Visual-Spatial Abilities Are NOT Related to the Speed of Mental Rotation

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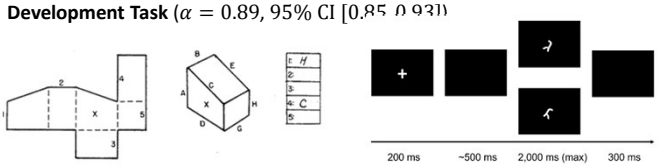
Individuals' reaction time (RT) slopes in tasks of mental rotation (Shepard & Metzler, 1971) have been found to be related to other measure of visual-spatial abilities, and thus are viewed as a psychometric measure of visual-spatial abilities (Harris et al., 2013). The common interpretation of individual RT slopes is as a measure of the speed at which the rotation is carried out (Searle & Hamm, 2017). However, EEG studies have found that the process of mental rotation continues after response selection has been carried out (Band & Miller, 1997; Heil et al., 1998), casting doubt on the interpretation of RT slopes as measures of the speed of mental rotation. So, are visual-spatial abilities related to the speed of mental rotation?

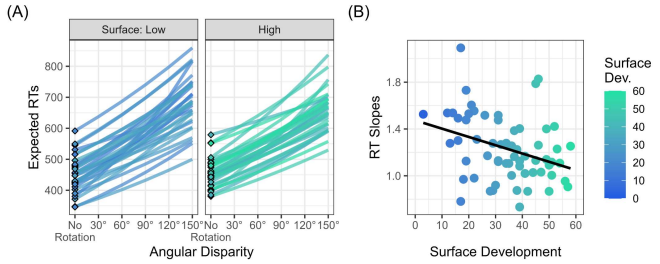
Method

- Sixty-two students (23 males (37%); $M_{age} = 24.24$ years, range [20, 26]).
- Completed **the Letter Rotation Task** while EEG activity was recorded.
- Visual-spatial abilities were measured by performance on **the Surface Development Task** ($\alpha = 0.89$, 95% CI [0.85, 0.93])



Assessing Individual Differences in Mental Rotation Speed Using ERPs

Behavioral Results

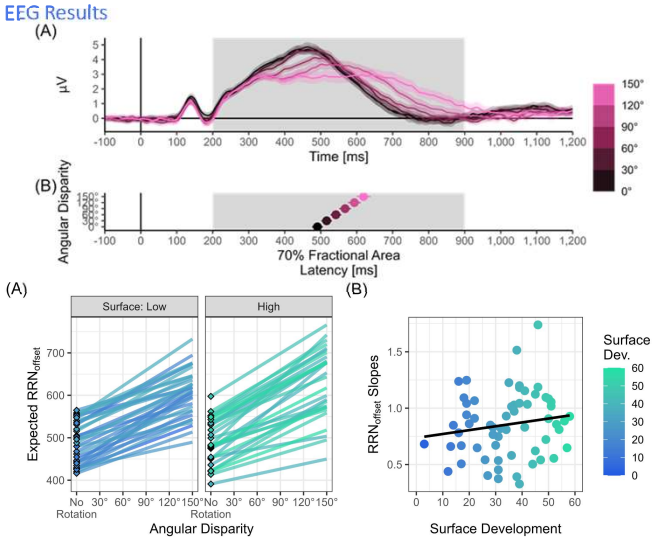


Results replicate the finding that better spatial abilities are related to reduced angle slopes.

Results suggest that individual difference in speed of mental rotation are not related to visual-spatial abilities!

Why then are we seeing this association behaviorally?

EEG Results



Behavioral Computation Models of The Effects of Angular Disparity

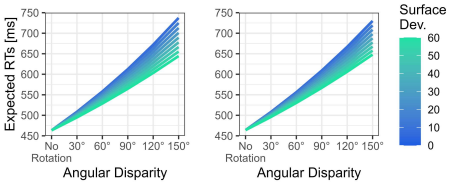
Comparing two computational models:

- Differential speed model (DSM):

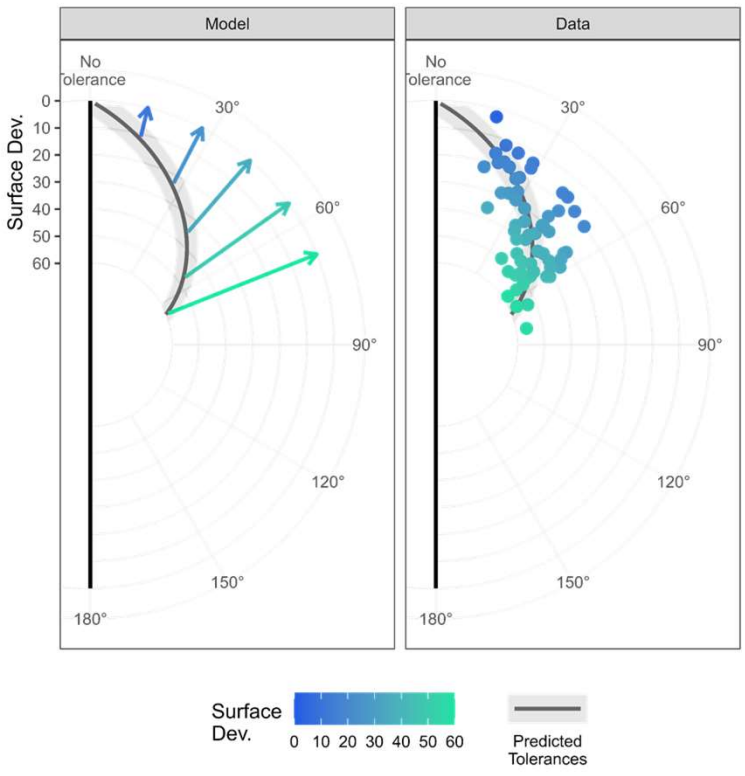
$$E[RT|Surface, Angle] = \theta_0 + (\theta_{price} - \theta_{D1} \times Surface) \times Angle$$

- Differential angle model (DAM):

$$E[RT|Surface, Angle] = \theta_0 + \theta_{price} \times \max(0, Angle - \theta_{D2} \times Surface)$$



The DAM is able to explain the observed behavioral pattern, and has a better fit than the DSM.



The Individual differences in visual-spatial abilities are related to **angular tolerances**, not speed of rotation!

Discussion

- Even simple tasks such a mental rotation, which on their face seem like simple unidimensional processes, are in fact complex, non-linear, and multifaceted.
- Cognitive processed are not purely sequential (McClelland, 1979; Moran et al., 2015; cf. Sternberg, 1969).
- We present here evidence **against** the common interpretation of RT slopes as reflecting the speed of mental rotation.
- Instead, the effect of angular disparity on RTs seems to reflect a different kind of efficiency in processing – one related to the degree by which a cognitive operation must be carried out to completion before a task-guided behavior can be successfully achieved.
- It is this (rather than speed) that is related to visual-spatial abilities.

References

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