Changing ports: The role of motor task variation

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Introduction

- Laparoscopic tools are 1st order sliding levers which are inserted through a port in the abdominal wall while the workspace is viewed remotely on a visual display (Fig. 1).
- The physical properties of laparoscopic tools require surgeons to learn complex visuomotor mappings which vary with port position.
- When port position is changed, different limb movements and forces are required to elicit the same visual outcome.
- Exposure to a variety of visuomotor mappings improves learning of a novel mapping (Braun et al., 2009).
- Here we examine the hypothesis that exposure to a range of ports can improve later performance on a novel port.

Figure 1: The laparoscopic environment

Methods

- A tablet laptop running bespoke software (Culmer et al., 2009) was placed in a laparoscopic box trainer. A laparoscopic grasper was used to guide cursor on a remote display (Fig. 2A).
- Participants completed 30 training trials consisting of 20 movements to sequentially appearing targets (Fig. 2C). Participants were instructed to "move along the line to each dot as quickly and accurately as you can".

Groups:
Surgically naïve participants (N=19; 10 male; age 16-31) were split into two groups. A baseline aiming task demonstrated equal performance between groups.
- **Group S (N=10):** Completed Training through port P1 (Fig. 2B).
- **Group M (N=9):** Completed Training through ports P1, P2, P3 in a pseudo-random order.

Test:
- 24 hours after training participants completed 14 Test trials identical to those encountered in previously. However, all participants completed these trials through novel port site T1.

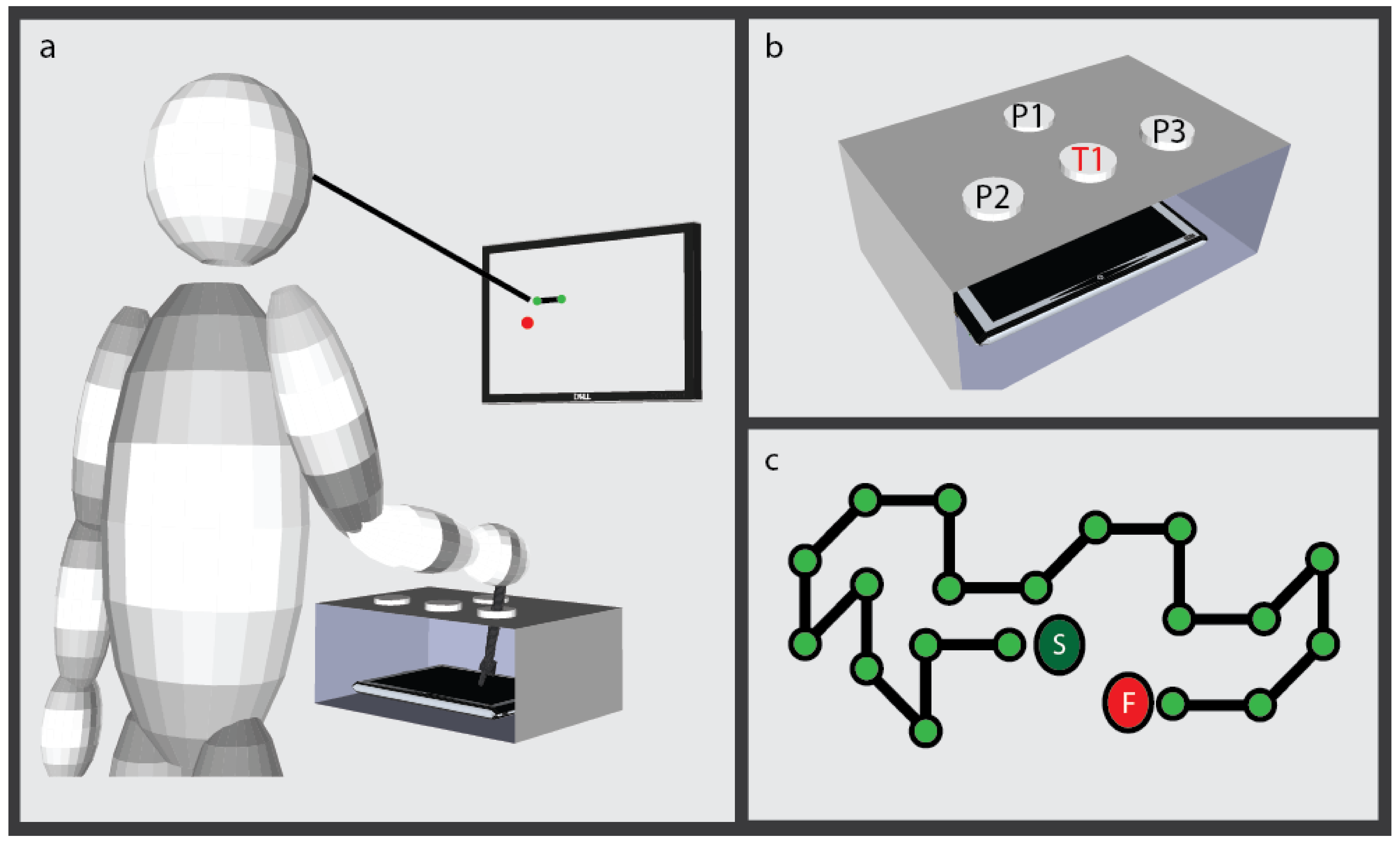

Figure 2: A) The experimental set up. B) Four ports were used throughout the study. Group S trained only with ports P1, while Group M trained with P1, P2, P3. Test trials were performed using port T1. C) A total of 20 movements were made during each learning and test trial. Dots appeared sequentially such that only the current and the next target dot were visible.

Results

Measures:
1) Movement time (MT; time taken to move from one dot to the next).
2) Path length (PL; length of the path from one dot to the next).
3) Speed Accuracy Composite Function (SACF: MT X PL).
4) Normalized Jerk (NJ; derivative of acceleration, normalized with respect to movement length and duration).

Analysis
- Performance at Test was compared between groups using independent t-tests.
  - **Group M** showed a statistically reliable performance advantage over **Group S** as indexed by **SACF** (t(17)=2.23, p<0.05; Fig.3A).
  - While there was no group differences in **PL** (t(17)=.29, p>0.05; Figure 2C), **Group M** showed reduced **MT** compared to **Group S** (t(17) = 2.29, p<0.05; Fig. 3D).
  - **Group M** displayed smoother movements as indexed by **NJ** (t(17)=2.23, p<0.05; Fig. 3B).

Results – cont.

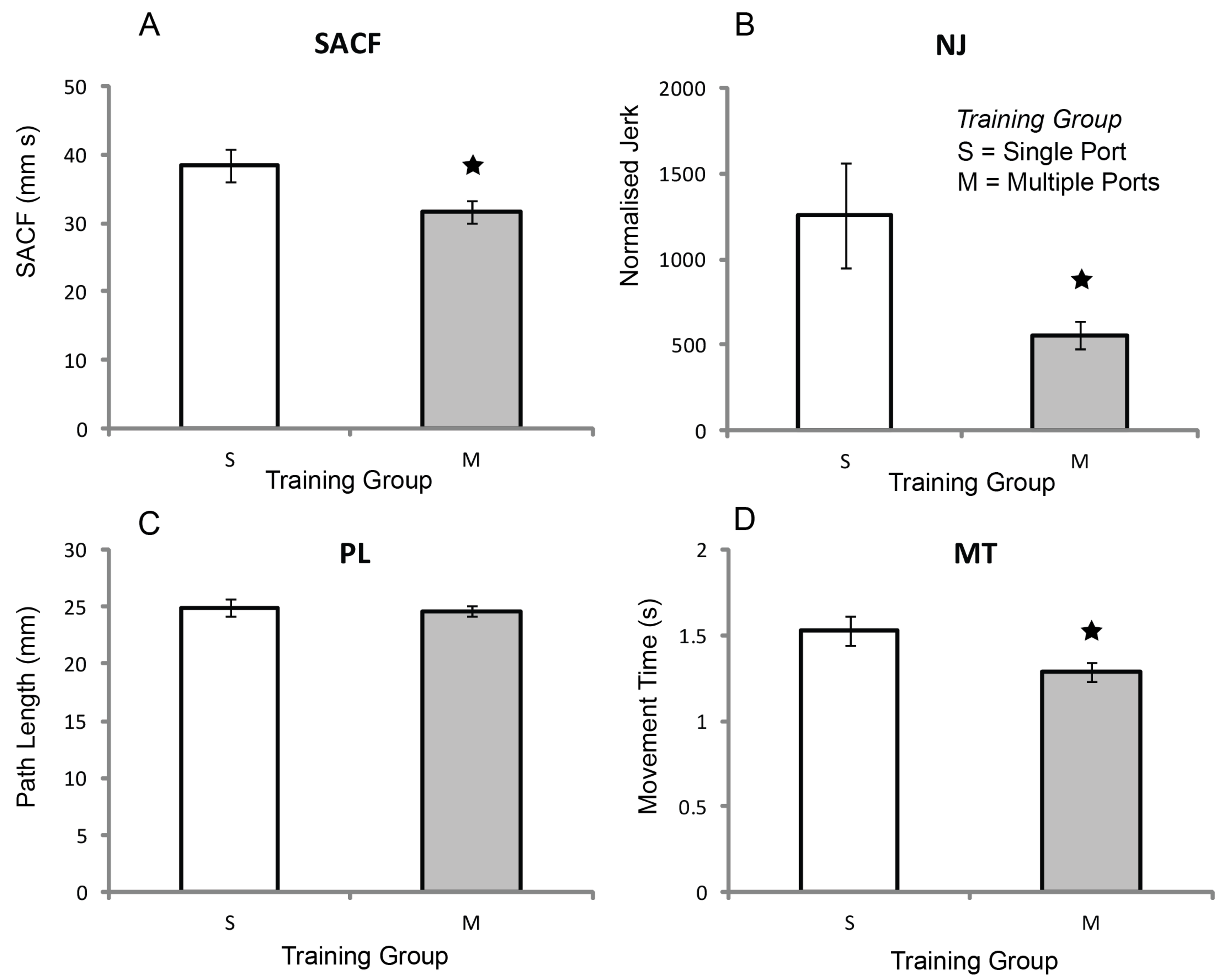

Figure 3. Performance measures A) Speed Accuracy Composite Function (SACF), B) Normalized Jerk (NJ), C) Path Length (PL), D) Movement Time (MT). Bars = SEM.

Conclusions

- Performance at the novel port site was best after training on with multiple port site.
- This finding may reflect structural learning mechanisms which allow the CNS to extract information about how task parameters co-vary in order to improve future learning (Braun et al., 2009).
- Given the stochastic nature of the laparoscopic environment, surgical training should incorporate motor task variation. Surgical simulators should be designed to allow parametric variation of surgically relevant variables.

References

References: Braun DA, Aertsen A, Wolpert DM, et al. Motor task variation induces structural learning. *J Neurosci* 2009; 29(20):6472-8.
Culmer PR, Levesley MC, Mon-Williams M, et al. A new tool for assessing human movement: The Kinematic Assessment Tool. *J Neurosci Methods* 2009; 184(1):184-192.