

# Embodied mental rotation: A special link between egocentric transformation and the bodily self

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## Introduction

In mental rotation there are two different classes of mental transformation strategies, which seem to represent different cognitive operations: object-based and egocentric transformations (Zacks, Mires, Tversky, & Hazeltine, 2002). Whereas in object-based transformations the observer's position remains fixed, in egocentric transformation tasks participants are asked to mentally change their own perspective (Devlin & Wilson, 2010). This study was conducted to investigate the involvement of motor processes in both transformation types against the background of the embodiment-approach. The key idea of this renewed viewpoint is that many cognitive processes that were formerly defined as purely "cognitive", are also deeply rooted in body-related experiences with the environment. Based on the previous literature, egocentric rotations are supposed to be embodied to a higher extent (Kessler & Thomson, 2010). The investigation of this issue contained the recruitment of motor experts vs. non-motor experts to alternate the degree of motor expertise. Furthermore, by analyzing stimuli using the own versus another person's body, we wanted to examine if the embodiment is more distinct in egocentric transformations than in object-based rotations.

## Goal of the Study

- 1.) We predicted that motor-experts should outperform non-motor-experts especially in egocentric transformations which are assumed to be more embodied.
- 2.) We expected that a self-advantage resulting in faster reaction times and a higher accuracy is more pronounced for egocentric transformations, and less pronounced or even reversed for object-based transformations.

## Method

### Participants

- Eighty-nine adults between 18 and 32 years old participated in this study, 42 motor experts recruited from an athletic group (*mean age* = 22.43, *SD* = 1.9) and 39 non-motor experts referred to as the non-athletic group (*mean age* = 22.67, *SD* = 2.7).
- The motor experts differed from non-motor experts in the amount of training sessions by practicing more often (4.9 times/week on average, *SD* = 1.3) than the non-athletic group (1.03 times/week, *SD* = 0.96),  $F(1,80) = 206.46$ ,  $p < .001$ ,  $\eta_p^2 = .74$ .

### Material

#### Mental rotation test:

- Chronometric mental rotation test (cMRT) with four different conditions: 1) object-based-other, 2) object-based-self, 3) egocentric-other, 4) egocentric-self, presented in four separate blocks, as illustrated in Figure 1.
- Object-based vs. egocentric transformations  
For the object-based task, two pictures of the same kind of stimuli were presented side-by-side in the centre of the computer screen (see Figure 1, left). The two stimuli were presented pairwise in five different angular disparities of 0°, 45°, 90°, 135° or 180°, in which the right stimulus was obtained by the rotation of left stimulus, resulting in a same-different judgment. In the egocentric condition only one figure was presented which raised either the left or right arm. Therefore, a left-right decision was required.
- Self vs. other trials
  - In the "self" trials, the experimental stimulus consisted of an image of their own body. In contrast to this condition, the "other" trials consisted of pictures of another person that was matched in gender and clothes.

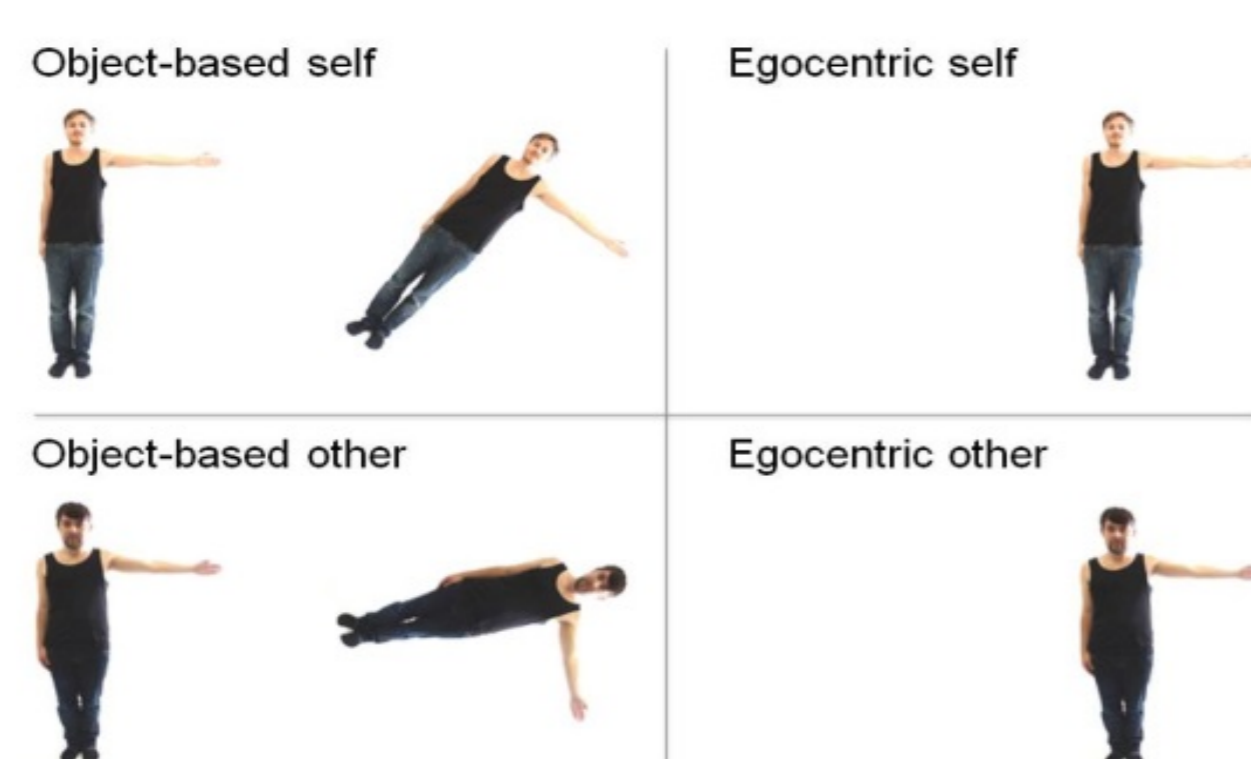


Figure 1: Examples of the stimulus material

## Results

### Reaction time: Object-based transformations

- The repeated-measures analysis of variance revealed a main effect of "stimulus type",  $F(1, 79) = 15.50$ ,  $p < .001$ ,  $\eta_p^2 = .16$ .
  - The main effect of "stimulus type" indicates that participants took longer to solve the self-condition ( $M = 1268.9\text{ms}$ ,  $SD = 45.9$ ) compared to the other-condition ( $M = 1158.9\text{ms}$ ,  $SD = 32.9$ ).

### Reaction time: Egocentric transformations

- The repeated-measures analysis of variance revealed a main effect of the factor "group",  $F(1, 79) = 8.45$ ,  $p < .001$ ,  $\eta_p^2 = .09$ .
  - The main effect of "group" indicates that motor-experts ( $M = 942.0\text{ms}$ ,  $SD = 41.1$ ) solved egocentric transformations faster than non-motor experts ( $M = 1114.1\text{ms}$ ,  $SD = 42.6$ ).

Table 1  
Main effects for the factors "group", "view" and "stimulus type" for object-based and egocentric transformations (Mean RT and SE)

|               |                   | Transformation  |      |                 |      |
|---------------|-------------------|-----------------|------|-----------------|------|
|               |                   | object-based    |      | egocentric      |      |
| group         | motor experts     | 1220.9ms (51.9) | n.s. | 942.0ms (41.1)  | *    |
|               | non-motor experts | 1206.9ms (53.9) |      | 1114.1ms (42.6) |      |
| stimulus type | other             | 1158.9ms (32.9) | **   | 1029.2ms (30.9) | n.s. |
|               | self              | 1268.9ms (45.9) |      | 1026.9ms (30.9) |      |

\*=  $p < .05$ ; \*\*=  $p < .001$ ; n.s. = non significant at the .05 level

## Discussion

Results show a benefit of motor expertise and representations of another person's body, but only for the object-based transformation task. That is, the other-advantage diminishes in egocentric transformations. Since motor experts didn't show any specific expertise in rotational movements, we concluded that using human bodies as stimulus material elicits embodied spatial transformations, which facilitates performance exclusively for egocentric transformations. Regarding stimulus material, the other-advantage ascribed to increased self-awareness-consciousness distracting attention-demanding resources, disappeared in the egocentric condition. This result may be due to the stronger link between the bodily self and motor representations compared to that emerging in object-based transformations.

## References

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