Cognitive Development Center
psych.colorado.edu/cdc

Our goal in the Cognitive Development Center is to understand thinking and how it changes with development. We work with infants and children to explore the development of memory, problem-solving, and flexibility. Learning how these abilities develop should help us understand not only how infants and children think, but also how we come to think as adults.

Name of person who played with children in this project
Age of children in project
Dates project was conducted
Brief description of project
What we’ve discovered so far

Project Leader: Yuko Munakata
Age: 8 months
Dates: August 2002 - present
Description: Played a game with fun toys.
Major Findings: There is so much to learn about cognitive development.

Thank You!
We hope you enjoyed your visit to the Cognitive Development Center and enjoy reading about what we’ve learned.

None of this would be possible without parents like you who offer your time to contribute to the advancement of developmental science. Thank you!

Enjoy your visit?
We always have many ongoing projects in our center, and appreciate the help of parents like you who bring your children in to participate.

If you or your friends would like to participate in our projects, please visit www.psych.colorado.edu/cdc, call (303) 492-6389 or email cogdevctr@grey.colorado.edu

Want to find your child’s project quickly?
Before each summary is an info box containing a brief description of the project.
Hide and Seek

One of the first games that infants learn to love is “Peek-A-Boo”. This is not only a fun game for infants and parents alike; it also allows infants to explore the idea that even when people aren’t seen, they continue to exist. This is known as object permanence, and we are curious to find out how infants become aware of this concept.

Will You Look At That!

Project Leaders: Meg Ryan and Julia Scott  
Age: 5 months  
Dates: November 2003 - present  
Description: Watched box & cylinder on puppet stage.  
Major Findings: Infants’ early memories may be less robust than scientists thought.

One of the key questions we are trying to answer is what form infants’ early memories take. For example, are their memories of hidden objects fleeting, or robust? With very young infants it can be hard to tell if they remember: they can’t talk, and often have difficulty reaching for hidden objects. By using a violation-of-expectation task, in which infants are presented with either expected events or unexpected events, we hope to discover how much infants can remember. Infants tend to look longer at unexpected events, as if they are surprised that something unexpected happened, and are bored with expected events.

Out of Sight, Out of Mind?

Project Leaders: Jeanne Shinskey, Christina Briegleb & Christine Guasto  
Age: 7 months; 11 months  
Description: New & familiar toys were hidden in the dark.  
Major Findings: Babies prefer new toys in the light, old toys in the dark.

A traditional notion in cognitive development is “either you have it, or you don’t,” but object permanence may be the result of a gradually developing memory system. We believe that infants develop strong memories for familiar objects gradually, and cannot maintain memories for objects they have only seen once or have never seen before. This means that they should be able to remember a hidden object still exists if they are familiar with it, but not if they have never seen it before.

Infants have a very strong preference for novel toys over familiar toys, so if a familiar toy and a novel toy are presented together they will almost always reach for the novel toy. And, if the toys are shown one at a time, infants will reach for the novel toys more often than they will for the familiar toy. In contrast, if infants’ memories are stronger for familiar toys than for novel toys, when toys are hidden they should be more likely to remember that the familiar toys exist, and so reach more for hidden familiar toys than for hidden novel toys.

One problem with hiding toys is that if they are hidden
inside or under another object, infants must figure out how to get at the toy by moving a cover or reaching inside a container. Infants also might get distracted by other people or objects nearby. To make reaching for hidden toys as easy as possible, we decided to hide toys by turning out the lights in the room.

Infants were given a toy with a distinct shape and color (a black cylinder, a red heart, a green ring, etc.). This toy was placed on a table, and the infant was allowed to reach for the toy. This was repeated until the infant wouldn’t reach for the toy anymore. Having become officially bored, the infant was finally given some new toys. Infants received four different kinds of trials: novel toys in the light, novel toys in the dark, the familiar toy in the light, and the familiar toy in the dark. We counted how many times infants reached for new toys and familiar toys in the dark and in the light.

When toys were visible, 7-month-old infants showed a distinct novelty preference, with most (83%) of infants reaching more for novel toys than familiar toys. But when the toys were hidden, only 12% of infants reached more for the novel toys, while 54% reached more for the familiar toy, and 34% reached equally (most of these infants did not reach for any of the toys in the dark). This suggests that infants do have a stronger memory for objects they are familiar with than for objects that are completely new to them, and so can remember hidden familiar objects better.

Next we looked at the same thing with 11-month-old infants. These older infants preferred novel toys both when they are visible and when they are hidden. When toys were visible, 90% of the infants reached more for novel toys than familiar toys. When toys were hidden, more infants (40%) reached more often for novel toys than those who reached more for familiar toys (18%). This suggests that by 11 months, infants’ memories have developed to the point that they have a strong memory representation of an object even if they’ve only just seen it. This also shows that infant’s understanding of object permanence may begin with familiar objects, and later extends to all objects.

**Project Leaders:** Jeanne Shinskey & Kendall Smith  
**Age:** 10 months  
**Dates:** February 2003 - November 2003  
**Description:** Toys were hidden under one of two covers.  
**Major Findings:** How you hide a toy matters - behind, inside, or under.

Can infants keep track of where an object is hidden? If two hiders are placed side by side, and a toy is hidden several times in one hider (location A) and then hidden at the other hider (location B), infants will often look for the toy at the first hider, where they are used to finding it. This is known as the A-not-B error, and it may result from the hiders being very similar. Usually the hiders function in the same way (e.g. both covering the toy), and look the same (e.g. two cups). This may make it hard for infants to differentiate between the two hiders.

We thought infants might be able to remember where the toy was hidden better if the two hiders worked differently, such as one covering the toy and one blocking the toy, or if they remember the familiar toys better? Infants might instead be reaching more for familiar objects because they want the comfort of a familiar object in the dark. They also might reach more for familiar objects because they have so much experience picking up the familiar object that they know how to retrieve it better than they know how to retrieve a novel object.

To test these possibilities we are placing toys behind a rotating screen, which is raised to hide the toy. Infants must pull the screen down to get to the toy. Since infants aren’t in the dark, they shouldn’t need to reach to seek out comfort. Also, infants get the toy if they just pull down the rotating screen, so there should be no advantage from knowing how to pick up familiar objects. If infants still prefer familiar toys when they are hidden, we will know that they remember familiar objects better than novel objects when they are hidden.

**Do Infants Judge a Hidden Toy By Its Cover?**

**Project Leaders:** Patrick Keane, Bret Harris, & Bethany Gorski  
**Age:** 7 months  
**Dates:** March 2004 - present  
**Description:** New & familiar toys were hidden behind a rotating screen.  
**Major Findings:** How you hide a toy matters - in the dark vs. behind a screen.

Infants appear to remember that familiar toys exist when they are hidden in the dark. But what if the reason that they reach more for familiar toys than novel toys isn’t that
they looked different, such as a hat and a box. So we hid toys with two kinds of hiders: hiders that worked the same way, but looked very different (a blue baseball cap and a brown box, that cover the toy) and hiders that looked the same, but worked differently (a blue cylinder the toy was placed inside, and blue half-cylinder the toy was placed behind).

Infants correctly searched for toys in the B location the same number of times whether the hiders worked differently or looked different. This could mean that infants' memories for a toy’s location aren't helped by using hiders that work in different ways. Or, infants' memories could be helped by using hiders that work in different ways, but their memories are helped just as much by hiders that have different appearances. Since we were comparing these hiders to each other, we were unable to see a difference.

We are currently developing a new project that will focus on just one difference in hiders, using hiders that look the same but work differently. By comparing infants’ performance on these hiders to performance on hiders that look and work the same, we hope to discover if different hider functions help infants remember where a toy is hidden.

**Breaking Habits Is Hard To Do**

Imagine you’re driving home from work. After taking the same route day after day, you probably feel you could make this trip in your sleep. But what if there’s a mini-emergency (maybe the kids decided to turn the kitchen into a swimming pool) and you have to pick up dinner? Now you must take a slightly different route home, and even if you repeat the change in directions over and over – “left on Pearl Street, left on Pearl Street” – you might drive past the appropriate turn without realizing it. The ability to break a habit and do something different is an example of cognitive flexibility, something children have an even harder time with than adults.

Children’s difficulties with cognitive flexibility can be seen in a simple (to adults, at least) card sorting game. Children are shown cards with pictures of blue flowers or red trucks, and asked to sort them one at a time into trays marked by target cards of a red flower or a blue truck. Some children are asked to sort the cards by shape first, and some are asked to sort by color first. Then they are asked to switch and sort the same cards by the other rule. So children sorting by shape before should sort by color, and vice versa. Typically, 3-year-olds sort cards correctly by the first rule, but when asked to switch rules they continue sorting the cards using the first rule.

Why do children have such a hard time switching from one rule to the next? We believe the answer is the way children's memories develop. Old and new rules (or behaviors children do or do not have experience with) use two different kinds of memory. Old rules create latent memory traces, biasing children to continue following the old rules, while new rules create active memory traces. Ultimately, these active memory traces will be able to compete with the latent memory traces, but active traces develop later, so 3-year-olds’ memory for the new rules are too weak to compete with their memory for the old rule.

We’ve created variations of the card sorting game to learn what factors are important to children’s flexibility, and what makes it easier or harder for children to break a habit and use the new rules.

**Practice Makes Perfect**

| Project Leader: Jennifer Brace |
| Age: 36 months |
| Dates: March 2003 - February 2004 |
| Description: Sorted “morph” or line cards between rules. |
| Major Findings: Kids learn from practice better than from instructions. |

Sometimes children may find it difficult to switch to a new rule because their memory for this rule is too weak to compete with their memory for the old rule. Strengthening their memory for the new rule should help children switch rules. Practice with using the new rule should build a stronger memory trace for that rule, making children more likely to switch to the new rule than if they just receive direct instructions. Children played one of three variations of the card sorting game, so we could see if children were helped more when they had guided practice with the new rule, when they heard explicit instructions, or when they received both.

In the guided practice condition, children sorted a series of cards that at first could only be sorted using the new
Children who had been sorting by color were given black trucks and flowers that gradually became red or blue:

![Image of black trucks and flowers]

Almost all of the children who received both practice and instruction (94%) switched and sorted cards correctly using the new rule, as did most of the children who just got practice (81%). Very few of the children who were just given instructions switched rules (25%). This suggests that practice does strengthen children's memory for new rules, and instructing children with guided practice is more effective than just explaining a new rule when they must overcome a strong habit. Going back to picking up dinner on the way home from work, driving a different route might be very difficult if the change is just explained (even if it is a good explanation), but easier if you can follow someone on a practice trip, and easier still if the directions are explained and you follow someone.

New Shapes, Same Rules?

**Project Leaders:** Sarina Chien & Jason Pfaffly

**Age:** 39 months

**Dates:** March 2003 - August 2004

**Description:** Sorted cards with new shapes and colors.

**Major Findings:** Children can apply some types of memory better than others in new situations.

Strong active memory traces don’t just help children switch from sorting cards by one rule to sorting the same cards by a different rule. We believe they also help children generalize rules, or apply them to any kinds of cards.

We think latent memory traces can only be used in the specific situation where the rule was originally taught. For example, the latent memory rule for the shape game might be “put trucks in the truck tray and flowers in the flower tray”, and so only trucks and flowers (never frogs or boats) could be sorted. Active memory traces, on the other hand, might be “put cards in the tray that has the shape they’re most like”. This rule could be used to sort any cards.

Children first played the standard card sorting game. Then the red flower and blue truck target cards were taken off the trays and replaced by a gray cloud and a gold jagged shape. Children were told to just keep doing what they were doing, and given gold clouds and gray jagged shapes to sort. Then the target cards were changed again, to a green block shape and a pink squiggly shape, and children were given green squiggly shapes and pink block shapes to sort.

We believed that children who had been able to switch from using the first rule to using the second rule (switching from sorting by color to shape or shape to color) and so had strong active memory traces would be able to apply the rules to these new shapes. Children who switched rules did not sort the new cards by a consistent rule because they had been using rules specific to flowers and trucks or red cards and blue cards.

Most children who switched rules in the original card sorting game sorted the new cards, with 69% consistently using one rule. Fewer children who had not switched were able to sort the new cards, with only 55% consistently using one rule. This is not a very large difference, but we realized that the new card tasks were not particularly difficult, since the new colors and shapes matched the new target cards exactly. So children may not have needed an active rule to sort the novel cards consistently. Also, when the target cards changed, children may have thought it was time to play a new game. So even if they had an active rule, they may not have thought to apply it to the new game.

We decided to try again, making the generalization task with novel cards more difficult, and keeping the target cards the same throughout. The new cards in this case were slightly distorted variations on the trucks and flowers:

These cards were similar to the original blue and red trucks and flowers, and were clearly more like one tray in color and one tray in shape, but they weren’t identical. We looked again to see if children who did switch between the original two rules would be better at sorting these new cards.
89% of the children who switched rules sorted the new cards consistent with what they did before (according to the second rule), whereas 67% of the children who did not switch rules sorted the new cards consistent with what they did before (according to the first rule). This difference is clearer, but children mostly differed only in their ability to sort new cards by the new colors; all children, who did and did not switch rules, sorted the new shapes correctly. This is probably because the new shapes were not very demanding. Even without an active rule of shape, children may have sorted the new shapes correctly, because they were still trucks and flowers like the old cards. In contrast, the new colors were not that similar to the old red and blue cards and could easily be given their own names, such as orange and green. In this case, children may have needed an active rule of color to sort them correctly.

So, we made the shapes just as challenging as the colors. We changed the blue and red trucks and flowers that children first sorted, designing the shapes so the flower was very round and the truck very square and boxy.

Once children had played both the shape and color games, they were given new cards to sort: a teal TV, a greenish fridge, a green house, an orange tennis ball, a yellowish magnifying glass, and a yellow apple. All of these cards had a color and a shape that could easily be given their own name (the “yellowish” card could be described as yellow or orange) but that were similar to the target cards (three round cards; three boxy cards; three close to blue and three close to red).

Children who switched rules applied this rule consistently to novel cards, whereas children who did not switch rules (and continued to follow the first rule in the original game) did not apply this rule consistently to novel cards. This should be surprising, because children who did not switch rules used the same rule throughout the original game (had sorted all cards by either color or shape) and so had more practice with it, but did not apply this rule to the new cards, while children who had switched rules had less practice with the new rule, but were able to apply this rule to the new cards. However, this is consistent with our idea that children are using different kinds of memory traces if they switch rules (active memory traces that apply across different examples) than when they continue with old habits (latent memory traces that are specific to the examples they have seen, and cannot be applied to new cards).

**Hold that Thought**

| Project Leader: Jennifer Brace |
| Age: 36 months |
| Dates: May 2004 - August 2004 |
| Description: One minute walk down hallway between rules. |
| Major Findings: The passing of time affects some types of memories more than others. |

Active memories for new rules may differ in another way from latent memories for old behaviors: active memories may not last as long. As a result, if children experience a delay in the middle of the sorting game, their memory for the new rules may be more affected than their memories of the previous rule.

Children played the standard version of the card sorting game, sorting blue flowers and red trucks first by shape and then by color, or first by color and then by shape. One key change was made: children took a quick break in the middle of the game -- a one minute walk down the hallway and back. Some children took this break just after sorting cards by the first rule, so that we could observe the effects of a delay on children's memories for old behaviors. Other children took the break just after the new rule was explained, so that we could observe the effects of a delay on children's memories for a new rule.

The delay had a much larger effect on children's memories for a new rule than on their memories for the old behaviors. Compared to children with no break, children who took a break *after the new rule was explained* had a much harder time switching to the new rule (only 14% switched successfully). This suggests that children have a very hard time holding onto their memory for new rules over a delay. In contrast, compared to children with no break, children who took a break *before the new rule was explained* switched to the new rule just as often (31% switched successfully). This suggests that children have a much easier time remembering their old behaviors over a delay.

Across the various card sorting games, children seem to use two different types of memories with unique advantages and disadvantages: latent memories develop earlier, as seen in “Practice Makes Perfect,” active memories generalize to novel stimuli better than latent memories, as seen in “New Shapes, Same Rules,” and latent memories are more robust across delays than active memories, as demonstrated by “Hold that Thought.”
Who We Are

Center Director
Dr. Yuko Munakata

Center Coordinators
Daisy Pierce (2004- )
Kendall Smith (2002-2004)

Postdoctoral Associates
Dr. Nicholas Cepeda
Dr. Sarina Chien
Dr. Jeanne Shinskey

Graduate Students
Maria Khartonova
Jason Pfaffly
Jennifer Stedron

Community Volunteer
Donna Fisher

Undergraduate Students
Steve Baumann, Katye Blackwell, Amanda Bowles, Jennifer Brace, Christina Briegleb, Jessica Cade, Molly Fennell, Chelsea Glasscock, Bethany Gorski, Alexa Gottschalk, Christine Guasto, Bret Harris, YunHee Han, Patrick Keane, Lauren Keeler, Shireen Lalezari, Kate Latti, Luke Meiser, Ashley Mekelburg, Anna Morgenthaler, Meghan Ryan, Julia Scott, Sarah Taylor, Lauren Thomas, Erin Thorpe.

Lab Milestones

The Cognitive Development Center recently received a 5-year, $1 million grant from The National Institute of Child Health and Development.

Graduates: Jennifer Brace, Christina Briegleb, Chelsea Glasscock, Alexa Gottschalk, Christine Guasto, YunHee Han, Bret Harris, Luke Meiser, Meghan Ryan, Lauren Thomas.

Ph. D. Thesis Defense
Jennifer Stedron - “Cerebellar Function in Down Syndrome”

Undergraduate Honors Thesis Defenses
Jennifer Brace - “Practice Makes Perfect: Improving Children’s Flexibility in a Card Sorting Task”
Chelsea Glasscock - “Parent Influence on Children’s Personalities: Is the Nurture Assumption Wrong?”
Meghan Ryan - “Understanding Infant Knowledge: The Case of ‘Robust’ Object Permanence Knowledge in 5-month-olds”

Undergraduate Research Grants

Undergraduate Research Award
Jennifer Brace won 3rd Place in the Psi Chi Allyn & Bacon Psychology Awards Competition with her Honors Thesis.

Moving On
Jennifer Brace is attending graduate school in Psychology at Carnegie Mellon University.
Kendall Smith is attending the Transpersonal Psychology Program at Naropa University.
Jeanne Shinskey is an Assistant Professor at the University of South Carolina.

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Do you remember your child’s visit with us – following the fish along the wall to our center, the games we played?

With your help, we’ve learned a lot about development of cognition and memory. Now we’d like to share all we’ve learned with you. Inside, you can find out exactly what the games your child played told us!