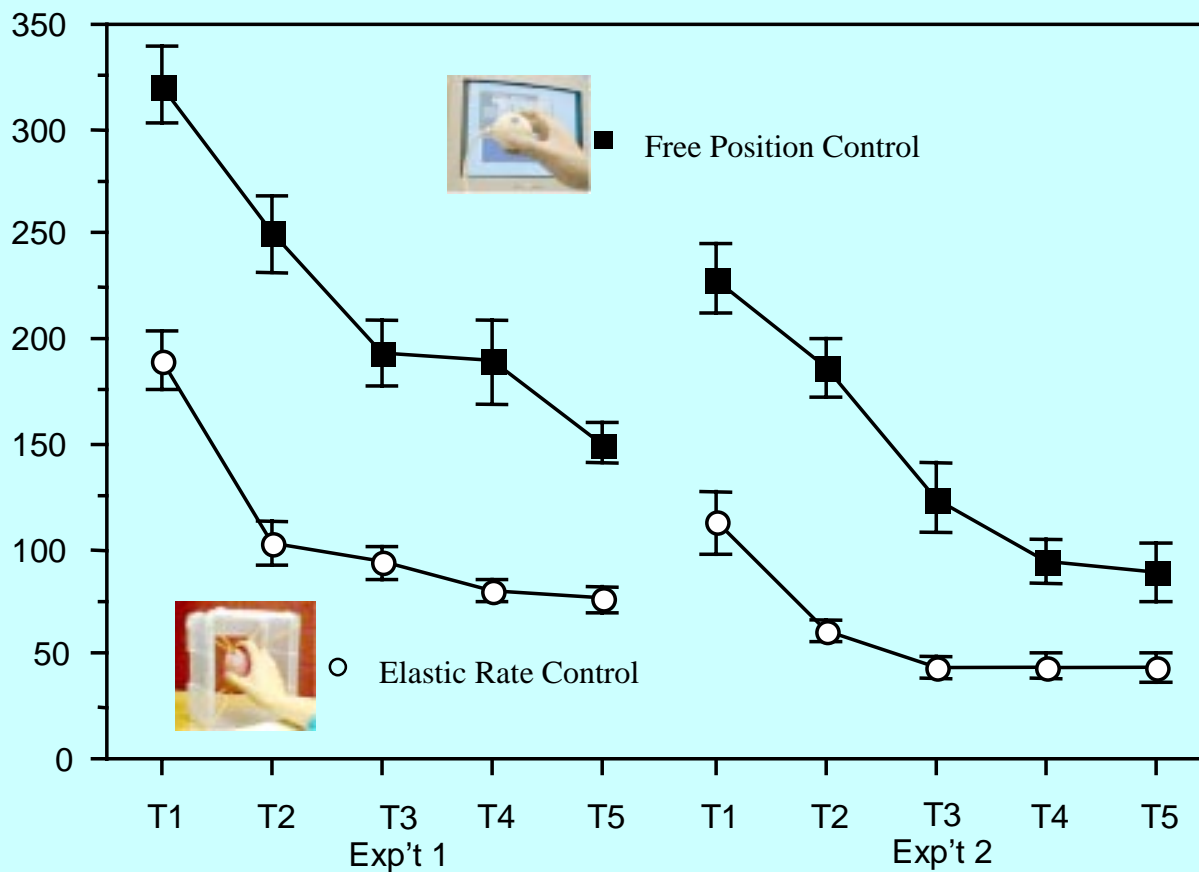
Same sensor, different manipulation techniques

Experimental Results: Time Performance

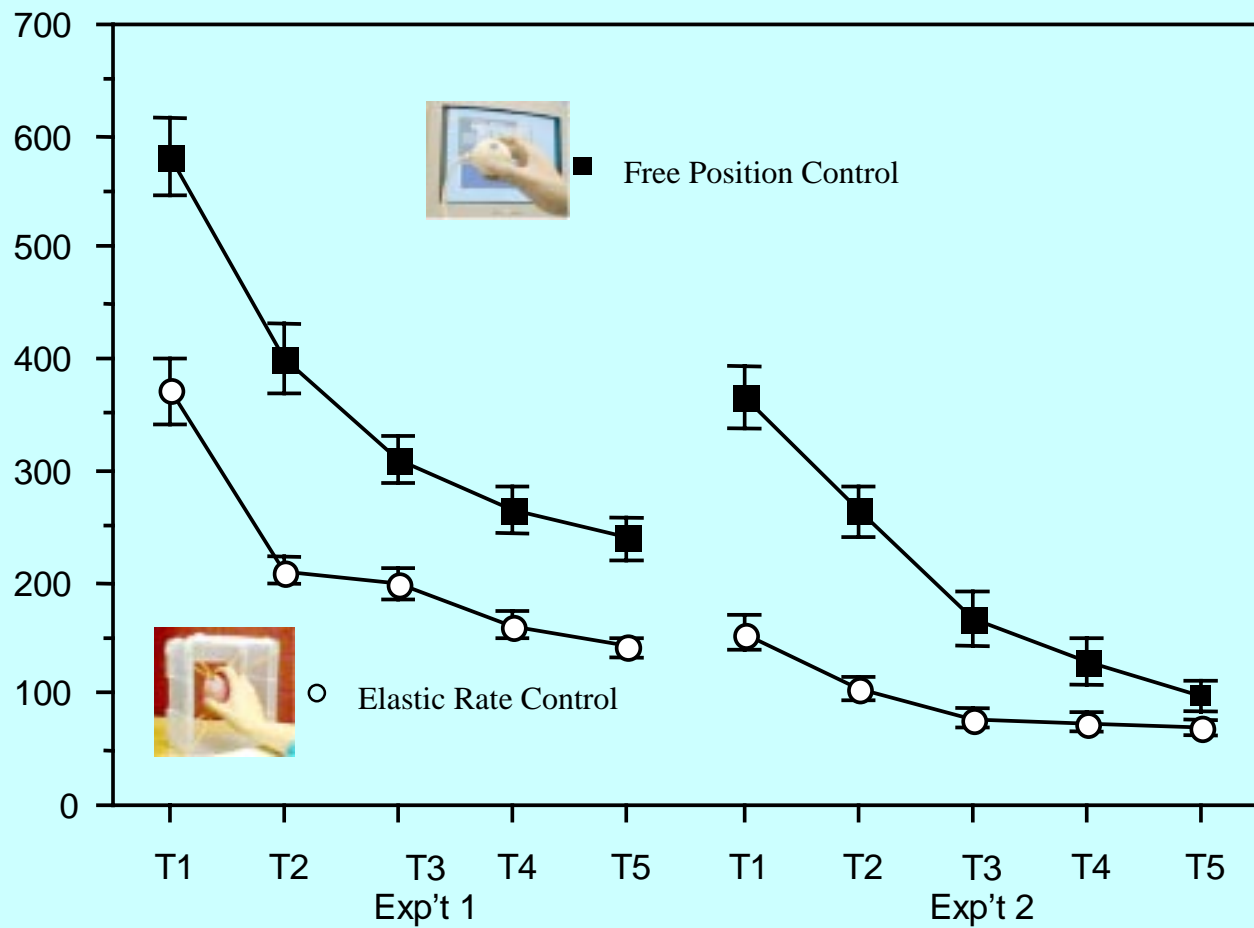
Trial Completion Time



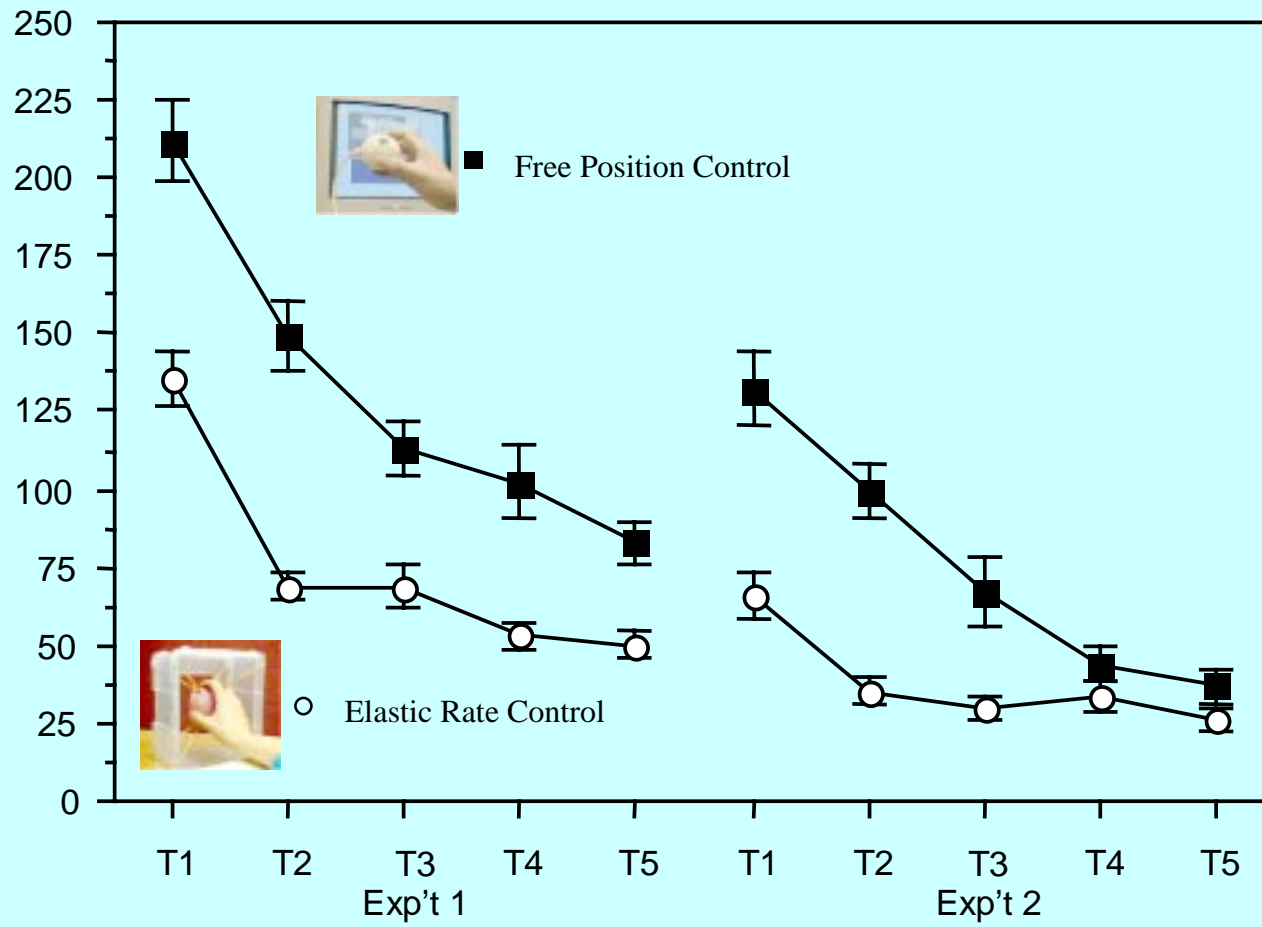
Coordination Measure: Translation Inefficiency



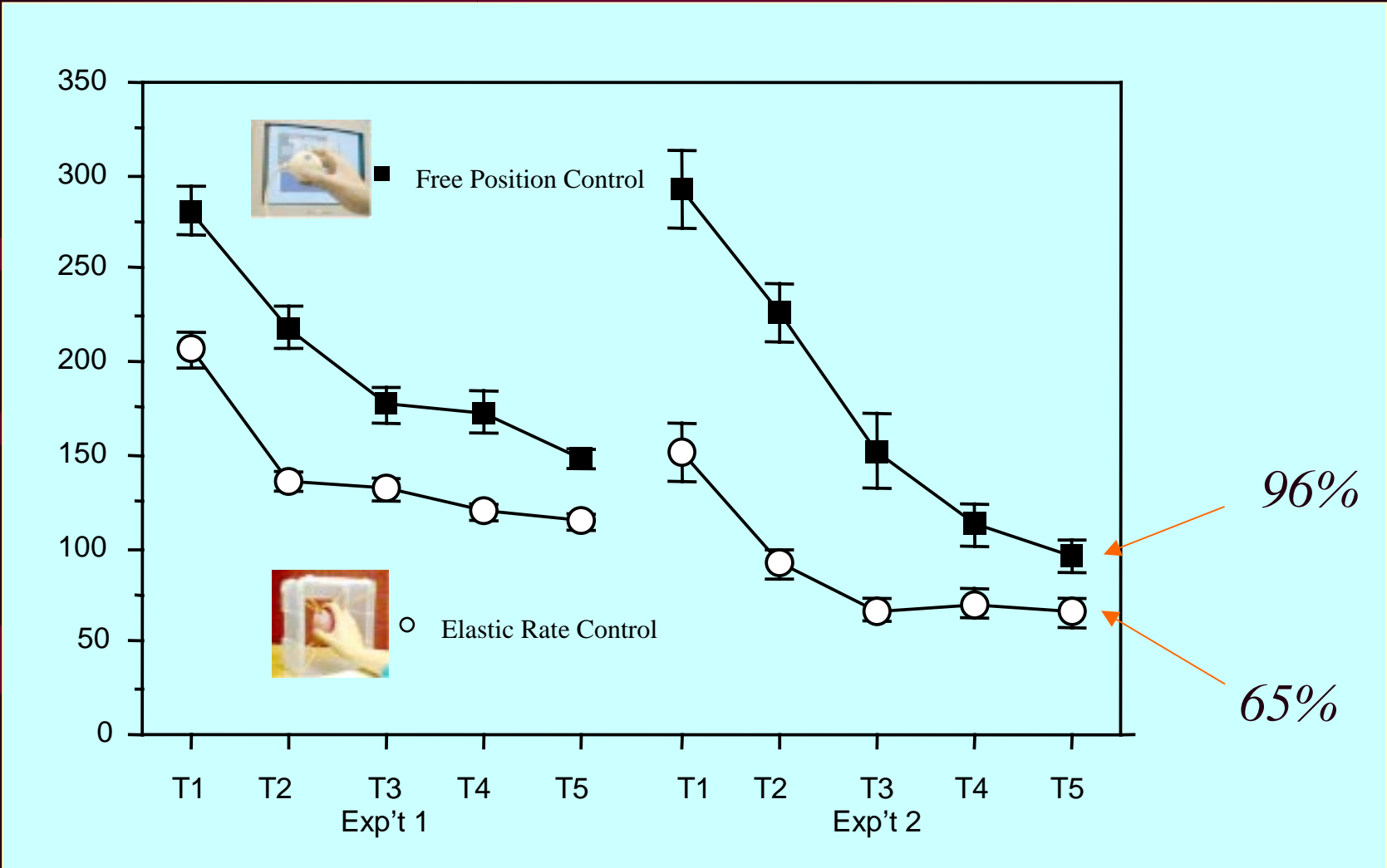
Coordination Measure: Rotation Inefficiency



Coordination Measure: Between Translation and Rotation

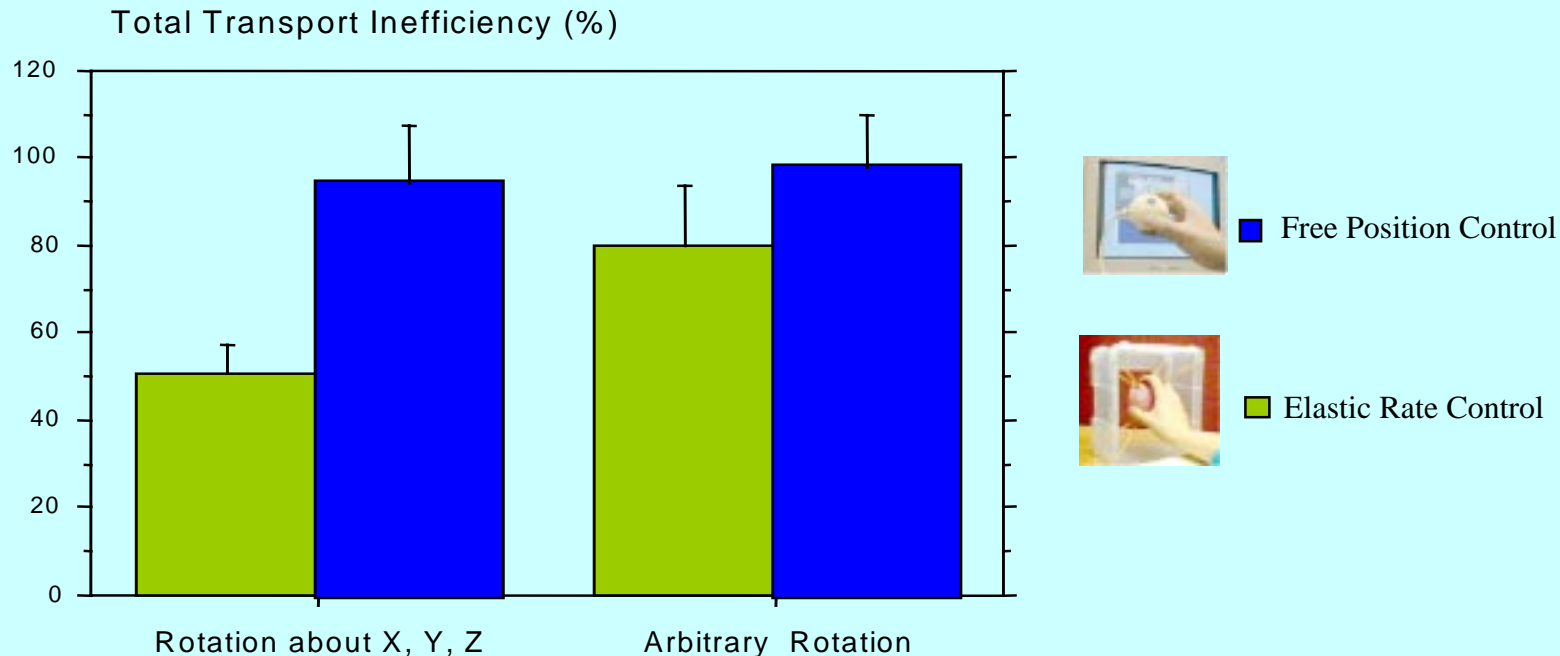


Coordination Measure: Total Transport



Cognitive Factors: The Effect of Mental Rotation

- 3D mental rotation (Parsons 1995)
 - Only possible when rotate about primary Axes
- Arbitrary rotation possible with interaction



What did we learn?

- methodology

- Pros and Cons of efficiency based coordination measure
 - Beyond time and accuracy measures could tell: new insight gained
 - It is a definition, not the only “correct” measure
 - Can be similarly applied to other problems
 - e.g. Two handed input (Fitzmaurice 1996)

What did we learn?

- 6 DOF Devices



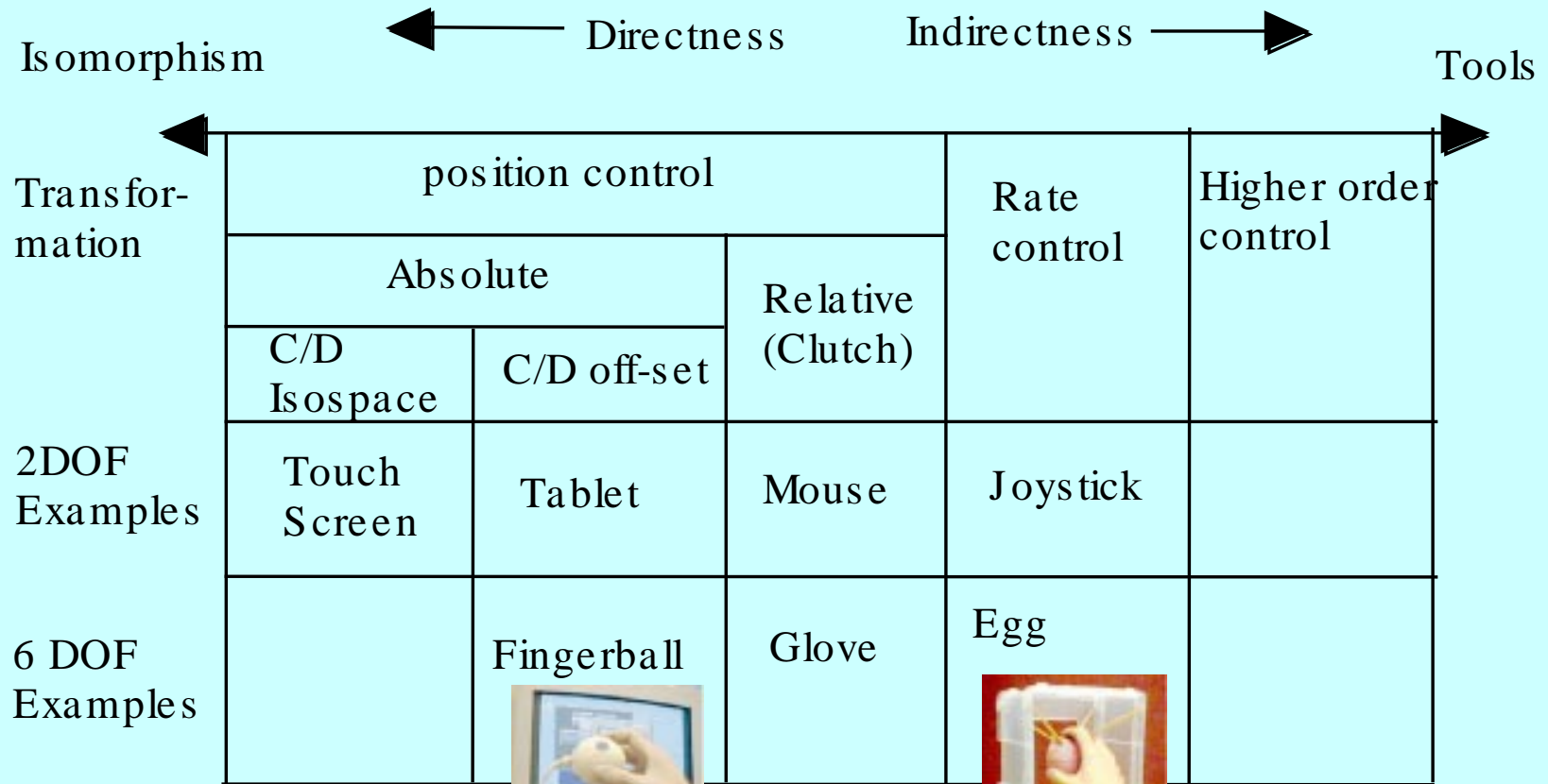
- Intuitive
- Faster to reach target



- Better Coordination
- Better trajectory

What did we learn?

- 6 DOF Devices



- Intuitive
- Faster to reach target

- Better Coordination
- Better trajectory

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