

Evaluating Haptic Feedback in Virtual Environments using ISO 9241-9

Robert J. Teather

Daniel Natapov

Michael Jenkin

Department of Computer Science and Engineering, York University, Toronto, Canada

www.cse.yorku.ca/~rteather, [~dnatapov](http://www.cse.yorku.ca/~dnatapov), [~jenkin](http://www.cse.yorku.ca/~jenkin)

Introduction

Target selection in VR

- Reaching/pointing motions, using 3D trackers

Fitts' law and ISO 9241-9

- Movement time (MT) given distance (A) and width (W) of targets:

$$MT = a + b \cdot \log_2 \left(\frac{A}{W} + 1 \right)$$

- Standardized evaluation of non-keyboard devices

- Calculate pointing throughput (TP) as:

$$TP = \frac{\log_2 \left(\frac{A_e}{4.133 \times W_e} + 1 \right)}{MT}$$

- Throughput allows comparison between devices, between studies

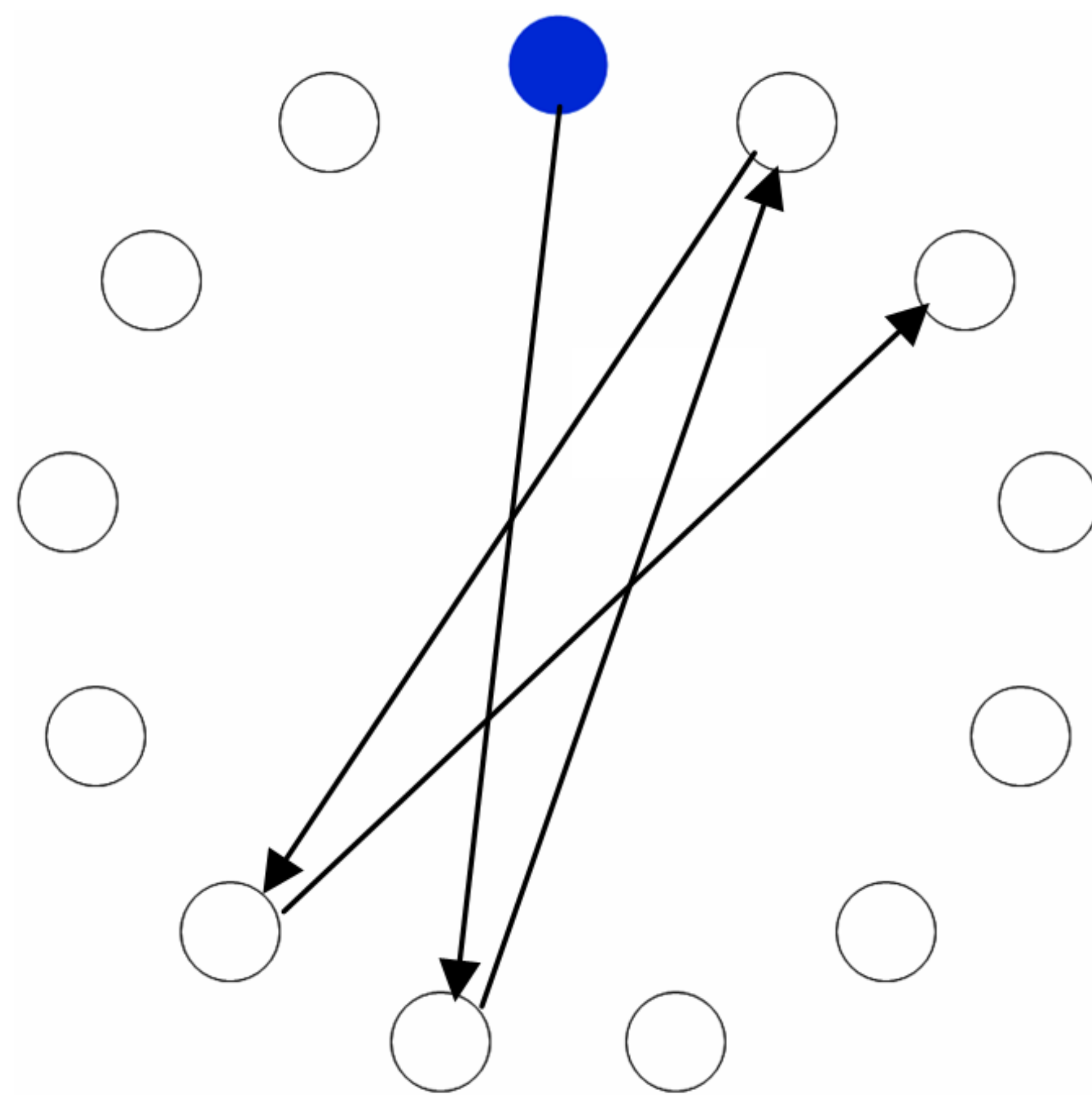


Figure 1. Standard ISO 9241-9 pointing task, in 2D.

Haptic feedback

- Shown to improve selection performance in VR
- Standardized evaluation not previously used

Main question: Can throughput detect the expected benefit of haptic feedback?

User Study

Objective

- Compare throughput in presence and absence of haptic feedback

Experimental Setup

- Twelve participants (7 male, aged 21 to 29)
- Used tracked stylus to select targets in a CAVE
- Transparent plastic panel co-located with spherical targets in haptic condition
- Participants clicked highlighted target

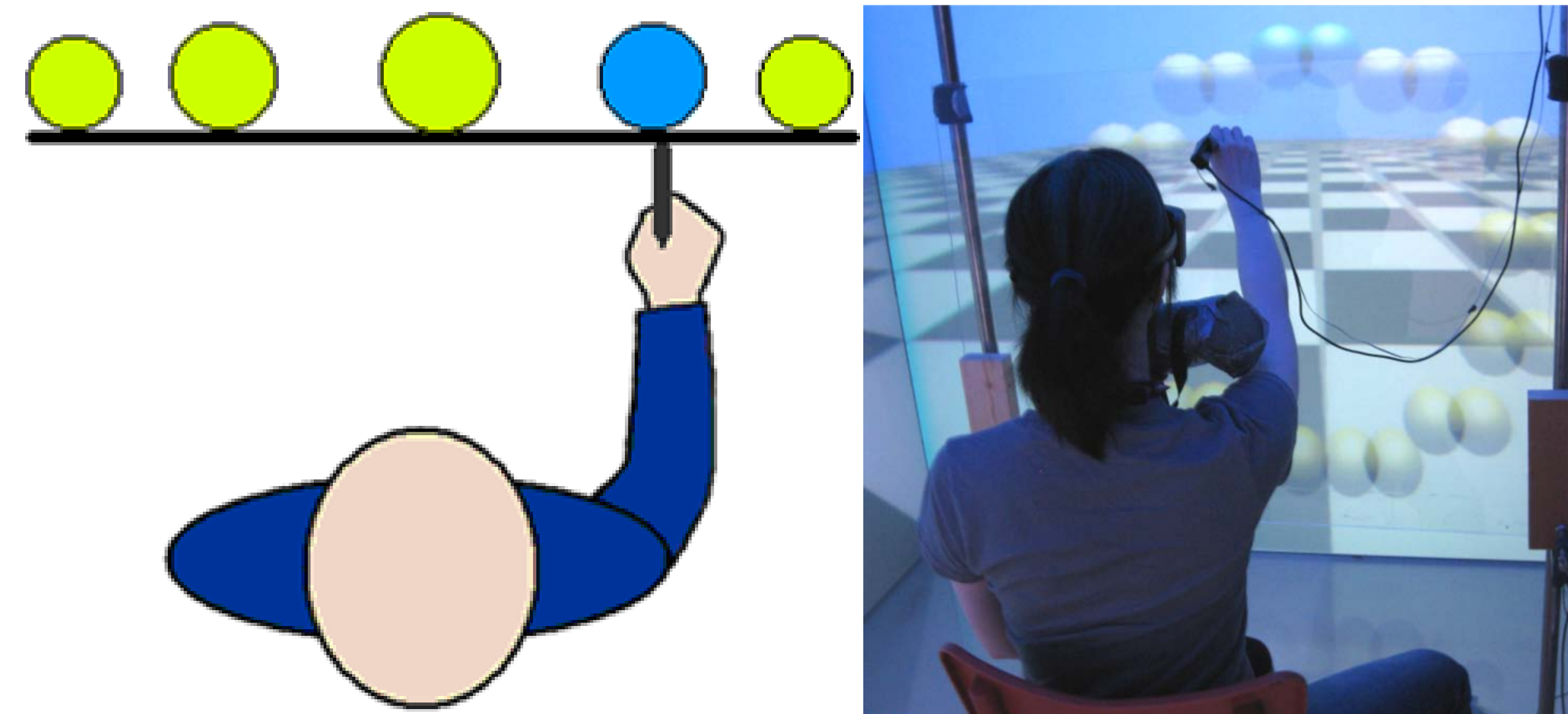


Figure 2. (Left) Relative positions of the participant, plastic panel, and the targets. (Right) Participant performing the task.

Independent variables

- 2 haptic feedback conditions: present or absent
- 3 target sizes: 2.8, 4.0, and 5.2 cm diameter
- 3 target distances: 22, 27, and 32 cm
- 3 blocks

Dependent variables

- Movement time (s)
- Error rate (%)
- Throughput (computed as above)

Results

Movement time – no significant difference

- Without haptics, 1.60 s (SD 1.17 s)
- With haptics 1.59 s (SD 0.99 s)

Error rate – no significant difference

- Without haptics, 13.3% (SD 7%)
- With haptics 11.1% (SD 6%)

Throughput – **significant difference**

- Without haptics, 2.37 bps (SD 0.74 bps)
- With haptics, 2.56 bps (SD 0.76 bps)
- $F_{1,11} = 6.47, p < .05$

Motion trail analysis

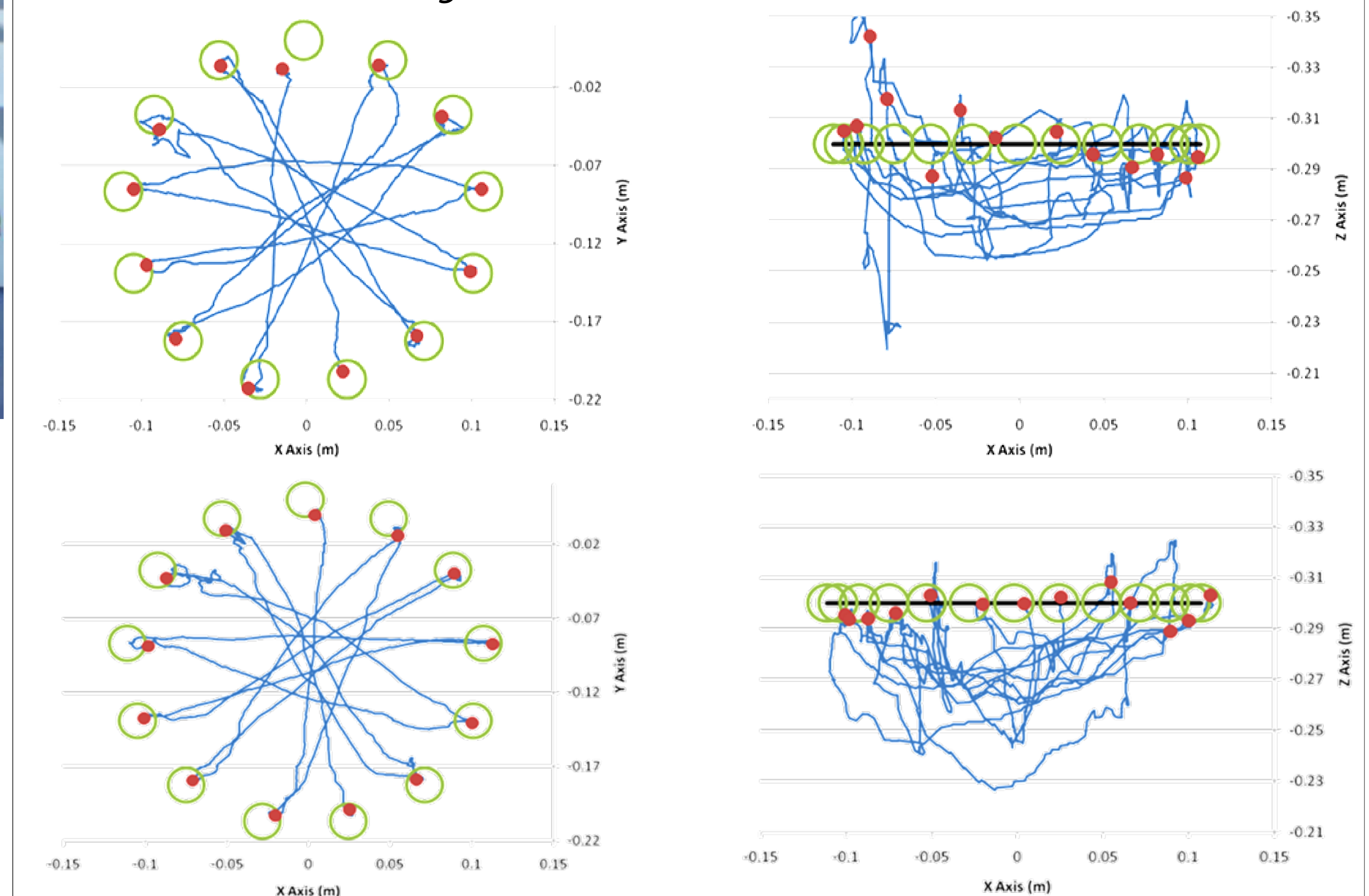


Figure 3. (Top) Without haptics. (Bottom) With haptics. Green circles: target position. Red dots: clicks. Blue trail: motion path.

Conclusions

- Throughput elicits differences between conditions
- Standard improves comparability of study