Spatial representations affect mental rotation performance and its strategies

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BACKGROUND & HYPOTHESES

Spatial abilities, by definition, extend from very trivial tasks like moving without bumping into furniture to reading a map or driving. In order to carry out these tasks we continuously process spatial information. And through the process we end up creating spatial mental models upon which we rely on for later use. Factors such as our preferences, representations, and strategies are suggested to affect the way we process spatial information. The current study, based on the previous work (Bijge & Taylor, 2016), investigates the underlying reasons for possible performance difference in spatial tasks.

Habitual use of spatial information: Survey vs. landmark perspectives

From very early on we learn to think about space in certain ways: how we prefer to receive spatial information and how we mentally represent this knowledge, a term we coined as habitual spatial thinking (Bijge & Taylor, 2016). Information could be processed at a more global level via survey perspective or at a more local level via route or landmark perspective. Pazzaglia and De Beni (2001) designed a questionnaire to categorize people as having survey-, route-, and landmark-centered representations. People who have survey-centered representations might be more comfortable with maps when learning new environments and the ones who rely more on landmark-representations might prefer verbal directions. The resultant mental representations are also related to performance on spatial tasks. People with a tendency to create survey-representations scored better on a mental rotation test compared to individuals who basically took a landmark or route-centered approach (Pazzaglia & De Beni, 2001).

Mental Rotation (MR) Task

One of the most commonly used tests to assess spatial ability is the mental rotation (MR) task. In classic MR experiments (Shepard and Metzler, 1971), participants decide whether two figures are the same or mirror images of one another. The most common finding is the decreased rotation rate and accuracy ratio with the increase in angular disparity between the figures. The other common finding is outperforming women in rotation (Jinn & Peterson, 1985; Lipps, Collar, & Peters, 2010; Voyer, Voyer, & Bryden, 1995). In reality this male advantage may be more ethereal. Some studies have found no sex difference (Butler et al., 2006; Jansen-Osmann & Holt, 2007; Jordan et al., 2002) and in other studies women were faster than men (Moë, 2009). Variability in MR sex differences suggests that other factors may contribute to MR performance.

Possible factors leading to differential MR performance

Strategies in MR: Two MR strategies have been proposed in the literature to account for this difference: holistic, and piecemeal (Kail, & Carpenter, 1979; Strasser et al., 2010). With holistic processing, the figure is rotated as a whole; with piecemeal, it is broken down into parts that are rotated separately. Moreover, men were suggested to use a holistic strategy and women are proposed to take a piecemeal approach to MR problems. If women and men use different strategies, this should be observed with response patterns in MR.

Stimuli characteristics: Participants viewed 3D cube figures that were either whole objects, akin to Shepard and Metzler's original figures, or the same figures cut in half to facilitate a piecemeal strategy (Bijge & Taylor, 2016; Naylor, Taylor & Cross, 1998). If MR performance differences relate to strategy choices, stimuli promoting either piecemeal or holistic processing should interact with the utilized strategy.

Current research

The current research, based on the previous work from Tufts University and WPI, investigates various factors such as stimulus characteristics mimicking possible strategy use and mental representation on MR performance. The present study examines an all women group from Istanbul Sehir University hypothesizing that the way we habitually represent spatial information could be a main factor in MR performance difference.

PREVIOUS WORK

Participants

1) Eighty-nine Tufts undergraduates (38 women and 51 men; 26 verbal, 63 map preference; 26 landmark, 20 survey representations) participated for partial course credit.
2) Fifty-three Tufts undergraduates (35 women and 18 men; 13 verbal, 40 map preference; 28 landmark, 35 survey representations) participated for partial course credit.
3) 110 undergraduates (60 women and 50 men; 62 landmark, 48 survey representation) at Worcester Polytechnic Institute (WPI) participated for partial course credit.

Procedure

Participants were presented with both whole and cut versions of 3D figures. Along with the MR task, they also completed a number of questionnaires. Through:
• Preferences Questionnaire, participants preferred maps or verbal directions when learning new layouts.
• Mental Representation Questionnaire (Pazzaglia & De Beni, 2001), participants were categorized to represent space with a survey- or landmark-perspective.

Results and Discussion

Overall,
• Angular disparity effect was observed across all experiments.
• Men rotated more accurately.

Whole figures were more efficiently rotated than cut figures. Moreover, they mimicked the pattern of cognitive strategies with more observed difference at greater degrees of rotation.
Participants who preferred maps over verbal directions were faster and more accurate at greater degrees of rotation, again mimicking distinct strategies.

RESULTS & DISCUSSION

Overall, whole figures were not rotated more accurately than cut figures. There was an interaction between Figure Type (whole vs. cut) and Angular Disparity. Participants’ rotation accuracy differed across whole and cut figures. At smaller angular disparities, participants rotated whole figures more accurately. However, at 120°, 150°, and 180°-degrees of rotation the pattern flipped and they were more accurate to cut figures.

As hypothesized, preliminary analyses showed differences among participants who mainly used landmark and survey representations, especially at greater degrees of rotation. Participants who were categorized as creating survey-representations were faster at higher degrees of rotation, as opposed to the ones with landmark-representations.

Taken together the current research enhances findings on factors contributing to MR performance. First factor was the different features of the stimuli. This experiment extended previous MR studies by introducing strategy-consistent stimuli (namely, cut versions of whole figures). Second factor was the way people habitually thought about spatial information including MR. Third factor was the interaction between Stimulus Type and Habitual Spatial Thinking. The combination of factors examined here is new to the literature.

In the literature, women were suggested to use a piecemeal strategy with MR and to rely more on landmark representations. However, the variation within the group indicates that there could be other factors accounting for MR performance. Drawing a possible link between how we come to habitually think about larger-scale environments and how we solve smaller-scale MR problems would be influential for future of spatial cognition.

CURRENT STUDY

Cognitive strategies used in MR problems were suggested to account for the variance in performance. Holistic strategy users rotate 3-dimensional figures as a whole whereas piecemeal strategy users rotate in pieces. However, there is not a direct link between sex and strategies, as suggested. Moreover, great variability in MR performance points to other possible contributing factors. Previous work found preference and mental representation to be those factors. The current study, therefore, investigates the effect of different mental representations on MR performance while keeping sex constant. If within an all women sample, different mental representations and strategies are found to affect MR performance it would suggest a link between habitual spatial thinking and MR.

Participants

Sixty-one women undergraduates from Istanbul Sehir University (28 survey, 33 landmark representations) were recruited in this experiment.

MR Stimuli

3-D block figures were presented in pairs. The pairs consisted of either whole figures or cut versions of the same stimuli. All the participants saw a block of whole figures and a block of cut figures, in counterbalanced order.

Mental Representation Questionnaire (Pazzaglia & De Beni, 2001) allowed participants to be categorized as creating more survey-representations, or landmark-representations when encountering larger scale environmental information.

Procedure

Participants completed the MR task first, which was then followed by the questionnaire.

Angular disparity effect was observed. Participants’ response rate (Figure on the left) increased and their rotation accuracy (Figure on the right) decreased. ADE shows that rotation performance is directly affected by the angular difference between objects.

REFERENCES

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