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# Force-field guidance in learning kinematic transformations

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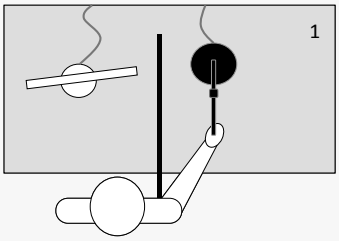
## INTRODUCTION

The HUMOUR project (Human behavioral modelling for enhancing learning by optimizing human-robot interaction) investigates and develops efficient robot strategies to facilitate the acquisition of motor skills. We present initial findings of our experiments on force-field guidance in learning to point with a visuo-motor transformation in effect. We chose a visuo-motor rotation of medium difficulty and three different guidance conditions: (a) no guidance (control condition), (b) target guidance, i.e., the manipulandum (PHANToM™ haptic interface) is attracted towards the target position, and (c) path guidance, i.e., the manipulandum is attracted towards the straight line linking start and target position.

## METHOD

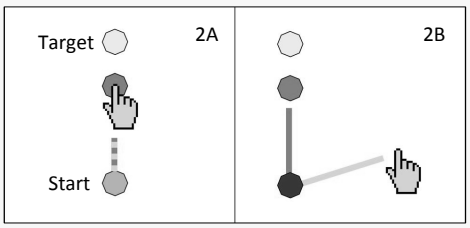
1 EXPERIMENTAL SETUP

Subjects were seated in front of a video screen (cf. 1). With their right hand, which was masked by a black curtain, they operated the manipulandum (PHANToM™ haptic interface).



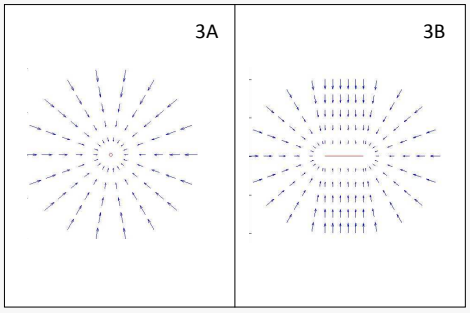

2 TASK AND TARGETS

In each trial the subjects' task was to move a cursor to one of 8 different, concentrically arranged targets. Without transformation, hand and cursor would move into the same direction (cf. 2A), whereas under visuo-motor transformation (cf. 2B) the cursor was rotated by 75°, so that the hand and cursor paths deviated.




3 CONDITIONS

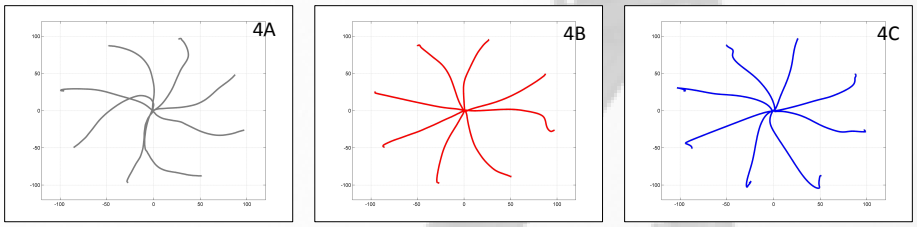
There were three experimental conditions. Subjects performed the task either with no guidance, with target guidance (cf. 3A), or with path guidance (cf. 3B).



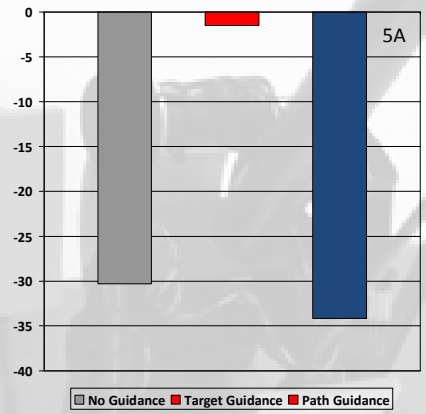

## RESULTS

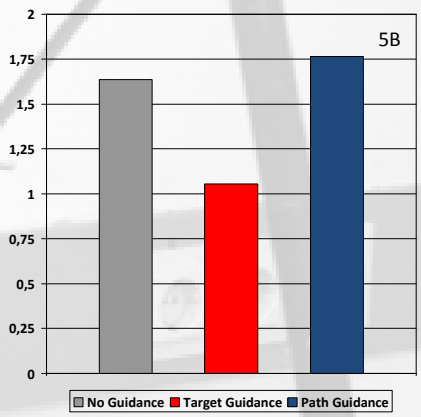
4 LEARNING

Figure 4 shows example trajectories of one subject per condition. About halfway through the practice period, trajectories under the no-guidance condition (cf. 4A) were still strongly curved, whereas they were much straighter under the target-guidance (cf. 4B) and path-guidance conditions (cf. 4C).



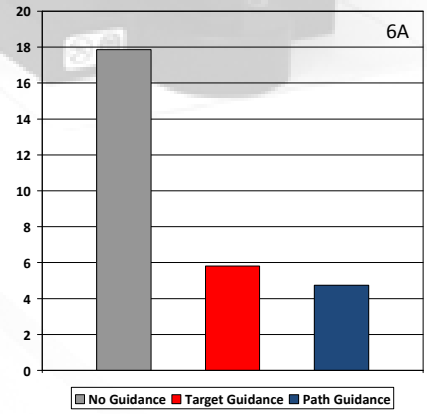

During the practice period performance measures such as initial direction error (cf. 5A) and movement time (cf. 5B) revealed a clear advantage for target guidance. In both conditions without guidance and with path guidance active movement production is more important, and initial directional errors were larger and movement time was longer.

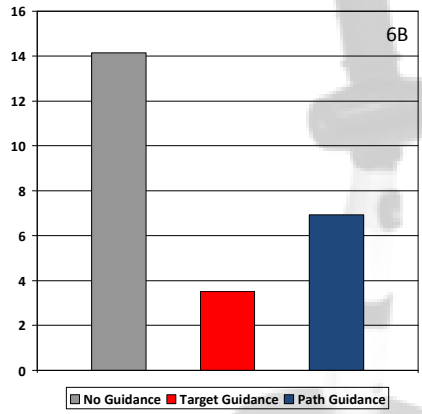



5 AFTER-EFFECTS

During practice visual feedback of the cursor position was available, so that subjects could reach the target accurately on every trial. After the practice period they had to perform some open-loop trials (i.e. the cursor was invisible) without visuo-motor transformation. After-effects revealed under this condition are considered to represent successful adaptation to the novel visuo-motor transformation. For both initial directional error (cf. 6A) and final direction error (cf. 6B) a clear advantage for the no-guidance condition was found.




## CONCLUSIONS

Our preliminary findings show a beneficial effect of target guidance on performance, but a detrimental effect of both target and path guidance on learning. Although path guidance requires active movement production during practice, which is not the case for target guidance, learning with path guidance was poorer than learning without guidance nevertheless. A potential key factor, which distinguishes guided from unguided practice, is the presence of errors and error feedback. Our goal is to enhance the guidance algorithms in a way that they facilitate both performance and learning.

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