

# User Performance in Complex Bi-manual Haptic Manipulation with 3 DOF vs 6 DOF

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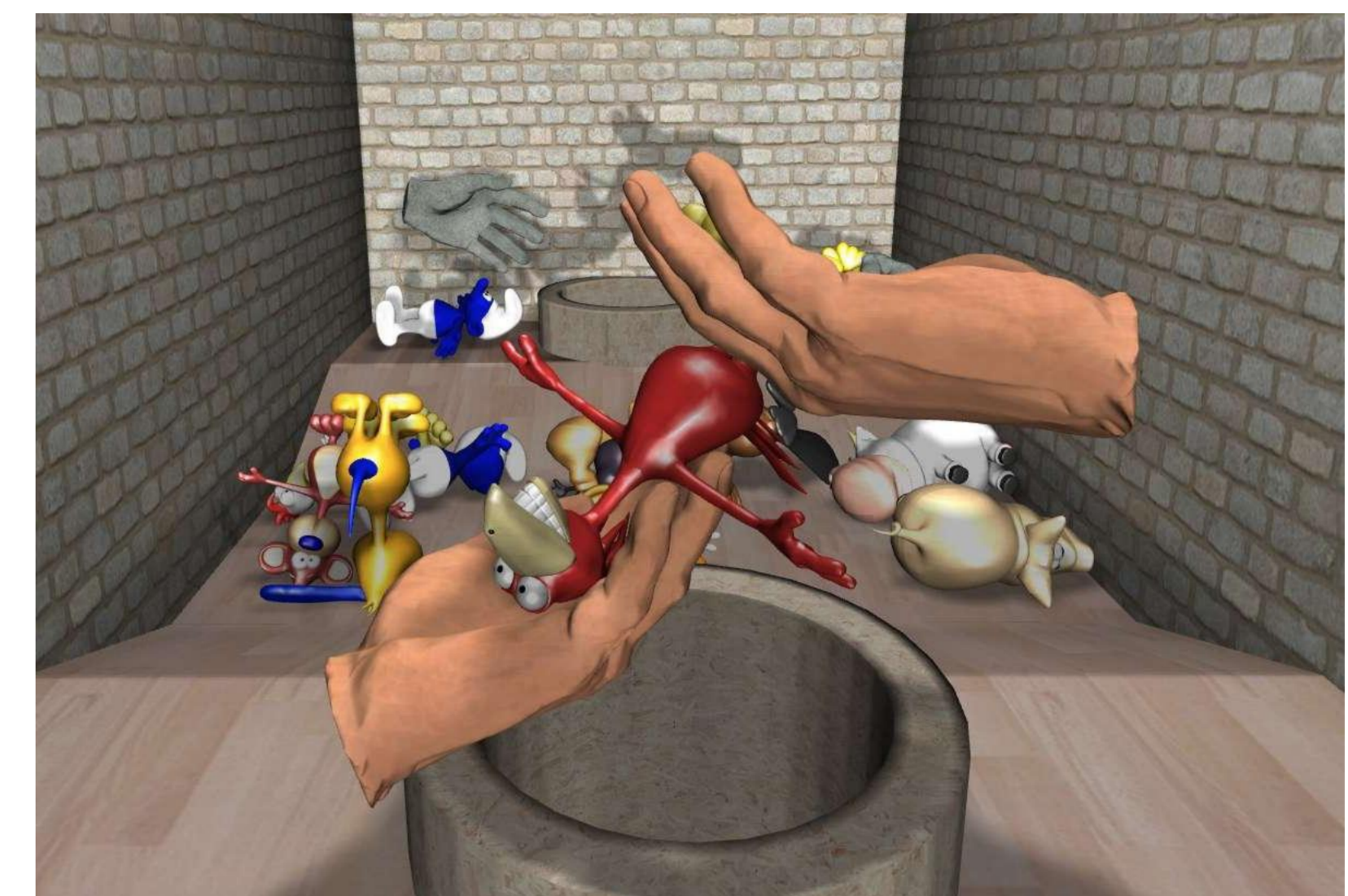
## Question

- The **cost** of haptic devices mainly depends on their **number of actuators**
- **Real-world** object manipulations comprises not only **forces** with 3 DOF but also **torques** with 3 DOF
- **Question:** Is the enhanced experience **worth the additional cost** for the 6 DOF devices?



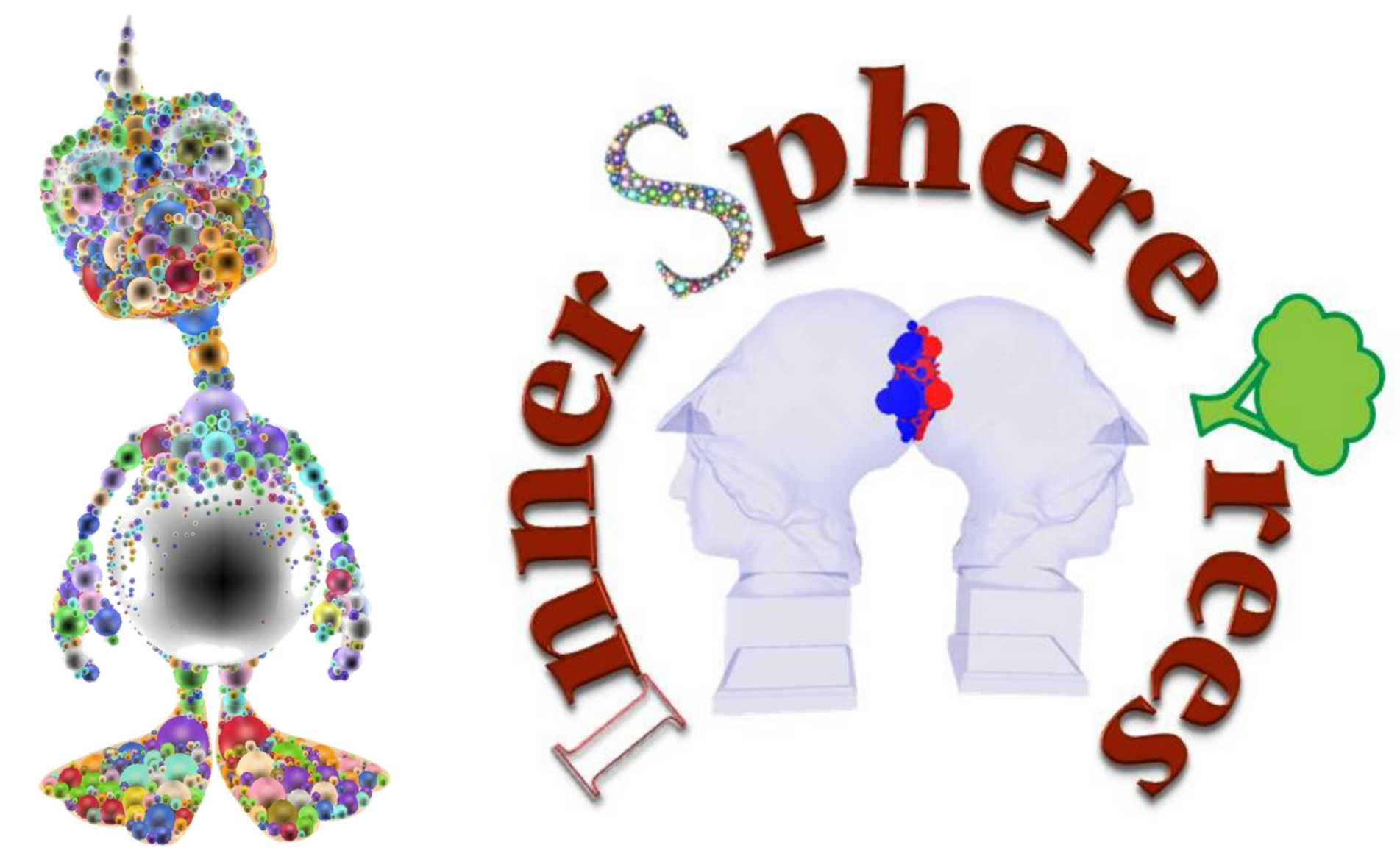
## Design of Experiment

- Requirements:
  - A **fair comparison** of devices with **different DOF**
  - A task that can be performed **only with complex bi-manual interactions**
- **Two-player haptic game** with physically based manipulations
- A **questionnaire**, recorded **forces** and **torques** and measurements of covered **distances** allow a **qualitative** as well as a **quantitative evaluation**



## Technical Aspects

- **Haptic workspace** that provides high-fidelity 6 DOF force-feedback in scenarios containing a **large number** of dynamically simulated objects
- ⇒ **Inner Sphere Trees:** 1000 Hz collision detection with continuous forces and torques using **penetration volume**



## User Study

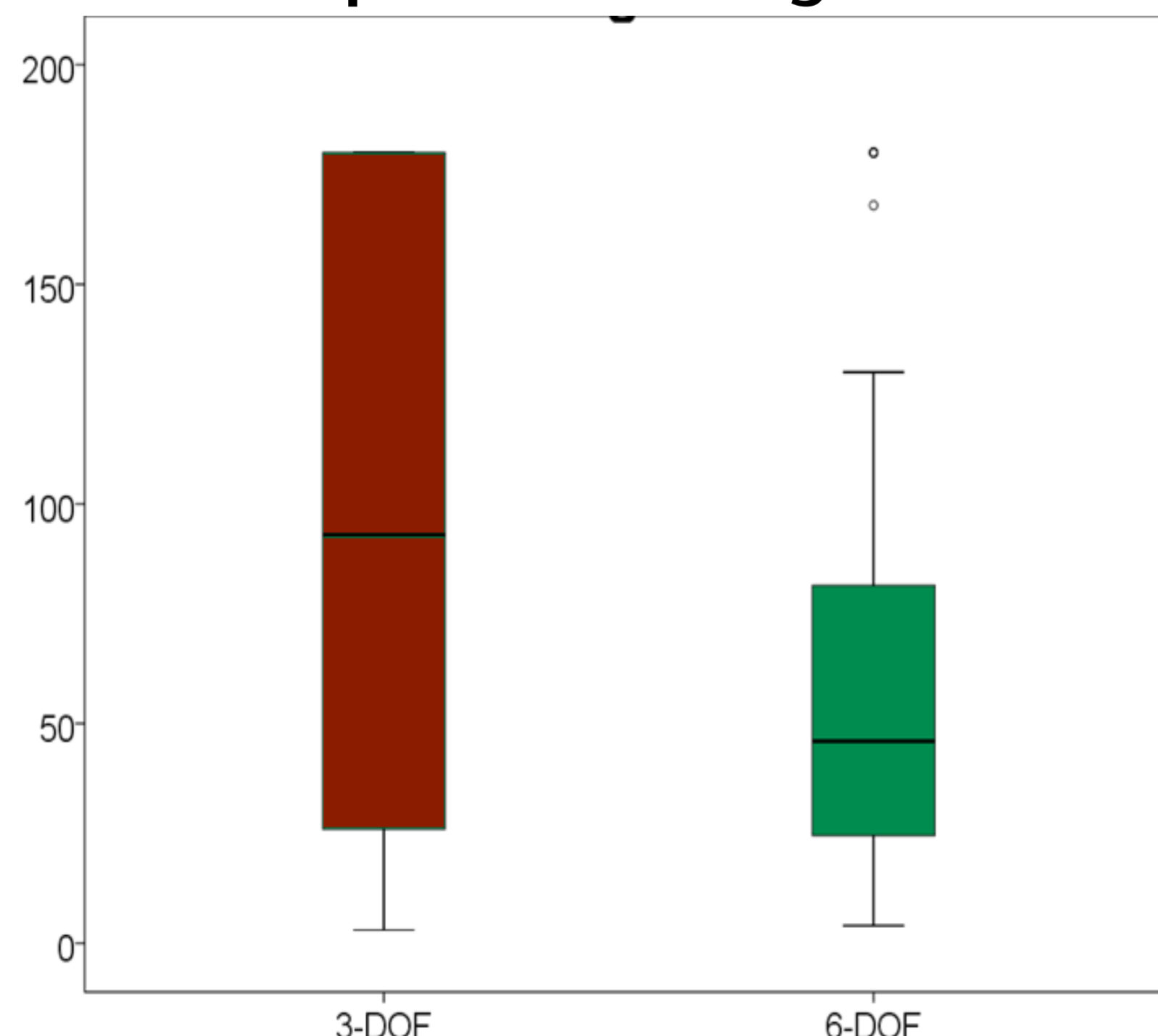
- 47 participants
- Age: 17-34 years
- 33 14
- 44 3
- Experience Level:
  - 27 play regularly
  - 5 regularly use VR
  - 8 used haptic device before



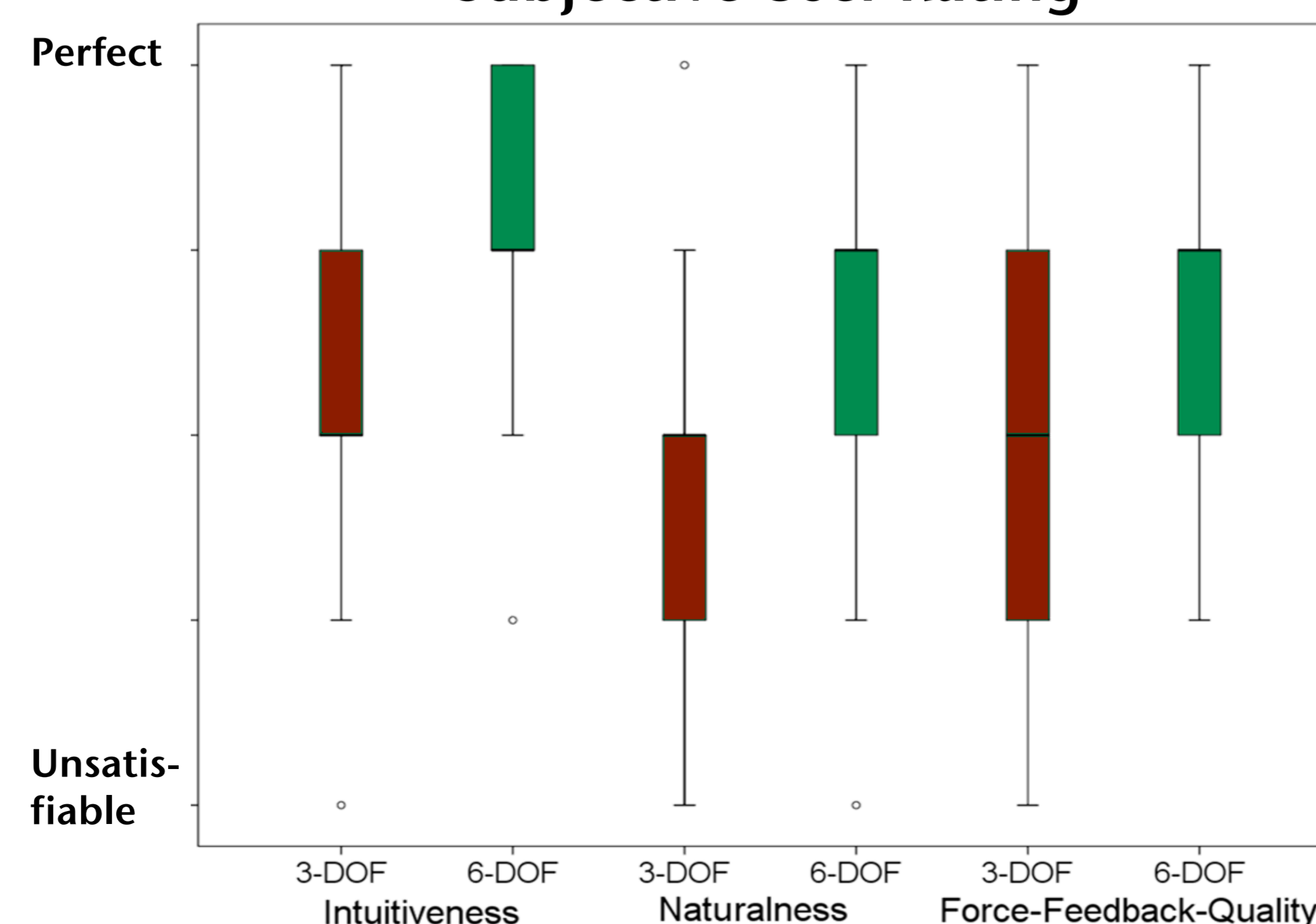
## Results

- 6 DOF force feedback devices **outperform** 3 DOF devices **significantly**, both in user **perception** and in user **performance**
- Significant **shorter training time** for 6 DOF
- **Higher efficiency** for 6 DOF
- 6 DOF provide significant better
  - **intuitiveness**
  - **naturalness** of the control
  - **quality** of the force-feedback

Required Training Time



Subjective User Rating



Device Efficiency by Distance

