The nature of the training effects of mental rotation : the limit for transfer to novel orientation

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INTRODUCTION

Repeating mentally rotating a figure increases the speed of mental rotation of the figure (Bethell-fox & Shepard, 1988). Although there are some studies about what causes the training effects (e.g., Wallace and Hofelich, 1992; Tarr and Pinker, 1989; Heil et. al., 1998), the underlying mechanisms remain unclear.

We investigated whether the training effects of mental rotation transfer to un-trained orientation and un-trained direction. If the training effects depend on the orientation of the figure, it is suggested that the training improves **retrieving the representation of the figure in respective orientation**. If the direction dependent training effects are observed, it is suggested that the training improves **rotation process**.

METHOD

Participants

35 (14 females) students aged 19-24 years old (mean age was 21.9 years old) were participated. They had normal or corrected-to-normal vision.

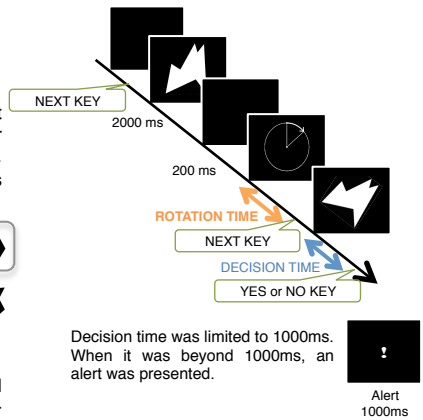
Stimulus

2 sets of 2D polygons were used. Each set has 4 polygons. One set was used for training, and the other was used for test. The assignment of the figure sets was counterbalanced across the participants.

Tasks

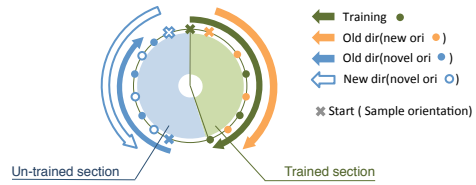
Participants performed the mirror-normal discrimination task. They pressed the left-arrow key when they saw normal figure and pressed the right-arrow key when they saw mirror-reversed figure, as quickly and accurately as possible.

Procedure



Decision time was limited to 1000ms. When it was beyond 1000ms, an alert was presented.

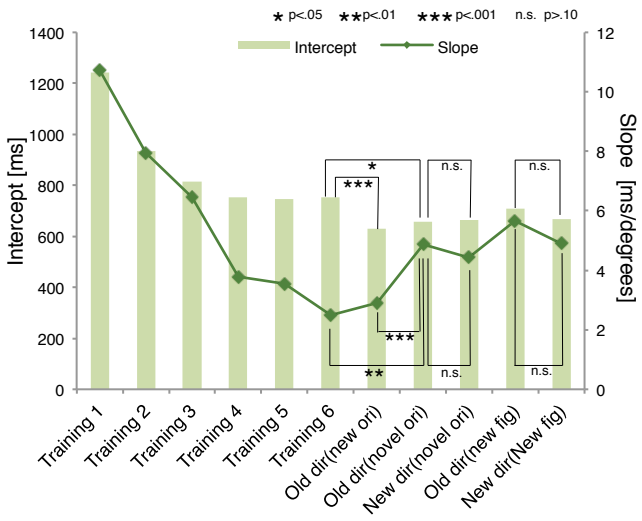
Design



	Conditions	Factors: Direction	Orientation	Figure
Training	Training	Old	Old	Old
Test	Old dir(new ori)	Old	New	Old
	Old dir(novel ori)	Old	Novel	Old
	New dir(novel ori)	*New*	Novel	Old
	Old dir(new fig)	Old	—	**New**
	New dir(new fig)	*New*	—	**New**

RESULTS AND DISCUSSION

5 participants were excluded from the analyses; a participant who did not finish the experiment and 4 participants whose decision time depended on the orientation more than rotation time did, suggesting that they rotated in the decision time despite they were instructed to rotate in rotation time. Only trials with correct responses were included in the analyses. We calculated slopes and intercepts of rotation time for each participant for each condition. The mean error rate was 6.85%.



About Orientation

The slopes and the intercepts showed a significant main effect within the one factor ANOVA (3 levels; Training 6, Old dir (new ori) and Old dir(novel ori)) [slope: $F(1,29)=36.850$, $p< .001$, intercept: $F(1,29)=10.277$, $p<.01$].

Multiple comparisons revealed significant differences for slopes and intercepts (see figure). The slope for Old dir(novel ori) condition was larger than that for Training 6 and Old dir(new ori). This suggests that the training effects well transfer to the orientation covered in the training and poorly transfer to the orientation not covered. Since intercept is considered to reflect encoding for preparing rotation for each figures, it is suggested that encoding process was continuously improving in the test phase.

About Direction

There is no significant difference between Old dir(novel ori) and New dir(novel ori) nor between Old dir(new fig) and New dir(new fig). This means that the training effects do not depend on the direction.

CONCLUSION

We investigated the transfer of the training effects of mental rotation to un-trained orientation and un-trained direction. Results were that the training effects transfer to the new orientation of the trained figure, but not to the novel orientation. They also transfer to un-trained direction of rotation. This suggests that the training of mentally rotating **improves the retrieving process** of the figures and **not rotating process**.