The Cognition and Learning Lab

INDIANA UNIVERSITY FALL 2024 NEWSLETTER

UNLOCKING EARLY LEARNING INSIGHTS

CONTENT AT A GLANCE

INTRODUCTION

Thank you for participating in research with the Cognition and Learning Lab this year! We have been very excited to start up in-person research studies at IU. Overall, our lab's research is devoted to learning about mathematical development throughout life, with a focus on early childhood. We are grateful to the families and school partners who have given their time and energy to make this research possible!

In this issue of our newsletter, we've included highlights from two studies aimed at understanding how children's spatial skills develop. In one study with pre-k to 3rd-graders, we found that children used a variety of strategies to solve proportional reasoning problems involving lengths, and that children who used more advanced strategies also did better on other assessments of math achievement. In another study of 1st to 4th-graders, children's spatial anxiety (the feeling of nervousness when doing spatial tasks) was related to lower mental rotation skill – but this occurred mainly for older children who were most skilled at remembering spatial information, and younger children did not show these relations. These results highlight the importance of investigating cognitive factors like strategies and memory, as well as emotional factors like anxiety to understand children's development of spatial skills. Since spatial skills are linked to success in science, technology, engineering, and math (STEM), these findings may help researchers and educators set children onto pathways to success in STEM.

In closing, thank you to everyone who has given their time so generously to these studies. Your participation is essential to answering these exciting research questions. We hope you find the information in this newsletter both interesting and useful. Our contact information is at the end of this newsletter if you have any questions. We wish you the best this year!

Sincerely,
Liz Gunderson, Ph.D.

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RESEARCH PROFILE

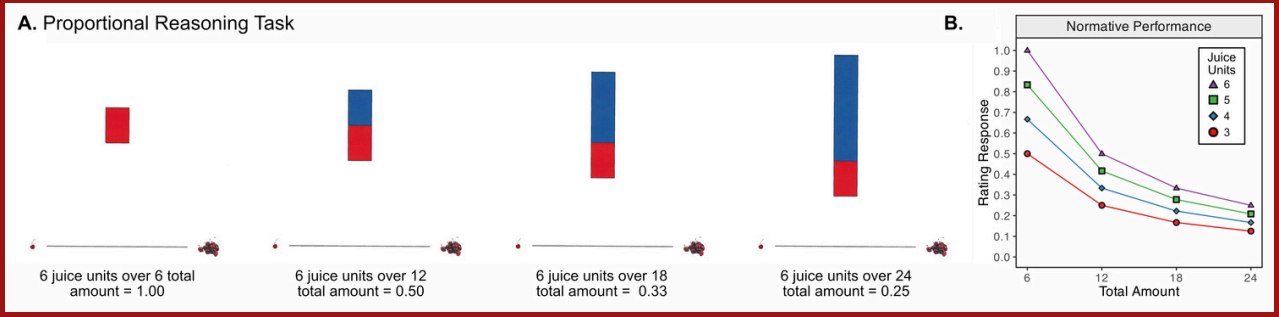
Roberto Abreu-Mendoza Ph.D., Postdoctoral Fellow

Early proportional reasoning relates to general math achievement in 4- to 8-year-old children

Years before learning about fractions, decimals, and percentages, children have a remarkable ability to work with proportions that are presented visually. For example, preschool children can make accurate guesses about the proportion of water and juice to know whether the taste will be right, and they can determine whether a child receives a fair number of cookies based on the number of cookies that a group of children received.

This ability is referred to as proportional reasoning and is a foundational ability for general math achievement and fraction understanding. However, instead of engaging in proportional reasoning, some children focus on the absolute quantities rather than the proportional ones. For instance, some children might think that a larger pitcher of strawberry juice will have a stronger strawberry taste than a smaller one, even if both have the same water-to-juice proportion.

To study the different types of strategies children use when working with proportions, 602 pre-k-to-third-grade students completed a proportional reasoning task and general math achievement and reading assessments. In the proportional reasoning task (Figure 1), children saw a proportion of water (blue segment) and cherry juice (red segment) represented as vertical red-and-blue bars.



RESEARCH PROFILE

Roberto Abreu-Mendoza Ph.D., Postdoctoral Fellow

Children judged how much the mixture would taste like cherries and showed their answer by marking a location on a horizontal line, where the left-hand side represented “not at all like cherries” and the right-hand side represented “very much like cherries.” Some proportions had the same amount of juice (red segment) but different amounts of water (blue segment), allowing us to study whether children were correctly focusing on the water-to-juice proportion or incorrectly focusing on the size of the bar or the size of just one segment of the bar.

Based on their performance, children were classified into four groups. One group engaged in proportional reasoning, correctly integrating the blue (water) and red (juice) segments. A second group paid attention only to the total size of the bar. Two other groups focused on the size of the red (juice) segments, but one underestimated the quantities while the other overestimated them.

The four groups of children showed different math achievement levels. Children who engaged in proportional reasoning --integrating the water and juice segments-- had the strongest math achievement levels, followed by children in the underestimation group. Remarkably, the groups that overestimated the red segment’s size or only focused on the total size of the bars had the lowest math levels. Finally, the groups were more similar in their reading abilities, suggesting that proportional reasoning strategies are more related to math achievement than to reading achievement.

These results show that pre-k-to-elementary-school children use a variety of strategies to solve proportional reasoning problems. Specifically, children who are not yet proficient at proportional reasoning often incorrectly focus on the total size of the bar or the size of just one segment of the bar, instead of focusing on the proportion. Importantly, these strategies relate to their math outcomes, which suggests that helping children who struggle with proportional reasoning might lead to improvements in overall math achievement.

RESEARCH PROFILE

Xinhe Zhang, Graduate Student

As children develop, spatial anxiety and visuospatial working memory impact their spatial ability

Children's ability to visualize and mentally manipulate objects—known as spatial ability—is crucial for their cognitive development and can predict later academic success in science, technology, engineering, and math (STEM) fields. By understanding the factors that influence spatial ability, researchers and educators can better support children's growth in this area. In a recent study, our lab explored how both cognitive and emotional factors impact children's spatial skills. Specifically, we examined the roles of visuospatial working memory and spatial anxiety.

- *What is visuospatial working memory?* Visuospatial working memory is the ability to hold and manipulate visual and spatial information in the mind. For example, when we drive from home to school without using a map, we rely on visuospatial working memory to picture the route in our minds.
- *What is spatial anxiety?* Spatial anxiety is the nervousness or discomfort some people feel when engaging in spatial tasks, such as reading a map or imagining the movements of objects.

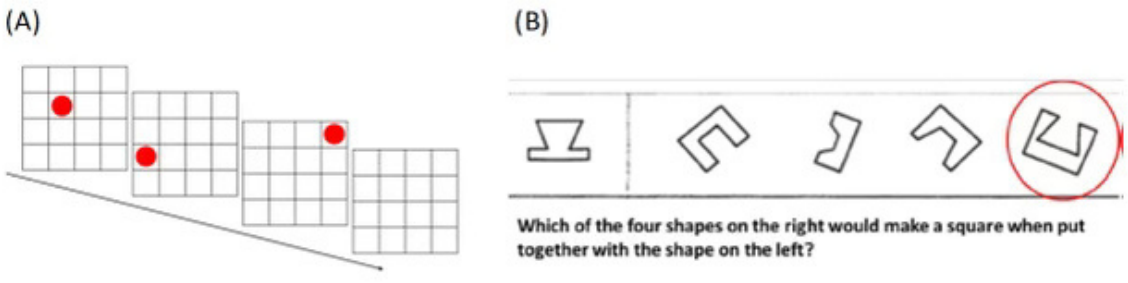


Figure 1. (A) Example for measuring visuospatial working memory. In this task, a series of location of the red dot was presented for a short period. Children need to remember these locations and then recall the locations after the red dot disappeared. (B) Example for measuring spatial ability.

RESEARCH PROFILE

Xinhe Zhang, Graduate Student

We measured spatial anxiety, visuospatial working memory, and spatial ability in children from 1st grade to 4th grade (See Figure 1 for examples). We found that children with strong visuospatial working memory tended to have higher spatial skills. One reason for this may be that these children use effective spatial strategies, such as mentally rotating or combining shapes to solve problems. In contrast, children with lower visuospatial working memory may rely on less efficient strategies, such as comparing individual parts of objects.

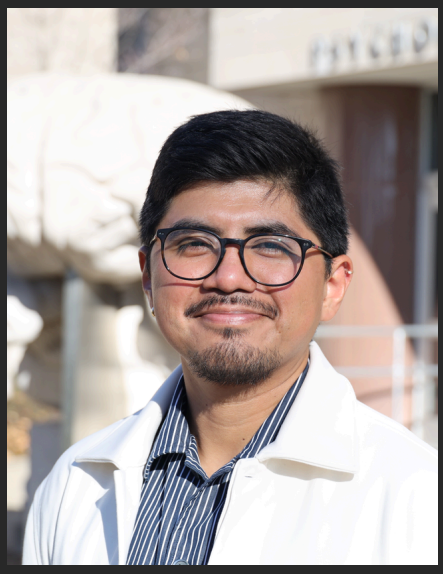
More interestingly, we found that higher spatial anxiety was associated with lower spatial skills for children with high visuospatial working memory—particularly in 4th graders. When these children experience spatial anxiety, it can limit the visuospatial working memory resources that are available, making it harder for them to use efficient spatial strategies.

These findings highlight the importance of addressing both cognitive and emotional factors when supporting children's spatial ability development. Encouraging activities that build spatial skills and helping children feel confident with spatial tasks can be helpful for children's cognitive growth and readiness for future STEM learning.

MEET THE TEAM

Elizabeth Gunderson, Ph.D., is a Professor in the Department of Psychological and Brain Sciences at Indiana University Bloomington. She received her Ph.D. in Developmental Psychology from the University of Chicago in 2012 and her B.A. in Computer Science & Psychology from Yale University in 2005. Dr. Gunderson's research focuses on the cognitive and socio-emotional factors that affect young children's academic achievement, especially in the domain of mathematics.

Roberto A. Abreu-Mendoza, Ph.D., is a postdoctoral fellow in the Department of Psychological and Brain Sciences at Indiana University Bloomington. He completed his Ph.D. in Psychology at Rutgers University-Newark, under the supervision of Dr. Miriam Rosenberg-Lee. Roberto is interested in examining which cognitive capacities and neural correlates allow for the development of numerical abilities in the course of a person's life.



Hyekyung Park, Ph.D., is a postdoctoral fellow in the Department of Psychological and Brain Sciences at Indiana University Bloomington. She completed her Ph.D. in Psychology at Ohio State University, supervised by Dr. John Opfer. Hyekyung is interested in investigating cognitive factors that are related to children's numerical skills and exploring strategies that enhance mathematical thinking.

MEET THE TEAM

Xinhe Zhang is a fourth-year graduate student in Dr. Gunderson's Lab. She received her M.Sc. in Psychology at the University of Birmingham in 2017. She is interested in the development of spatial and numerical processing, with a focus on the relationship between spatial and numerical processing, and the mechanisms of spatial training and numerical training.

Mariana Sosa is a first-year graduate student in Dr. Gunderson's Lab. She received her M.Sc. in Cognitive Neuroscience at Universidad Complutense de Madrid. She is interested in the development of numerical and spatial skills, with a focus on understanding the ways in which parents and teachers can effectively support learning in these domains.

MEET THE TEAM

Noah received his B.A. in Psychology with a Clinical Psychology Certificate from Indiana University in 2023. As a research assistant in Dr. Linda Smith's Cognitive Development Lab, he studied possible contributors to the A-not-B error in 9-14-month-old children, including interaction timing and attention. He aims to pursue a Developmental Psychology PhD to further explore how children's experiences shape their learning and development.

Leslie received her B.S. in Psychobiology from UCLA in 2023. As a research assistant in Dr. Catherine Sandhofer's Language and Cognitive Development Lab, she examined the acquisition of antonyms in 3–6-year-olds as a result of their learning environments. She hopes to continue to unravel the mechanisms that determine how children develop and learn typically and atypically and utilize neuropsychological findings to implement research-based interventions in the educational and healthcare system.

MEET THE TEAM

Kelsey Rose
B.S Expected Fall 2024
Major: Cognitive Science
Minor: French

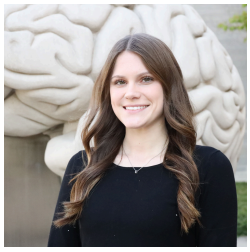
Ashley Nirtaut
B.A Expected Spring 2025
Major: Psychology
Minors: Business and Sociology

Amadeus Wagner
B.S and B.A Expected Spring 2026
Majors: Neuroscience and Philosophy
Minors: Psychology and Ethics

Anna de Four
B.S Expected Spring 2027
Major: Neuroscience
Minors: Chemistry, Healthcare Management and Policy

Annie Beardmore
B.S Expected Spring 2025
Major: Clinical Psychological Science
Minor: Spanish

Belle Paris
B.S Expected Spring 2025
Major: Cognitive Science
Minor: Computer Science



Cecilia Meneghini
B.S Expected Spring 2026
Major: Psychology
Minor: Spanish

Lyndsey Gentil
B.S and B.A Expected Fall 2026
Majors: Psychology, Criminal Justice
Minor: Film

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If you would like more information about our research, or are interested in participating, please contact us via e-mail or phone

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Check us out on the web !

https://cognitionandlearning.lab.indiana.edu/