Cognitive Development Laboratory Newsletter

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Hello from the Cognitive Development Lab at Wesleyan University!

Here's an update on some of our recent research findings - all about numbers! Many thanks to the families, preschools, and children who make this work possible!

What we do

How do children learn about the world around them - about language, numbers, objects, space, and people? To find out, we design studies to gain insight into children's thinking and how it changes.

Our current studies are focused in four areas:

How do children learn and reason about numbers and basic math?
How do children's intuitions about numbers connect with learned skills like counting or basic arithmetic?

How much of children's understanding of the world is dependent on language?
How do delays in language development affect children's conceptual knowledge?

How do children navigate through space?
How do children use physical landmarks to find their way? How do they use the spatial layout?

How do children reason about people?
How do they decide whom they should trust? How do they choose who would be a good friend?

Lab news

We now have two child development labs in one building! To help keep things organized, we have color-coded our operations.

🟡 The **2nd floor Yellow Lab** is home to Dr. Hilary Barth and her students.

🔵 The **4th floor Blue Lab** is home to Dr. Anna Shusterman and her students.

You can reach both labs by calling **(860) 685-4887**.

New lab opens!

Dr. Anna Shusterman joins Dr. Barth as faculty co-director of the Cognitive Development Lab. Thanks to a spectacular renovation, the new lab is buzzing with undergraduate researchers and participating families.

Congratulations to our graduating seniors!

Jess Sullivan and Joseph Feldblum will be joining Teach For America. Keera Bhandari is staying to complete a five-year BA/MA degree in Developmental Psychology. And hats off to Nicole Gray, Rachel Jacobson, Phoebe Jones, Andrew Smith, Cory Savereid, and Meghan Duberek!

Arithmetic Study

Past research shows that humans have an approximate sense of numerical quantity that gives them a rough intuitive understanding of some mathematical concepts, even before they have any formal training in school. In fact, even babies and animals seem to share this "number sense". In this series of studies, we are exploring the extent of these abilities. Can preschool children understand how arithmetic operations work, in an approximate fashion, before they learn how to perform symbolic arithmetic?

In the studies, we present 4- and 5-year-old children with games involving animations on a computer that "act out" arithmetic problems with objects and sounds. For example, 32 blue balloons would appear on the screen, and then they would be covered by a wall. Then 12 rapid popping sounds would be heard, and the experimenter would explain to the child that some of the balloons had popped. Then 25 red balloons would appear and would also be covered up, and the child would be asked, "Are there more blue balloons, or more red balloons?" We know that children are not using verbal counting to come up with their answers, because the objects disappear too fast to be counted exactly (and many of the children in the study cannot yet count to 32).

Thanks to carefully designed control conditions, we can tell that children did not use other kinds of non-arithmetic guessing strategies - they really did add or subtract in these studies! We are interested in finding out more about how these early intuitive understandings may guide children's later acquisition of symbolic math skills.

Spots on Paper Study

In this series of studies, we’re trying to understand the sorts of quantitative information that children and adults automatically and unconsciously understand when they see a group of objects. In a series of computerized studies with adults, we found evidence that that the brain does easily seem to figure out roughly how many things there are in a set, but that it does not automatically figure out how much space they take up. Now we are using a different version of the study to see if we find the same results with children. This new version is more entertaining for kids - we presented children with sets of colorful spots that varied in size and number and that had been “painted” onto a piece of paper. They were shown two of these sets side by side and were asked either “Which piece of paper has more spots?” or “Which piece of paper has more paint?” The first question was meant to see whether young children could automatically understand number information when a group of objects was presented too quickly for them to count. The second question was asked in order to find out whether these same children could accurately judge how much total color was on the page.

Our results seem to suggest that while young children were very accurate in determining which piece of paper had more spots on it, they were much less accurate in determining which piece of paper had more paint on it. The results we have so far suggest that kids may automatically calculate the number of objects they see, but not how much space they take up. This finding fits well with our previous results from adult studies. We are now looking at these data carefully in order to explore the specific perceptual mechanisms that might underlie adults' and children's judgments.

Estimation Study

In this study, we were interested in exploring how children's verbal counting skills relate to their understanding of the logical structure of the number words and the counting system. For example, a skilled counter knows that number words appearing later in the counting sequence should always map onto larger quantities. Do very young children also understand this? Do they know it as soon as they learn how to count, or do they need to reach a particular skill level before they understand it?

Previous research suggested that children don’t start to understand that bigger number words should map onto bigger sets until they have learned how to count up to 100 reliably. But in our estimation studies, we have found something different. We presented 5-year-old children with cards showing up to 300 small pictures (simple shapes, or stickers), and asked them to guess how many things they saw. They could only look at the card for a moment, so they couldn't count - they had to guess. Children seemed to understand that they should guess larger number words for larger sets even if they had not yet learned how to count very high. For example, even kids who could not count higher than 30 produced larger estimates (bigger number words) for sets of 140 items than for sets of 100 items.

These results show that children do have some partial knowledge of the ordering of number words and the way they relate to quantities, even before they have developed strong counting skills.

Word Learning Study

We know that even very young children can easily attach novel descriptive words to single objects: after seeing a striped plate and hearing it called a “ziv plate”, children may come to associate stripedness with the word ziv. But we don’t know if children can just as easily map a novel descriptive word onto a whole group of objects. How would a child interpret a novel word presented like an adjective and applied to a whole set of things? Would they assume the word applied to a property of the individual objects? For example, if they were shown a group of 16 small red candies, would they assume "ziv" meant "small" or "red" or "delicious"? Or, would they think the word should apply to a property of the whole set, so that "ziv" might mean "arranged close together" or "many" or maybe even "about 16"?

We conducted a series of studies with preschoolers to see whether they would interpret a novel word as though it referred to a property of a whole set of objects. We were especially interested in the possibility that they might attach a very rough numerical meaning to the novel word. We already know that it's difficult for young children to focus specifically on number when they are presented with small groups of objects, like two or three. For example, imagine seeing three small interesting toys and being told "Here are ziv toys." The novel word "ziv" could mean small, or interesting, or grouped-close-together: it has many different possible meanings. In a situation like this, young children are not likely to interpret "ziv" as meaning "three." But a large amount of research suggests that numerical properties may become much more prominent to children for larger sets. So we are currently investigating the possibility that young children might interpret novel descriptive words in terms of approximate numerical meanings if they were applied to large sets. This study is still in progress. So far, it looks as though the youngest children we tested do not attach numerical meanings to these novel words, but older preschoolers may.

How Children Learn the Principles of Counting

How do children learn to count? Well, it depends what you mean by counting! One process that children need to learn is how to recite the count list –to say each number in order, to use one number word for each object in the group of things that they wish to count, and to realize that the last word tells them how many objects are in the set: "One, two, three, four, five – there are five!"

It turns out that there is much more to the process of counting. For example, if you ask a child to give you three M&Ms from a pile, he might do it, but if you ask for four, he might give you the whole pile! Even though he can count to ten or twenty, this child would be called a "three-knower." Most children between two and four years old can be identified as one-knowers, two-knowers, or three-knowers. At some point, children make a sudden and amazing leap into understanding how and when to use counting for all of the numbers up to at least eight. These children are called "counting-principle knowers" or "CP-knowers."

What fuels this conceptual leap for children? In our study, we tested two theories: the **add-one rule** and the **later-greater rule**. The **add-one rule** is the idea that for every counting number (for example, seven), the next number in the list is exactly one more (eight). This property of counting is what makes counting a powerful mathematical tool. The **later-greater rule** is the idea that numbers that come later in counting represent greater quantities than numbers that come earlier. For example, since *seven* comes later in the count list than *four*, seven is bigger than four.

We created two games to test whether CP-knowers understand these rules better than two- and three-knowers. Children were tested on the numbers one to ten. In the Add-One Game, children watched an experimenter put toys into a bucket and say "Look, I'm putting three toys in the bucket!" Then the experimenter added another toy and said, "Look, I'm putting in one more toy!" Then the experimenter asked the child how many toys were now in the bucket: "Now are there four toys or eight toys in there?" CP-knowers were much better than other children in playing the Add-One Game.

In the Later-Greater Game, children watched the experimenter put toys into one bucket ("I'm putting seven in here!") and then another bucket ("I'm putting eight in here!"), and were asked "Which bucket has more toys?" Surprisingly, two-knowers understood the later-greater rule for the numbers one to ten! They could reliably tell us that the bucket with eight toys had more than the bucket with seven toys. This is a first demonstration that children understand something about the numbers beyond their "known number."

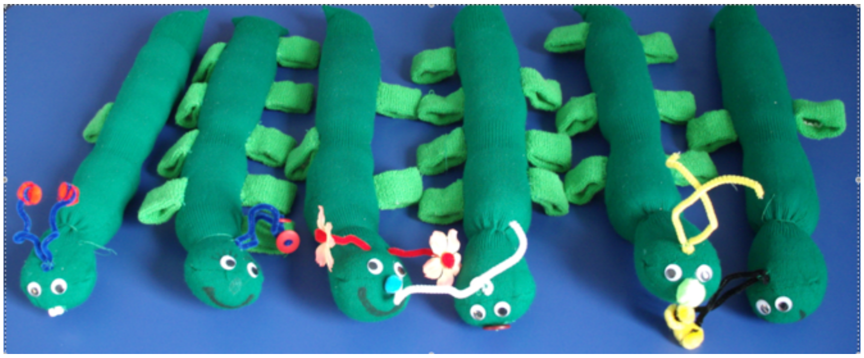
This pattern shows that **children learn the later-greater rule before they learn the add-one rule** and helps us to see how children lay a foundation for further math skills. We have now found the same pattern of results in two studies in Cambridge, MA and Middletown, CT. With new confidence that we have discovered some key principles of early counting, we are working hard to crack the puzzle of how children learn numbers.

The Caterpillar Game

Previous research suggests that even infants can think about one, two, or three objects quite easily. But how do children start to think about four, seven, or ten? One possibility is that children learn because their parents teach them how to count – in other words, learning the *words* for numbers gives children the *concepts* for numbers. Another possibility is that children's minds naturally develop the ability to reason about numbers. Recently, researchers discovered an Amazonian tribe that doesn't have precise number words, and found that their number reasoning is rather fuzzy. This discovery prompted a great deal of interest about whether counting words are important for a basic understanding of numbers. We set out to test this question in children.

To test children's **linguistic number knowledge**, we used a classic game called Give-A-Number. In this game, a child is asked to put one toy duck into a pond (a bowl), then two ducks, three ducks, and so forth. The highest number that the child can accurately provide is called his or her "knower level." Most young children can be identified as one-knowers, two-knowers, three-knowers, or "counting-principle knowers" who can always answer the question up to eight objects.

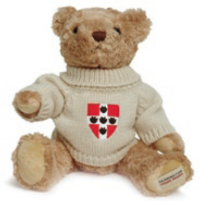
To test children's **non-linguistic number knowledge**, we created a game called the Caterpillar Game. Children were introduced, one at a time, to caterpillars who all had different numbers of feet. The children were asked to go across the room to bring back socks for each caterpillar's feet. This task led children to *think* about numbers in order to get the right number of socks, without prompting them to *talk* about numbers – giving us insight into their non-verbal reasoning process.



How did children do? When the caterpillar had just two or three feet, all of the children did very well. But when the caterpillar had more feet (we tested six, seven, and nine), only the advanced counters – the CP-knowers – brought an appropriate number of socks. They didn't always bring the exact right number, as adults would do by counting, but they brought more socks for the nine-footed caterpillar than for the six-footed caterpillar. Less advanced counters always brought about five socks for both caterpillars, suggesting that they didn't pay close attention to the different numbers of feet once there were more than three.

These results suggest that children who are better counters are also better at thinking about numbers above three. **We think this reveals an interesting relationship between talking about numbers (language) and thinking about numbers (thought).** We are using more tests to uncover the mysteries of this relationship in the development of counting. In the near future, we want to know whether learning how to count actually changes children's ideas about numbers, or whether their ideas change before they learn how to count. Stay tuned!

Thank you!



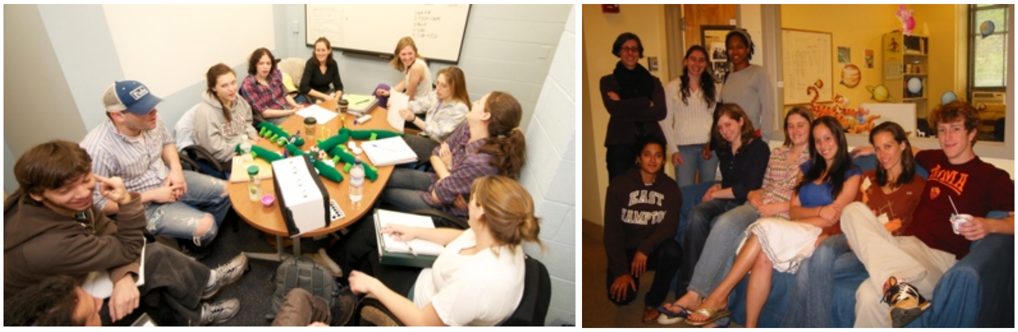
Here at the Cognitive Development Lab at Wesleyan University, we study how children think and learn about the world around them.

Our studies depend on you: the local families, schools, and daycare centers that help us with our research projects. In this newsletter, you can read about some of our recent research findings. Thank you for your generous support!

Contact us!

We are always looking for families to come play in our labs, and for schools and daycares who are interested in our research. Our studies are brief, fun for kids, and informative for parents and educators.

Please contact us if your family is interested in participating in studies. You can share your contact information by phone or on our website. We'll call to let you know when we have a study for your child's age group.



Left: *Members of the Shusterman lab designing new studies.*

Right: *Members of the Barth lab in their Yellow Suite.*