Sensorimotor Learning in Environments with Unnatural Physics

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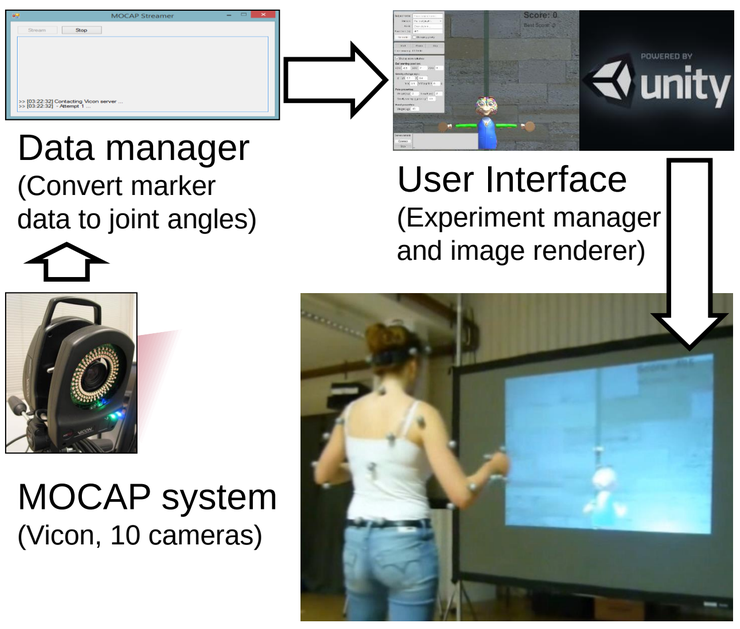
1. Introduction

- Hypothesis: Human motor control is influenced by an abstract internal representation of physics (e.g. Hamrick et al. 2001; Kaiser et al. 1985; Battaglia et al. 2013).
- This representation should be independent of the task.
- Consequently, novel tasks consistent with physical laws should be learned faster.

Question: Is learning slowed down for tasks with unnatural physics?

2. System Architecture



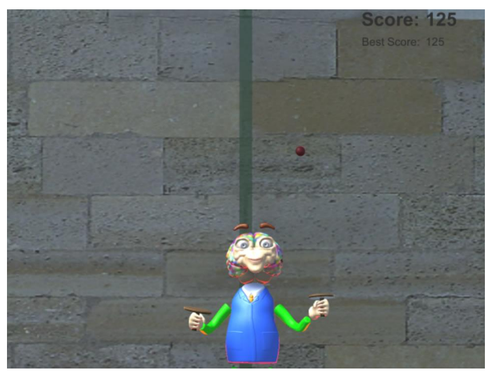
Data manager
(Convert marker data to joint angles)

User Interface
(Experiment manager and image renderer)

MOCAP system
(Vicon, 10 cameras)

3. Experimental setup

Tasks



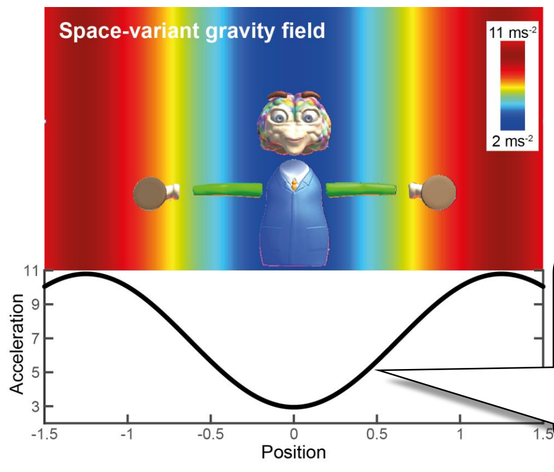
“Keep the ball in the air as long as possible by alternating between the juggling hands”

Scoring scheme:
- Encourages juggling height at ~2m
- Consecutive hits by the same hand are unrewarded

“Balance pole in upright position for as long as possible”

Scoring scheme:
- Highest score is assigned if the pole remains exactly upright

Unnatural physics

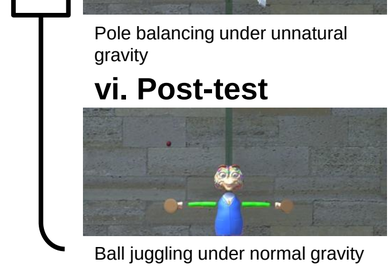


- Low gravity in centre
- Higher gravity (close to normal) on the sides
- Optimised for playability

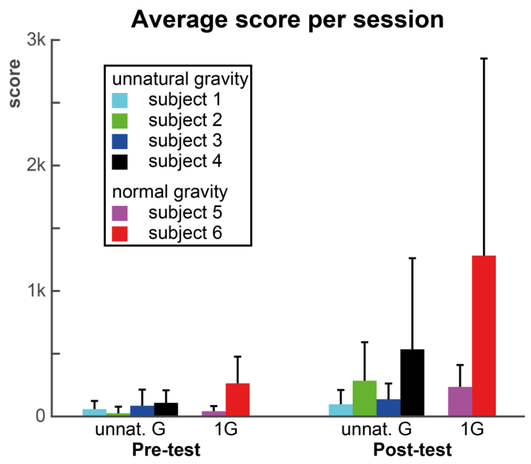
$$G = 9.81\left(\Delta y + A\sin\left(2\pi f x - \frac{\pi}{2}\right)\right)$$

Δy - gravity displacement scale
A - sin wave amplitude
f - frequency
x - distance from play zone centre

Protocol

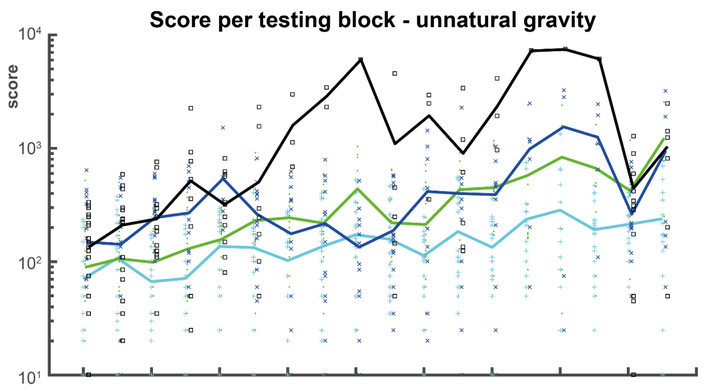


4. Adopting to the VR task

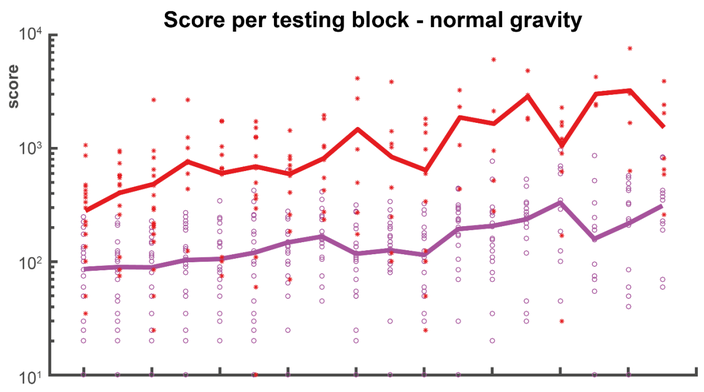


- Both subject groups learn the task in the pre-test phase of the experiment
- Learning process continues through the duration of the experiment

5. Learning the juggling task

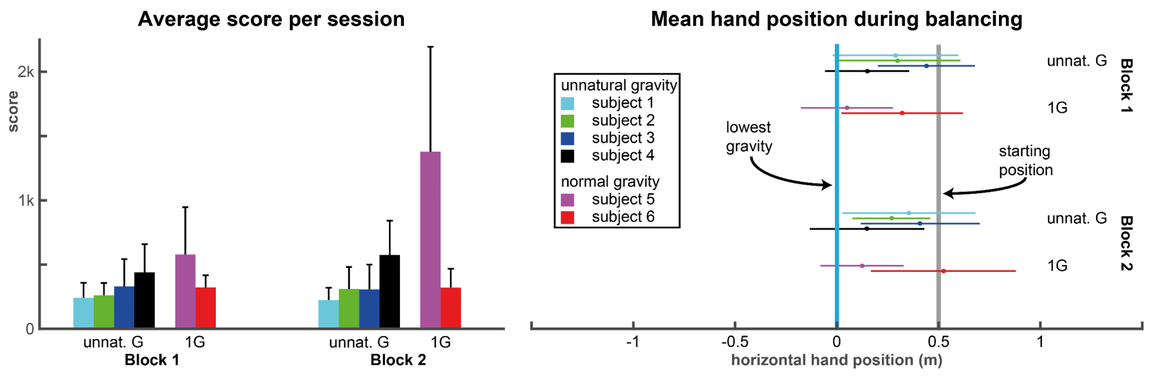


- Consistent learning in both groups
- Unnatural gravity group: Evident performance drop in last few trials, possibly due to fatigue or search for a new strategy



- Learning confirmed by other measures, e.g. maximum score per block, number of restarts per block or number of consecutive juggles

6. Transfer task



- No evident differences between groups in either score or average position for balancing the pole
- More subjects needed to draw conclusions

7. Conclusions

- **Both groups adapt to the task successfully**
- **Participants learned task easily in environment with unnatural physical law**
- **More subjects needed to investigate transfer of learned physics in between tasks**

Acknowledgements

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 604102 (HBP), Koroibot FP7-ICT-2013-10/ 611909, AMARSi- EC FP7-ICT-248311; DFG GI 305/4-1, DFG GZ: KA 1258/15-1; BMBF, FKZ: 01GQ1002A, FP7-PEOPLE-2011-ITN(Marie Curie): ABC PITN-GA-011-290011,CogIMon H2020 ICT-23-2014 /644727.

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