Thank you!

We hope you had fun with 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.

Enjoy your visit?

We always have 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 contact us!

If you are moving or have welcomed a new family member, please let us know so we can update your information.

Contact Information:

(303) 492-6389
cogdevctr@grey.colorado.edu
http://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, language, problem-solving, and flexibility. Learning how these abilities develop can help us understand not only how infants and children think, but also how we come to think as adults.

Want to find your child’s project quickly?

Each story includes an info box containing a brief description of the project.

Name of person who played with children in this project
Age of children in project
Dates project was conducted
Brief description of project

Leader: Yuko Munakata
Age: 8 months
Dates: August 2002 - present
Game: Played with fun toys.
Major Finding: There is so much to learn about cognitive development.

What we’ve discovered so far
Out of Sight, Out of Mind?

Object permanence refers to the concept that things continue to exist when out of sight. We’re exploring how infants achieve this milestone.

**ANYTHING IS POSSIBLE!**

**Leaders:** Meghan Wright, Teesa Dutta  
**Age:** 5 months  
**Dates:** May 2006 - Present  
**Game:** Watched box and cylinder on stage.  
**Major Finding:** Infants detect impossible events using a habit-like memory or active memory.

Before infants are old enough to reach for objects, we can measure object permanence knowledge through how long infants look at possible and impossible events with hidden objects. Infants look longer at impossible events when their expectations are violated.

We explored the type of memory infants use to detect impossible events. Infants saw either a thick or a thin box hidden behind a screen. They then saw the box being removed from the stage. Finally, they saw a cylinder slide behind the screen. Both the thick and thin box events are possible, since the cylinder can fit behind the screen without the box.

Infants looked equally at thick and thin box events, suggesting they used an active memory to remember we removed the box and recognized both events were possible. But, they also looked just as long as infants in an earlier project, in which the box was not removed and the thick box event was impossible. This suggests infants may have relied on a habit-like memory for the box, and thought it was still behind the screen so the thick box event was impossible.

**ILLUMINATING EARLY KNOWLEDGE!**

**Leader:** Chris Chatham  
**Age:** 10 months  
**Dates:** September 2006 - December 2007  
**Game:** Searched for a toy, with colored lights on the ceiling or in different rooms.  
**Major Finding:** Changing learning context could help children search for a hidden toy.

Infants have a hard time breaking habits. After 10-month-olds find a toy in one location, they often keep looking for the toy there even if they see it being hidden in a new location. Infants may quickly form a habit-like memory for the initial location of the toy that needs to be overcome when the toy is hidden in a new location. Such rapidly formed memories can often be specific to context, so a change in context might help infants reach to the new location.

When given a choice between a new toy and a familiar toy, infants typically go straight for the new toy; however, this preference reverses when toys are hidden in the dark. We think that infants show more object permanence understanding with familiar toys because they can remember them better, but infants might reach more for familiar toys in the dark because they want the familiar toy for comfort or because they know how to grasp this toy better than toys with new shapes.

We put toys behind a transparent or opaque rotating screen that infants could pull to retrieve the toy. The lights were always on, so infants would not choose a toy just for comfort. The movement of pulling down the screen was the same for all toys, so reaching for familiar toys would not be easier than reaching for new toys.

When toys were visible, infants reached more for the new toy than the familiar toy, as expected. When toys were hidden, infants reached equally for familiar and new toys; however, when we offered the screen with no toy behind it at the end of game, infants often still pulled down the screen. They may have just wanted to play with the screen.

**GETTING PAST BARRIERS!**

**Leader:** Yura Oh  
**Age:** 8.5 months  
**Dates:** July 2007 - December 2007  
**Game:** Found toys hidden behind rotating screen.  
**Major Finding:** The screen was as fun as the toys!

When given a choice between a new toy and a familiar toy, infants typically go straight for the new toy; however, this preference reverses when toys are hidden in the dark. We think that infants show more object permanence understanding with familiar toys because they can remember them better, but infants might reach more for familiar toys in the dark because they want the familiar toy for comfort or because they know how to grasp this toy better than toys with new shapes.

We put toys behind a transparent or opaque rotating screen that infants could pull to retrieve the toy. The lights were always on, so infants would not choose a toy just for comfort. The movement of pulling down the screen was the same for all toys, so reaching for familiar toys would not be easier than reaching for new toys.

When toys were visible, infants reached more for the new toy than the familiar toy, as expected. When toys were hidden, infants reached equally for familiar and new toys; however, when we offered the screen with no toy behind it at the end of game, infants often still pulled down the screen. They may have just wanted to play with the screen.

When given a choice between a new toy and a familiar toy, infants typically go straight for the new toy; however, this preference reverses when toys are hidden in the dark. We think that infants show more object permanence understanding with familiar toys because they can remember them better, but infants might reach more for familiar toys in the dark because they want the familiar toy for comfort or because they know how to grasp this toy better than toys with new shapes.

We put toys behind a transparent or opaque rotating screen that infants could pull to retrieve the toy. The lights were always on, so infants would not choose a toy just for comfort. The movement of pulling down the screen was the same for all toys, so reaching for familiar toys would not be easier than reaching for new toys.

When toys were visible, infants reached more for the new toy than the familiar toy, as expected. When toys were hidden, infants reached equally for familiar and new toys; however, when we offered the screen with no toy behind it at the end of game, infants often still pulled down the screen. They may have just wanted to play with the screen.
changed the light color, then changed it back, or never changed it at all, or walked them into the hallway and back, or never left the room at all.

As expected, infants were more likely to find the toy in its new location when the room's light color was different or they were taken to a different room, but this difference was very small. Infants’ habits seem somewhat specific to context but may depend on memory development.

Cognitive abilities change remarkably between three and seven years. We explore these changes using card-sorting games. Children often sort cards by the first rule given, but continue to apply this rule even when they are asked to switch. We explore why children do this and what allows them to eventually switch flexibly.

**It's All in the Cards**

### Where Do The Cows Go?
**Leaders:** Chris Chatham, Maria Kharitonova  
**Age:** 3 years  
**Dates:** October 2006 - November 2006  
**Game:** Sorted cows by size or number.  
**Major finding:** Children who switch between color/shape also switch between size/number.

In our center, most of the card-sorting games children play use colored (red or blue) trucks or flowers. We redesigned the game with cows that varied in size and number. Children who switched rules with trucks and flowers also switched rules with the cows, suggesting that flexibility generalizes across different rules.

### Which Practice Makes Perfect?
**Leader:** Julia Stadele  
**Age:** 3.5 years  
**Dates:** December 2006 - February 2007  
**Game:** Sorted color-changing trucks/flowers or color-changing rabbits/boats.  
**Major Finding:** Practicing with different shapes helps children switch between different rules.

Practice helps children switch rules, but are some types of practice more helpful? In our card-sorting game, children sort blue trucks and red flowers by color/shape. We came up with two kinds of practice. Before switching to shape, children practiced with colorless (black) shapes that gradually got their color back. Some children practiced with the specific rule (trucks and flowers) they would use later. Other children practiced with the general rule (shape) using boats and rabbits, the shape they did not see later.

We asked children to switch twice after the practice: from sorting by color to shape, then back to color. All children switched from sorting by color to sorting by shape, but children who practiced with trucks/flowers had a harder time switching back to color than children who practiced with rabbits/boats. We believe this means...
that practice with trucks/flowers focused children on specific features of shapes much more than practice with rabbits/boats did.

**NOT LIKE THE OTHER**

**Leaders:** Joedy Hulings, Maria Kharitonova, Lauren Gindin  
**Age:** 3 years  
**Dates:** July 2007 - June 2008  
**Game:** Sorted cards and played odd-one-out.  
**Major Finding:** Picking the odd-one-out did not help children switch to a new rule.

Children who switch flexibly may think in more abstract terms (“match by shape”) while children who don’t switch might think in more concrete terms (“trucks go with trucks”). If we encourage children to think abstractly, would they behave more flexibly?

We created two kinds of “odd-one-out” games. In both games, children were asked to pick the one odd (different) object from a set of four shapes or colors. The “narrow” game covered a small range, like slightly different triangles or shades of blue. The “wide” game covered a broader range (see figure), like cool vs. warm colors or rounded vs. angular shapes. The wide game was designed to encourage more abstract thinking.

Children who switch flexibly may think in more abstract terms (“match by shape”) while children who don’t switch might think in more concrete terms (“trucks go with trucks”). If we encourage children to think abstractly, would they behave more flexibly?

Children sorted cards by shape and color with the odd-one-out game in between. The wide odd-one-out game did not help children switch more than the narrow game, possibly because not all children understood the odd-one-out game. Those who understood the rule switched more than those who did not.

**TRUCK GOES WITH FLOWER?**

**Leader:** Katye Blackwell  
**Age:** 3 years  
**Dates:** July 2006 - June 2007  
**Game:** Sorted cards by size/place/number, shape/color; played hide-&-seek on computer.  
**Major Finding:** Feedback & closeness to switch affect how children learn new rules.

Children have a hard time switching between rules, perhaps because they don’t realize they are doing something wrong. Giving feedback helps some children switch, but others ignore feedback.

Still others do something unexpected: creating a new rule after a new game is introduced and playing an “opposite” game, “trucks go with flower” or “red goes with blue.” Why do some children play this opposite game while others switch or ignore feedback?

One idea is that children need a very clear idea of what they are doing wrong in order to apply feedback. Children who are close to switching rules may know something is wrong from feedback, but they are not sure what and don’t know what to change. Children who are further from switching may have a strong idea of what they are doing and stay focused on the first game they played even after receiving feedback.

Another idea is that some children learn better from negative feedback, while others learn better from positive feedback. Children who played the opposite game might learn better from negative feedback, while children who kept playing the same game learn better from positive feedback.

To find out what children do with negative feedback, we asked them to play a card-sorting game. One group of children sorted cards with worms: first by size, then by place. Another group of children sorted cards with cows: first by size, then by number. Sorting by place or number is harder than sorting by size; most children needed feedback when they did not switch.

To see how close children were to switching on their own, children sorted blue trucks and red flowers by shape and color. In between, children practiced with solid colors: blue or red cards, which should help switching.

To see whether children learn better from positive or negative feedback, children played a “hide-and-seek” game on a computer. They guessed which rocks or characters a butterfly was hiding behind. When children did not find the butterfly, they saw either nothing or a red X (negative feedback). Children who learn better from negative feedback might change choices (pick the other rock or character) when they don’t find the butterfly, but children who learn better from positive feedback might not.

Children who played the opposite game in response to feedback were further from switching on their own than children who ignored feedback. Also, children who started playing the opposite
to negative feedback. star

**Why Am I Wrong?**

**Leader:** Katye Blackwell  
**Age:** 5.5 - 6.5 years  
**Dates:** May 2007 - August 2007  
**Game:** Played computer games: listening and judging, matching, and hide-and-seek.  
**Major Finding:** How children learn new rules depends on their awareness of conflicts, working memory, and sensitivity to negative feedback.

Five- and 6-year olds have a hard time when rules switch from judging whether a speaker is happy or sad based on what a person says to based on how she says it. Most of them think a speaker saying “My mommy gave me a treat” is happy even if it is said in a sad voice. To explore how feedback helps children behave more flexibly, children played three games on a computer. First was a listening and judging game to measure children’s conflict awareness: children heard happy statements in a sad voice, or vice-versa, and judged the speaker’s mood based on what she said and how she said it. We asked children, “Was there anything silly?” at the end of the game. Children who say, “When she was happy she talked sad,” for example, are aware of the conflicts, which might help them switch. Second were matching games to see how children remember rules: children matched stripes and dots, and also pictures by shape (cat, bird, and fish), then color (red, blue, and yellow), and size (big, small, and medium), while remembering the rule on their own. Third was a hide-and-seek game to measure children’s sensitivity to negative feedback: children found animals behind rocks and learned the animals’ favorite hiding spot with feedback (see “Truck Goes With Flower?”). If they don’t care about receiving negative feedback, they might not need a need to change their behavior. Conflict awareness, working memory, and sensitivity to negative feedback were all important in helping children behave flexibly. Children who described how the speaker said something happy but in a sad way, matched pictures by rules faster, and chose a different hiding place when they didn’t find an animal, all used negative feedback to switch to a new rule. star

**Exercising That Mental Flexibility**

**Too Many Choices!**

**Leader:** Hannah Snyder  
**Age:** 4 - 5 years  
**Dates:** August 2007 - July 2008  
**Game:** Picked pictures that went together and thought of words from categories.  
**Major Finding:** Abstract thinking helps switching across different situations.

There are lots of ways of being flexible. Our card-sorting games look at how children behave when we tell them to do something different, but it is just as important to be flexible without instructions. We looked at how children think about pictures in a new way on their own. Children picked two pictures that go together in one way, and then two that go together in a different way. For example, if there is a red shoe, a blue shoe, and a blue boat, you could pick the two shoes first, and the two blue things second. Many 4-5-year-olds make the first selection easily but not the second one.

We explored how flexible thinking might be important when choosing from many possible answers. When naming things from categories (such as animals), there are many possible answers to pick from. Flexibility might help with thinking of words from categories, because they involve thinking of one group of items (e.g., zoo animals) and then switching to another group (e.g., pet animals).

Children who switched more during the first game also switched more between groups when naming things in the second game. Their switching was related to their abstract thinking, so we next tried encouraging abstract thinking by providing children with labels for groups (e.g., farm animals). As expected, these labels helped children to think of more words and switch more between groups than children who we provided with less-abstract labels for things (e.g., goat). star
How do active, abstract, and specific memories relate to one another? To see, we had children play computer games over several sessions.

One was a card-sorting game: switching between sorting things by size and number. This game measured active memories: the ones that allow you to mentally repeat the rule (e.g. “size, size”), which might help children behave flexibly. Another game was matching colors, like whether an orange star was more like a red star or a blue star, which requires thinking abstractly about the dimension of color. Another game was deciding which of two similar-looking pictures had been seen before, such as two different shades of red. This looks at children’s specific memories.

Children who thought more abstractly remembered more pictures, but how they played these two games didn’t relate to how they played the active-memory (switching) game.

To look at the relationship in more detail, we had children play another series of games. One game was a computer game with the characters Spongebob and Blue from “Blue’s Clues.” We told children that Spongebob liked a watermelon but not a slinky while Blue liked neither. When these characters appeared followed by an item, children pressed a “happy” button (for items they like) or a “sad” button (for items they dislike).

Another matching game looked at how strongly children were aware of the current rule. Children matched pictures by their color (pink or purple). Another game required focused attention to remember the location of two colored squares. There were remarkable similarities between how children played this game and the Spongebob game: Controlled attention can help children across tasks.

We also played two “copycat” games. In one, children mimicked how we tapped on the table (once or twice) or had to control their urge to mimic and tap different numbers. Although some believe this ability to “inhibit” is central to cognitive development, we didn’t find connections between how children played this game and others.

In the other copycat game, children repeated back numbers we had just told them. Children who remembered more numbers were more likely to say when a cartoon character didn’t like the item most commonly liked by the other character.

Interestingly, children do not seem to mentally prepare their responses in advance. In the cartoon game, they could press the sad button as soon as Blue came on the screen, since Blue didn’t like a watermelon or a slinky. But they still waited for the item to appear. Children might react to their environment, rather than actively preparing for it, even if the action required is predictable. (See next story for developmental changes.)

These games helped us see how different skills relate: We found remarkable similarities in some, but a surprising lack of relationship in others.★★

As adults, we switch flexibly between holding information actively in mind when preparing for something (“proactive” memory) or simply recalling information when we need it (“reactive” memory), depending on the situation. Preschoolers depend heavily on reactive memory (see “All Together Now”). To explore the development of proactive memory, 8-year-olds played the same game as the preschoolers: pressing a “happy” button or a ‘sad” button when Spongebob or Blue appeared on the screen followed by items each liked or disliked. Eight-year-olds’ eye movements and response times showed they use more proactive memory than preschoolers. These findings suggest that proactive memory is more demanding and develops with age.★★
Cognitive Development Center Milestones

Our center received a 5-year grant from NIMH to study the development of executive function. Our Center Director, Dr. Yuko Munakata, was promoted from Associate Professor to Professor.

A sampling of our recent publications:


Masters Defenses

- Katye Blackwell. Is saying “That was wrong” enough?: Factors affecting children’s use of feedback to overcome perseveration.

- Chris Chatham. Developments in context processing: Reactive mechanisms isolated in preschoolers.

- Maria Kharitonova. Is there more to becoming “unstuck”? Exploring the relationship between flexibility and generalization in young children.


Undergraduate Research Grants & Awards

- University UROP (Undergraduate Research Opportunities) Grants: Meghan Wright, Deidre Lichty, Daniel Cashmore, Natalie Hutchison, Joedy Hulings

- Psychology SURF (Summer Undergraduate Research Fund) Grants: Joedy Hulings, Amanda Bennett, Kelly Reid

- Joedy Hulings and Melissa Hamline received the Jacob Van Ek Award for superior academic achievement and outstanding contributions to the University and/or the Boulder community.

- Amanda Bennett and Meghan Wright received the the Provost Achievement and Convocation Award.

- Meghan Wright received the Imogene Jacobs Award for outstanding Junior Psychology Major and a Colorado State University REU (Research Experience for Undergraduates) grant.

- Julia Stadele received 3rd Place in the Behavioral and Social Science category for her poster, “CS Scaf 3: Flexibility in Children” at the Roche Colorado Regional Science Fair and was a finalist at the Roche Colorado Boulder Valley Research Symposium.

Moving On

- Lauren Gindin is a graduate student in the Developmental Psychology program at the University of Connecticut.

- Nicholas Cepeda is an Assistant Professor at York University in Toronto, Canada.

- Amanda Bowles is attending medical school at the University of Colorado Health Sciences Center.
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 the development of memory and thinking. Now we’d like to share all we’ve learned with you. Inside, you can find out what the games your child played told us!