Evaluation of 12-DOF Input Devices For Navigation and Manipulation in Virtual Environments

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Overview

- Navigation & Manipulation common tasks in VR environments
- 6-DOF input devices
- Alternative: 12-DOF devices

➢ New evaluation techniques

Devices – The Cubic Mouse

[Fröhlich & Plate, CHI 2000]

- Tracker – 6 DOF
- Rods – 3 x 2 DOF
- Position Control (isotonic)
  - clutching
- Full tactile coordinate system
- Regrasping (rods)
- Maximum 8 DOF simultaneously

Devices – The YoYo

[Simon & Fröhlich, INTERACT 2003]

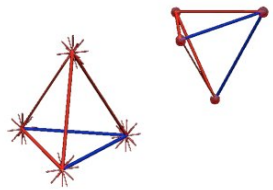
- 2 x 6 DOF
- Rate control (elastic)
- Unlimited range of control
- No coordinate system
- Grip change
- Maximum 6 DOF simultaneously

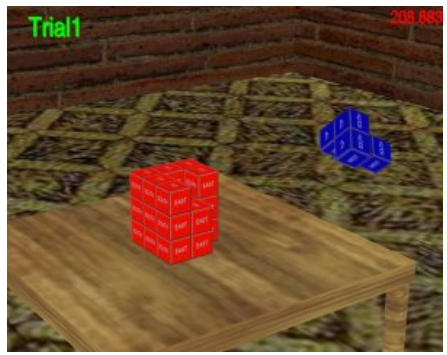
Devices – The Square Bone
[New Prototype]

- 2 x 6 DOF
- Rate control (elastic)
- Unlimited range of control
- Tactile coordinate system
- Access to all 12 DOF
- Maximum 12 DOF simultaneously
  - DOF of both sides

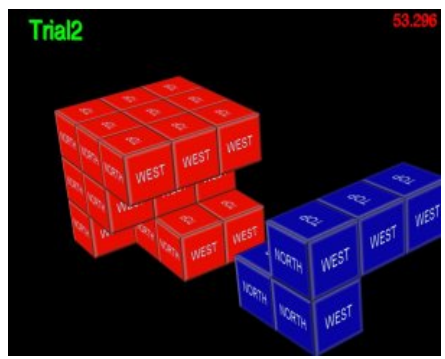
The Extended Docking Task

- Evaluations of 6-DOF devices
  - docking tasks
  - tracking tasks





- Extended docking task
  - combines navigation and manipulation tasks

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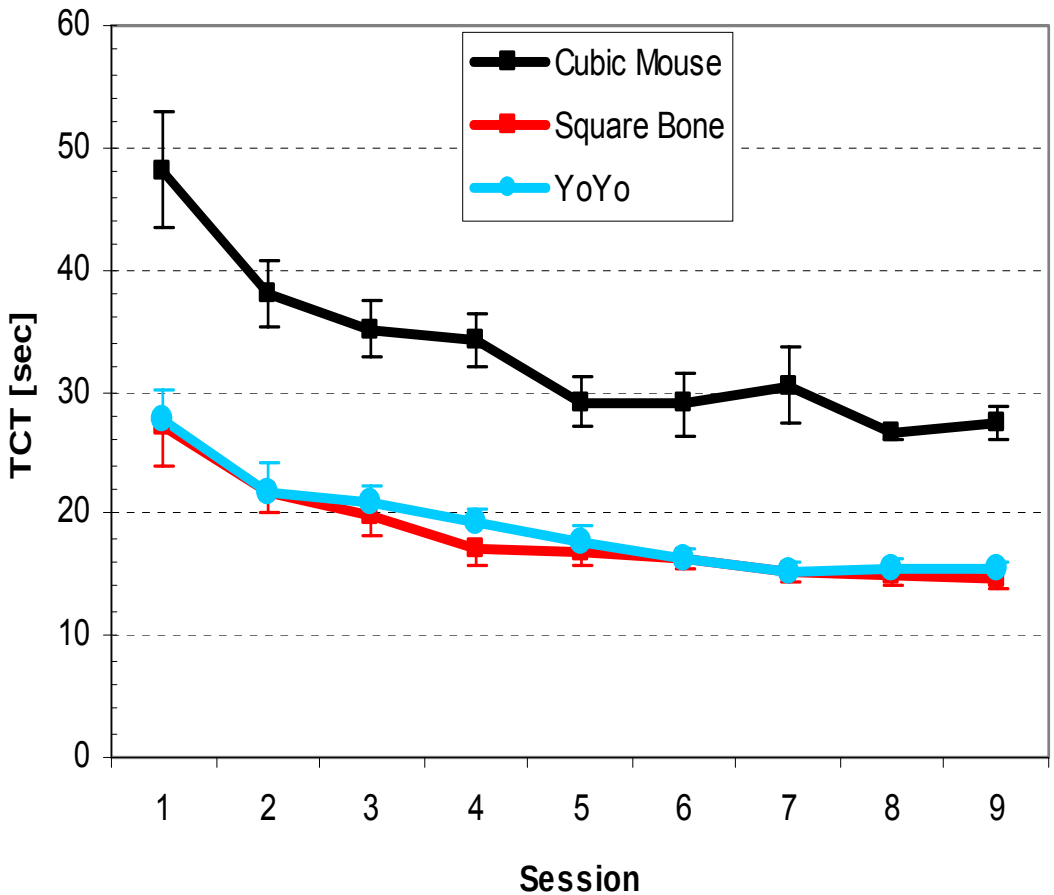
Experiment 1: Questions

- Device performance / comparison
  - Cubic Mouse worse than others due to separate DOF for manipulation
  - Cubic Mouse better due to isotonic control [Zhai 1995]
- How does learning affect device performance?
  - Isometric control evokes higher learning progress [Zhai 1995]

Exp. 1: Methods

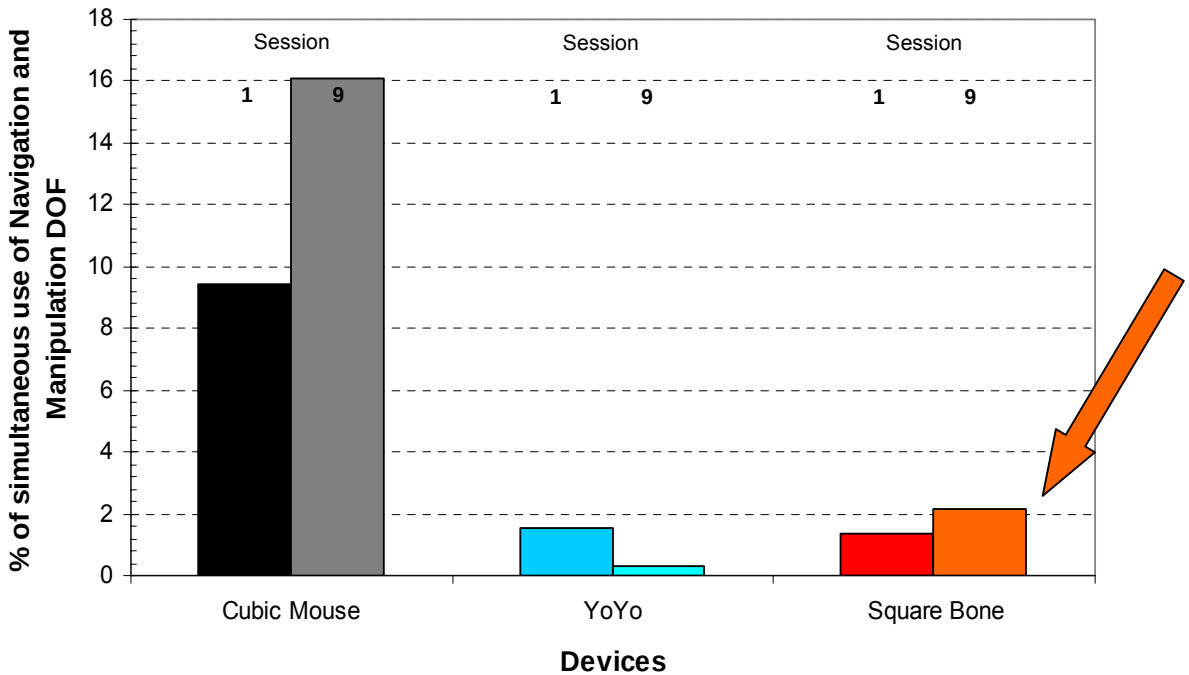
- Extended docking task
- Three devices:
  Cubic Mouse, YoYo, Square Bone
- 9 sessions within 5 weeks
- Details
  - 8 volunteers (23.6 year average)
  - all right-handed
  - previous experience with various input devices
  - 22‘‘ monitor with mono setup
  - average session duration: 45 min
  - ➢ 2160 overall trials

Exp. 1: Task Completion Times



- Cubic Mouse outperformed
- Variability decrease
- Comparable learning

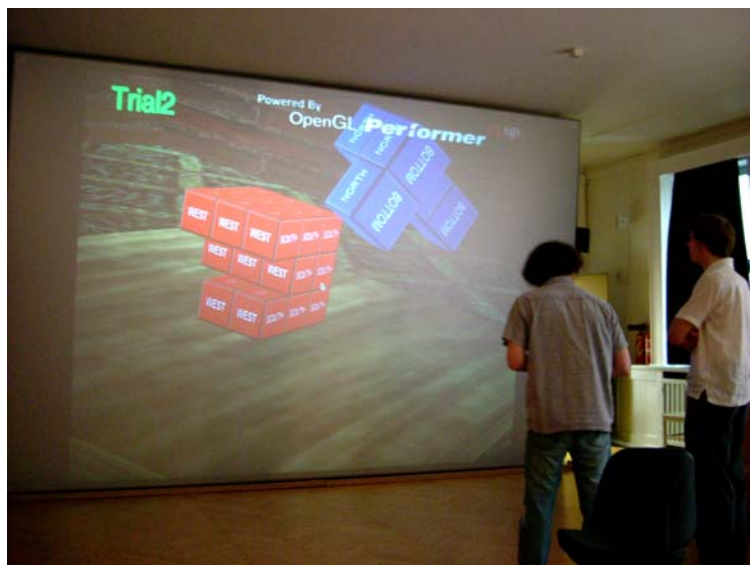
Exp. 1: Simultaneous Control



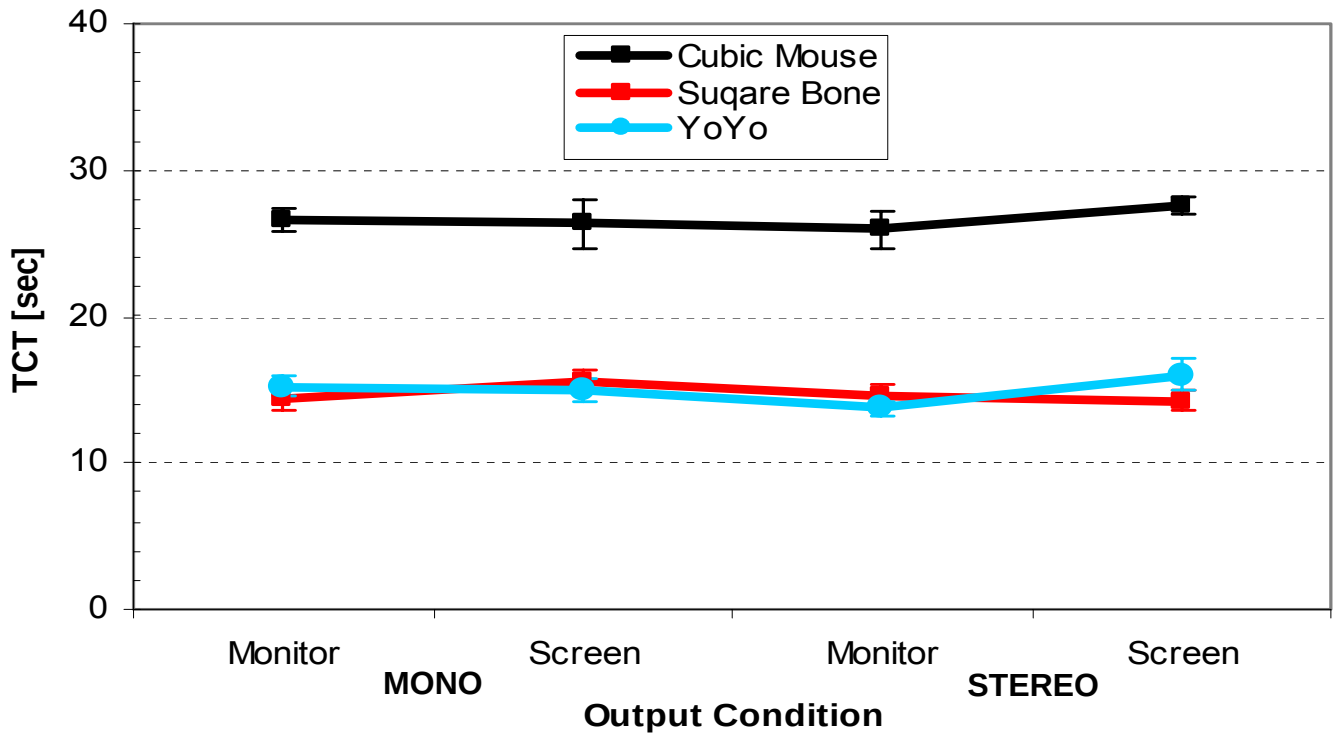
r = .13
p < .05

Exp. 2: Effects of changing display systems?

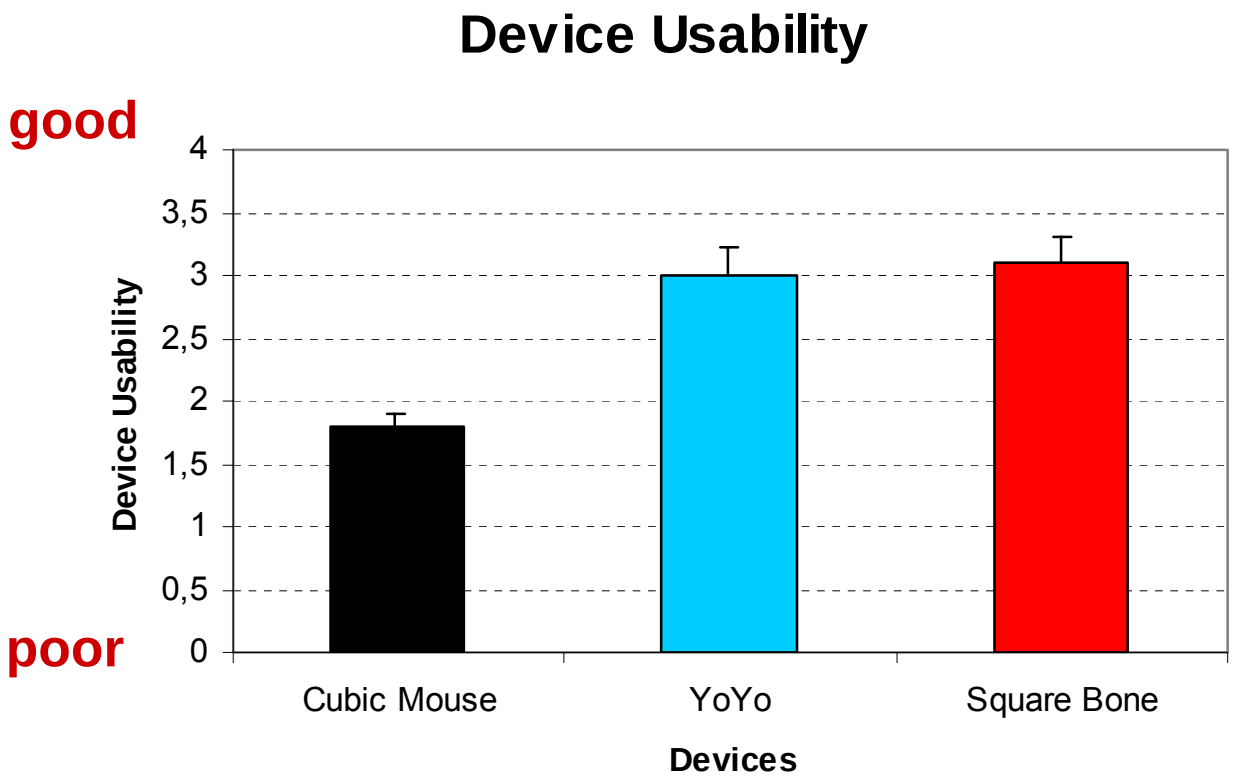
- Methods equal to Exp1, except:
  - same monitor vs. Large projection screen (4 m x 3 m)
  - mono vs stereo



Exp. 2: TCTs, different Output and Display Conditions



Exp. 1 & 2: Subjective Data



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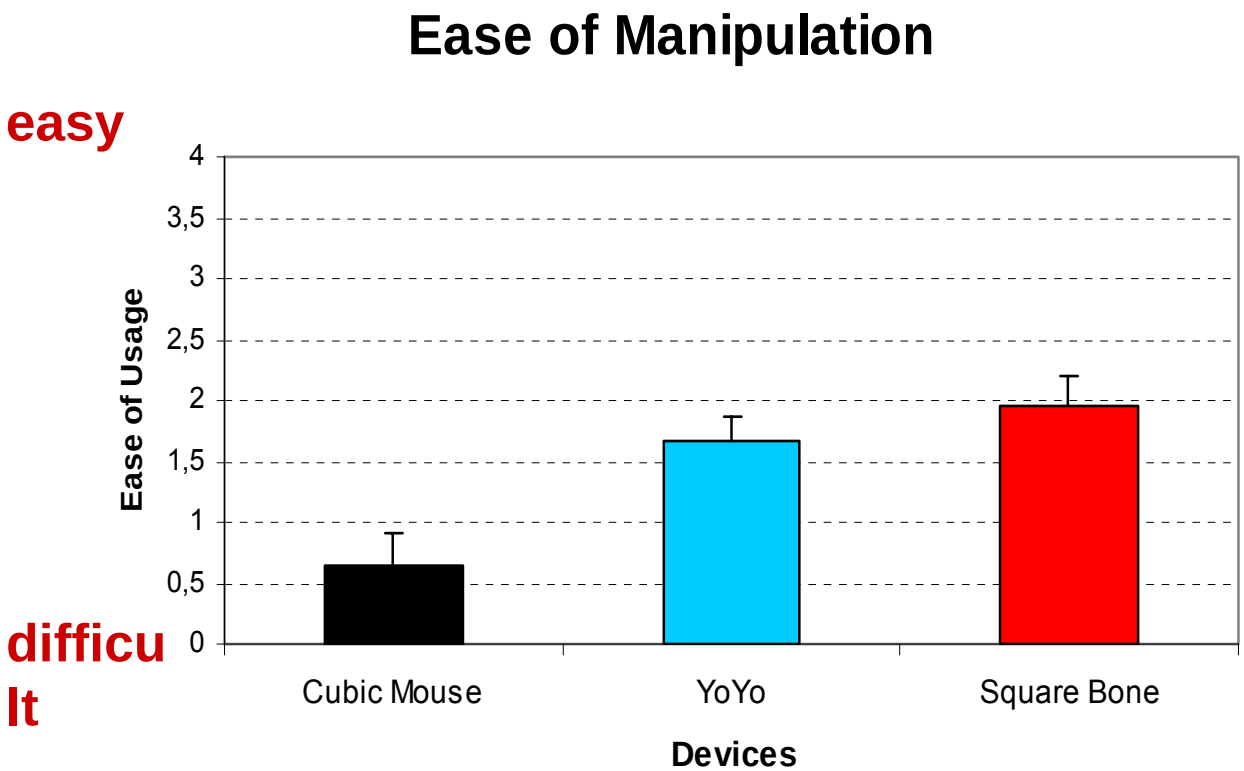

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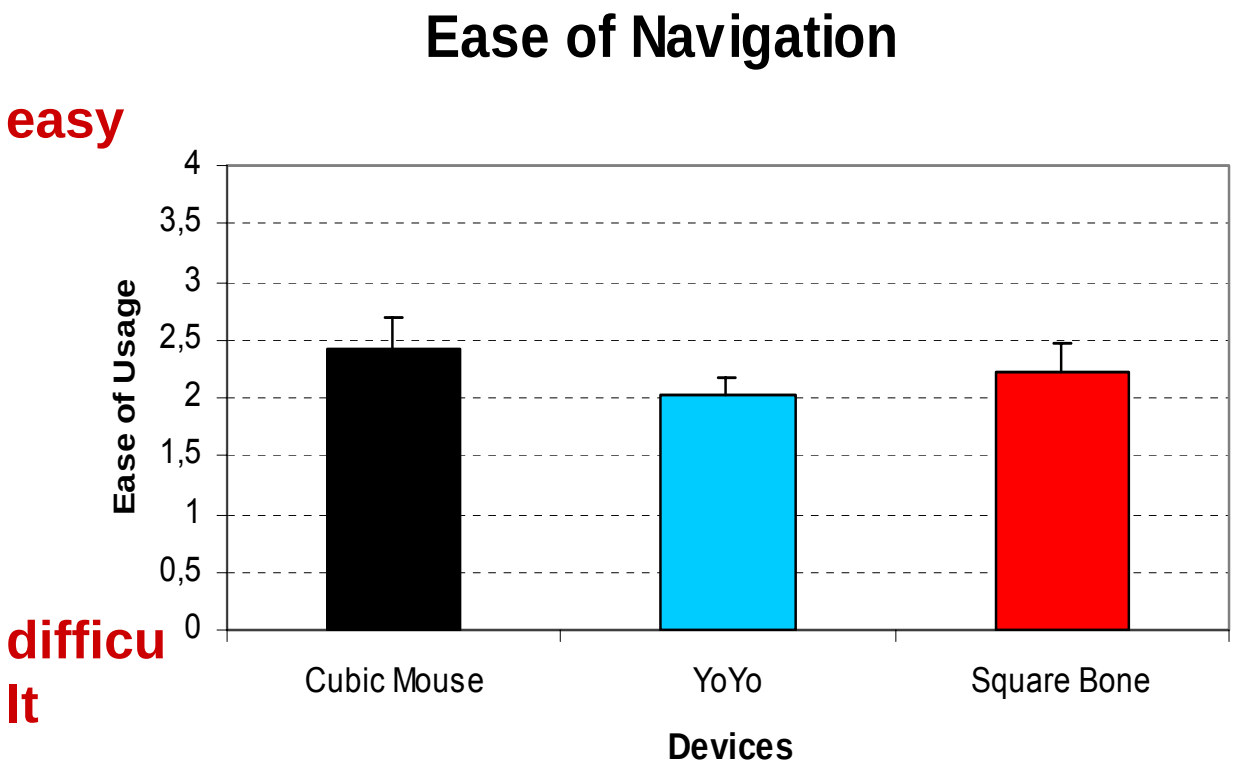


Conclusions (1)

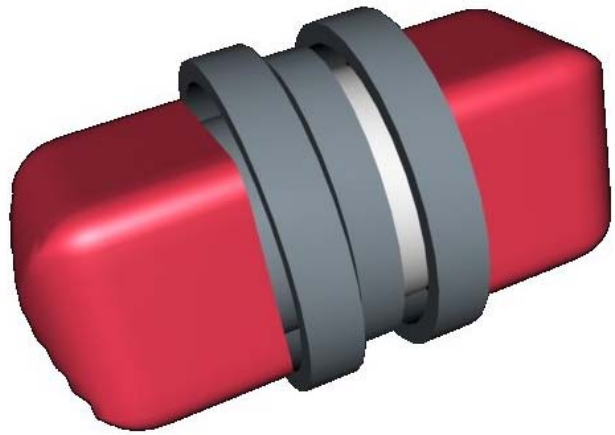
- Extended Docking Task produces reliable and valid results
- Cubic Mouse inferior vs. YoYo and Square Bone
  - high degree of DOF separation
  - only “city block“ trajectories possible
- Navigation with Cubic Mouse very easy
  - isotonic input control

Conclusions (2)

- Simultaneous control
  - experienced users only (2% of time)
- Effects of coordinate system?
  - effects masked
  - Square Bone‘s square handles uncomfortable
  - certain diagonal trajectories possibly avoided

Future Work

- Square Bone II
- Comparison with 6-DOF devices
  - Study additional tasks
  - Combine isotonic/ isometric input
  - Constrained interaction
  - … …



THANK YOU FOR YOUR ATTENTION!

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