Spatial Ability for University Biology Education

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Outline

• Visuospatial Abilities
  • Computer Tests to Measure Visuospatial Abilities
  • Mental Rotation and Mental Folding

• Spatial Ability Affects Biology Learning

• Biology Learning Affects Spatial Ability
  • Correlational data
  • Experimental data

• Conclusions
Visuospatial Abilities

• Working memory includes a visuospatial subcomponent\(^{(1)}\)

• The subprocessor is related to spatial ability\(^{(2)}\)
  • “Skill in representing and transforming symbolic or nonlinguistic information through space.”\(^{(3)}\)

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Computerized and Adaptable Tests to Measure Visuospatial Abilities in STEM Students

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Abstract. Performance in Science, Technology, Engineering, and Mathematics (STEM) disciplines can depend on the sub-abilities of spatial ability and visuospatial working memory. According to the STEM task, certain sub-abilities may be more important than others in predicting achievement. Similarly, some individual characteristics (e.g., gender) moderate some of these sub-abilities. For example, males on average have higher mental rotation spatial ability than females, whereas spatial working memory tends to be less prone to gender effects. In addition, the results of the tests measuring these sub-abilities can be changed by manipulating certain variables. We present a battery of nine computerized and adaptable instruments to measure these sub-abilities, with the aim of informing cognitive researchers about the processing abilities most vital for undertaking STEM tasks, and how they can be modified to suit learner characteristics.

Keywords: Spatial ability · Visuospatial working memory · STEM · Gender · Computer-adapted test

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Novel Virtual Card Rotations Test
Corsi Tapping Test

Visual Patterns Test

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Abstract. Studying and pursuing careers of Science, Technology, Engineering, and Mathematics (STEM) fields demand spatial ability. Completing a university degree in biology is no exception. The aim of this study is to summarize key findings showing that there is a two-way relation between university biology education and spatial ability. The first aspect of this relation is the most investigated: spatial ability facilitates learning biology. However, the other aspect is also possible: learning biology may improve spatial ability. We present empirical evidence to support both possibilities. The focus is on university biology, and the spatial abilities of mental rotation and mental folding (spatial visualization). We present findings showing that these spatial abilities affect university biology learning and achievement from textual and visual materials. We also present correlational studies and experiments showing that university biology learning positively affects mental rotation and mental folding.

Keywords: Biology · STEM · Spatial ability · Mental rotation
Mental folding and spatial visualization
Mental Rotation

2D or 3D
Mental Folding

Spatial visualization
Spatial Ability Affects Biology Learning

- 3D mental rotation
  - Multimedia cell biology

Spatial Ability Affects Biology Learning

• 3D mental rotation
  • Visualizations about fish locomotion patterns

Biology Learning Affects Spatial Ability

- Correlational data
  - 3D mental rotation

Biology Learning Affects Spatial Ability

• Experimental data
  • 3D mental rotation

Initial and Final Mean Medical Students’ Mental Rotation Test (MRT) Scores and Gender-Specific Scores at Boston University School of Medicine in 2008 and 2009

<table>
<thead>
<tr>
<th>MRT</th>
<th>Mean score (SD)</th>
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<tbody>
<tr>
<td>Initial MRT</td>
<td>26.1(^a) (±8.67)</td>
</tr>
<tr>
<td>Male (N = 166)</td>
<td>30.3(^a) (±6.90)</td>
</tr>
<tr>
<td>Female (N = 186)</td>
<td>22.3(^a) (±8.35)</td>
</tr>
<tr>
<td>Final MRT</td>
<td>31.6(^a) (±7.48)</td>
</tr>
<tr>
<td>Male (N = 112)</td>
<td>34.7(^a) (±5.86)</td>
</tr>
<tr>
<td>Female (N = 143)</td>
<td>29.3(^a) (±7.63)</td>
</tr>
</tbody>
</table>

Maximum score for MRT is 40 points.
\(^a\)P < 0.0001.

Conclusions

• Different visuospatial abilities
  • Different tests to measure them
  • Mental rotation (2D and 3D) and mental folding are common

• Spatial Ability Affects Biology Learning
• Biology Learning Affects Spatial Ability
  • Correlational data
  • Experimental data
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