The Development and Assessment of Cross-Sectioning Ability in Young Children

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Cross-sectioning, also referred to as "penetrative" thinking (Kali & Orion, 1996), is a particular spatial visualization skill that involves inferring a 2D representation of a 3D structure, and vice versa (Cohen & Hegarty, 2007). This imaginary slicing of a 3D object to a 2D plane is an essential skill for many of the sciences, ranging from anatomical cross-sections in biology and neuroscience to cross-sections of landforms in geology (Cohen & Hegarty, 2008). However, the development of cross-sectioning ability has not been uniquely identified in relation to other measures of spatial ability (e.g., mental rotation), in part because of a lack of adequate measures and the unknown age at which this ability emerges. Thus, we do not know the developmental trajectory of cross-sectioning skills and how this skill relates to spatial ability more broadly.

In our current study, we created a new method for assessing cross-sectioning skills in young children by using brightly colored foam shapes as the stimuli (see Figure 1 for the sample item). We also measured children's performance on a mental rotation task and the water-level task. Finally, we contrasted cross-sectioning performance using the real 3D objects with a 2D method using photographs of the actual shapes. Thus, we aim to successfully measure children's cross-sectioning skills to determine a) how cross-sectioning skills develop between the ages of 3 and 9 years, b) the association between cross-sectioning skills and other spatial reasoning tasks, and c) how the method of assessment impacts performance.

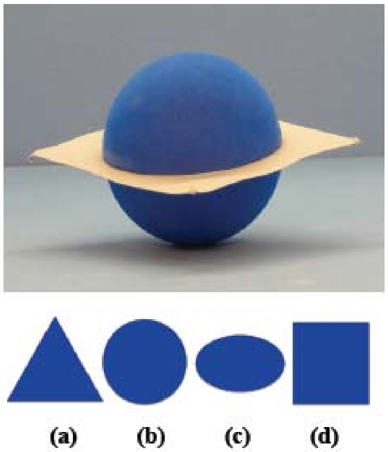

Figure 1. The sample cross-sectioning item shows a sphere bisected by an intersecting plane. Participants were asked to choose among four options to identify the resulting cross-section if the sphere were pulled apart.

Children successfully completed the cross-sectioning task using both the 3D and 2D methods. This suggests that children do reason about cross-sections and this ability can be assessed. Further, this ability develops over time as evidenced by a significant increase in performance with age. Difficulty of test items generally represented two categories: congruent items were easier in that the cross-section resulted in a similar shape to the overall object (e.g., cone cut vertically to result in a triangle cross-section), whereas incongruent items were harder due to the cross-section resulting in a different shape than the overall object (e.g., pyramid cut horizontally to result in a square cross-section).

Positive correlations between the mental rotation and cross-sectioning tasks were present across the 5 to 8 year age range. However, when controlling for age, mental rotation was not a significant predictor of cross-sectioning performance, which suggests these tasks are not measuring the *same* skills, particularly in children younger than 8 years old. Further, there was no significant correlation between performance on the cross-sectioning and water-level tasks. Thus, cross-sectioning ability is somewhat independent of both spatial perception and mental rotation. Additionally, there was a benefit of using the 3D task but only for 5-, 6-, and 7-year-olds. The 3- to 4-year-olds and 8- to 9-year-olds performed equally well using both versions of the task. We are currently examining if preschool children rely on a simple shape matching strategy rather than a spatial visualization process, and whether cross-sectioning is related to a more general spatial visualization skill by comparing cross-sectioning performance to performance on a version of a paper folding task that is appropriate for young children.