



DU Junior Scientist

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COGNITIVE DEVELOPMENT CENTER

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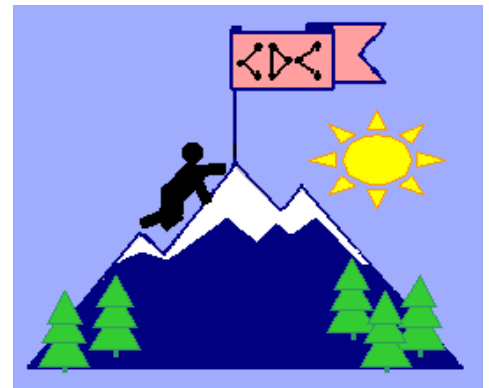
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We've moved!

Dr. Munakata, the director of the center, has accepted a position as associate professor at the University of Colorado, Boulder. The Cognitive Development Center will relocate there so that research can continue.

If you would like to continue to participate in studies at the Cognitive Development Center, please call: 303.492.6389

Our goal in the Cognitive Development Center is to understand thinking, and how it changes with development. We study cognitive development by investigating questions like: How do we remember where we left our car keys? (Or when we forget and have to search for them, why does this happen?) How do we solve problems, such as figuring out how to grab a pen that is just out of our reach? How do we make plans, from what we'll do before lunch today to what we'll do on vacation four months from now? How do we figure out where we are when we explore a new city for the first time? In our center, we work with infants and children to explore the development of such abilities in memory, problem-solving, flexibility, and navigation. Studying how these abilities develop should help us to understand not only how infants and children think, but also how we come to think as we do as adults.

Hide and Seek

How does memory for hidden objects develop during the first year of life? Early in infancy, babies look as if they quickly forget about an object as soon as it is hidden—as if out of sight is out of mind, literally. But recent research suggests that memory in infancy may be much more sophisticated than it appears. In the following three studies, we address several related questions about the development of memory for a hidden object. Why don't babies search for a toy hidden under a cloth before 8 to 10 months? How much stronger is a 7-month-old's memory for a hidden toy if the toy is their own familiar one instead of a new one? What helps 10-month-olds to follow the movement of a toy from one hiding location to another? Addressing these questions will ultimately help us better understand the nature and development of human memory.

Babies, Bibs, and Beverages

Why do babies fail to search for a toy hidden under a cloth before 10 months when they can find a toy in the dark at 6 months? According to one account, babies remember the toy is there, but planning to move the cloth out of the way first is too difficult; they succeed in the dark because there is nothing to move out of the way. According to another account, babies succeed in the dark because darkness interferes with their memory less than being in the light does.

First, we tested whether babies' advantage in the dark was genuine, because no prior work systematically compared hiding a toy under a cloth vs. in the dark. For example, most cloth studies used silent toys whereas most dark studies used toys that make sound. In our first two studies, we hid toys from 6-month-olds in the dark or under a cloth while keeping everything else the same. Half the time we hid a toy and half the time we hid no toy. Babies searched more on toy than no-toy trials in the dark than they did with a cloth; that is, they were more sensitive to the toy hidden in the dark. Thus, the advantage in the dark is genuine.

Now we are testing the two accounts for *why* babies are better in the dark. We are presenting 6-month-olds with toys hidden in the light or dark, where they must first either move a cover or not. If the first account is correct, infants should succeed more when they do not have to move a cover than when they do, regardless of being in

the dark or light. If the second account is correct, infants should succeed more in the dark than the light, regardless of whether they have to move a cover.

We began this study by hiding toys in the light or dark using two Plexiglas apparatus: one that babies could reach under, and one that required them to first open a door. However, we discovered that babies had difficulty reaching under the Plexiglas for the toy even when it was visible. Next we hid toys in the light or dark using "bibs". One bib fastened around babies' necks so they could reach under it for the toy. The other fastened around babies' waists so they had to first pull off a cover and then reach through a hole in the bib for the toy. But, we discovered that babies disliked having the bib around their necks! Now we are hiding toys in the light or the dark using liquids. Half the babies see a toy hidden in milk, so they simply reach in for the toy. And half the babies see a toy placed in water and then covered, so they must move the cover to get the hidden toy. So far, it's hard to tell whether babies are searching for the toy or just splashing for the fun of it! Eventually we hope to create the right apparatus to test whether babies do better in the dark because it interferes less with their memory or because the reach is simpler. Ultimately, this work will help us better understand how much of babies' behavior with hidden objects is affected by memory demands and how much is affected by reaching demands.



Something Old, Something New

In the first months of life, children explore all aspects of their environment and the world, which includes building knowledge of the permanence of people or objects that are hidden. That's why playing peek-a-boo is so fun for infants. We wanted to delve deeper into this topic and observe what situations allow children to show knowledge of a hidden object versus those situations where knowledge is less clear. Specifically, we wanted to focus on the actual objects to see if particular ones elicited different behaviors.

In this particular study, we use a set of one dozen toys from our center, selected by parents, which are completely novel to the infant. In addition, one familiar toy from home is used. One of each type of toy is placed on a shelf that is distant to the infant. To retrieve the toy, infants must hit a button to drop the shelf causing the toy to slide down a ramp directly to the infant. A screen that is transparent (making the toy visible) or opaque (making the toy hidden) is dropped right before the infant is allowed to hit the button to retrieve the toy. (See picture on page 6).

Previous studies have shown that when toys are visible, infants typically prefer to reach for a novel toy over a familiar toy. When toys are hidden though, infant's memory might lead them to do the opposite: search for a familiar toy more than a novel toy. We want to see if these theories hold true using the button apparatus. Since infants have more experience with a familiar toy, they might have a stronger memory for that toy once it is hidden. Evidence of this would be revealed if infants push the button more for a hidden familiar toy than for a hidden novel toy.

So far, we've noticed that infants tend to push the button slightly more when a familiar toy is hidden versus a novel toy. This could reveal that infants have memory for hidden objects much earlier in life than originally thought. Our ongoing research explores these preliminary findings.

Do Babies Judge a Hidden Toy by its Cover?

How do babies track a hidden object that changes location? Babies who find a toy hidden in location A will continue to search for it there, even after seeing the toy hidden in location B. This is called the A-not-B error. According to one account, memory for the toy in the new location fades quickly, and babies also have a difficulty inhibiting their habitual reach to location A.

Another recent account suggests that babies make the error because the hiders in both locations function the same way, making it difficult to distinguish the two locations. For example, the toy may be hidden under one cup in location A and under a second cup in location B. Because both cups hide the toy the same way (covering it), babies may have more difficulty differentiating the two locations. Babies may have difficulty tracking the location change when the two hiders function similarly (two cups), even if they look different (red cup vs. blue cup). An interesting prediction from this account is that babies may err less if the two hiders function in different ways. For example, if the toy is hidden *under a cover* in location A but *inside a container* in location B, babies may differentiate the two locations better.

We are testing this prediction with 10-month-olds using three types of hiding events. The toy is hidden under a cover, inside a container, or behind a barrier. Half the

time, the two hiders function the same way (e.g., two covers), and half the time they function differently (e.g., cover vs. container). We are also manipulating whether the two hiders look similar.

For example, instead of using two blue hats as covers in both locations, the cover in location A might be a blue hat and the cover in location B might be a brown box. The prediction from this account is that babies will err less when the hiders function in the same way, even if they look different.

The results from our first study suggested that babies did not, in fact, do better when the hiders functioned in different ways. If anything, they seemed to do slightly better when the covers looked different from one another despite functioning the same way. However, this tendency was not statistically significant.

We were concerned that babies may have had too little experience seeing how the hiders functioned before they had the chance to search for the hidden toy. To address this concern, we are now conducting a follow-up study. Although the study is not complete, the results appear to be similar. Babies seem to do better when the hiders look different than when they function differently.

Ultimately this work will help us better understand what kind of information babies use to track the location of objects and people that move out of sight.

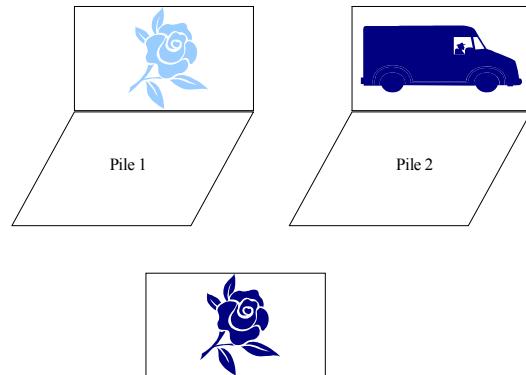


Breaking Habits is Hard to Do

Most people drive home from work the same way everyday. But if you have to run an errand after work, such as picking up dinner, then you would likely remember to take a different route in order to stop at the appropriate store. This ability to break a habit (not driving your regular route) and start a new behavior (driving to the store) is an example of cognitive flexibility. However, sometimes adults do not break their habit and end up driving straight home at inappropriate times. Like adults, children behave flexibly in some situations, but not others. What factors are important in children's flexibility? What factors make it easier or harder to break a habit?

Card Sorting Games

To try and understand what influences children's flexibility, we observed what they did while they sorted cards into two piles. Some children were first asked to sort the cards based on their colors, while others were first asked to sort the cards based on their shapes. Then, children were asked to sort the cards by the other rule, and this usually required children to place cards in the opposite pile from the first rule (look at the figure to see an example of how a card fits with each demand depending on the rule of the game). Typically, 3-year-old children sort cards correctly using the first rule, but continue to sort cards by the first rule when asked to switch and sort cards by the



Name Game

We wanted to know if saying the first rule and naming the cards by that rule helped children develop a stronger habit to sort cards by the first rule. To test this idea, a group of 3-year-olds were not given meaningful labels for just the first game and cards. They were told, "This is the sorting game. This one goes here, that one goes there". When asked to switch and sort cards by the second rule, more children in this group sorted cards by the second rule than a group of children who received meaningful labels.

"What is that?"

We also wanted to know if sorting familiar cards helped children develop a stronger habit to sort cards by the first rule. To test this idea, a group of children sorted cards that for the first rule had unfamiliar shapes or colors, such as cloud-like objects called "daxes" and stair-like shapes called "gubs". When asked to switch and sort cards by the second rule, more children in this group sorted cards by the second rule than a group of children who received familiar examples, such as a heart and star, for the first rule.

"How did I do?"

We also wanted to know if receiving feedback when sorting cards by the second rule would weaken children's habit to sort cards by the first rule. To test this idea, a group of 3-year-olds sorted cards and received feedback, such as "good job" or "that's not right. This one goes here", when sorting by the second rule. When asked to switch and sort cards by the second rule, more children in this group sorted by the second rule, but many still sorted by the first rule even with feedback.

Does practice make perfect?

We also wanted to know if prior practice sorting cards by the second rule would strengthen children's ability to sort cards by the second rule. To test this idea, two groups

of children sorted different cards in between sorting by the first rule and the second rule. One group practiced sorting cards that could only be sorted by the second rule. Another group of children sorted some cards that were not related to color or shape for the same amount of time. Surprisingly, when asked to switch and sort cards by the second rule, children in the practice group were just as good at switching as children in the unrelated group. Older children (3.5 and 3.75 year olds) were good at switching in both groups, whereas younger children (3 year olds) had difficulty switching in both groups

Listening Games

While 3-year-olds show difficulties with cognitive flexibility, they are not alone. Another study in our center has revealed that 6- and 7-year-olds who participated in a task utilizing rule-switching showed similar results. How is it that 6 and 7-year-olds with more experience with switching than 3-year-olds still have difficulty with flexibility?

Are Kids Hearing Things?

In this study, children played a computer-based listening game where they were instructed to first listen to the speaker's words, then switch and listen to the speaker's tone of voice, each time determining if the speaker was happy or sad. To potentially help children make this switch, we created an intermediate game (between the first rule and the switch to the second rule) involving a hand puppet named "Susie," as well as practice with the new rule on the computer. We hoped that we could gear children's focus on the new rule, the speaker's tone of voice. Children first produced either a happy or sad voice, and spoke the neutral phrase, "Tell me how I feel," and Susie would have to guess if the child was happy or sad. Next, children were asked to judge if the speaker on the computer was happy or sad when the same neutral phrase was spoken. In these games, children only had to focus on tone of voice because the content of the sentence was neutral.

Children had no difficulty with the first rule. Children

also performed near 100% during the intermediate games with Susie, and on the computer. After the switch, however, children still tended to use the original rule instead of the new one. Children in both age groups were asked if they found the game “tricky” or not, and if they did, why. Seven-year-olds recognized the trickiness more than 6-year-olds, noting that it was confusing when the speaker said something happy, but sounded sad. Despite this, they still had problems with the first rule change.

Future listening game studies are currently being planned to determine when there is an improvement in performance. We will investigate if the improvement is gradual over the years, or if there is a specific age when a jump in improvement is apparent. Regardless, there are many implications to the findings in everyday situations. Children seem to have difficulty switching rules, so when a teacher in the classroom starts a new activity, or a parent explains a new rule in the house, children may seem to recognize the rule, but it can be difficult for them to adjust when the new rule is in conflict with an old habit.

Overall, our research in the area of cognitive flexibility suggests that children’s ability to switch from an old habit to a new behavior is influenced by several factors. Sorting with meaningful labels and well-know colors and shapes make the habit stronger and harder to overcome. Providing any kind of intermediate game appears to make it easier to switch, but only for older children. However, on a positive note, providing feedback when trying to engage in a new behavior appears to weaken the habit, and children are more likely to switch to the new behavior. This is why reminders are helpful in breaking habits!

Wanted: Toddlers to Reorient. No Experience Necessary!

We've recently discovered that inexperienced walkers (14-month-olds) use the same information to reorient as more experienced walkers (24-month-olds).

When we last reported on these orienting studies, we told you that 24-month-olds use geometric cues, such as the shape of the room, to reorient themselves in rooms that also contain featural cues. In these studies, 24-month-olds watched a toy being hidden in one of four boxes placed in the corners of a white, rectangular room containing featural cues, such as a blue wall or some colorful posters. After being blindfolded and turned by their parents, toddlers tried to find the toy. To find the toy, children needed to reorient, or get their bearings in the room. Toddlers' searching reveals how they are reorienting. If toddlers successfully find the toy, this shows they are using the room's featural cues to reorient and remember the toy's location. In contrast, if toddlers find the toy only half the time, and search the corner opposite the toy half the time, this shows they are using only the room's geometry to reorient. This is because the correct corner and the opposite corner have the same geometric relationship; when the child faces these corners, for example, a short wall will be on the child's left and a long wall will be on the child's right. Although 24-month-olds tended to find the toy correctly on the first of four hiding trials, overall they used the room's geometry to search on later trials.

We wondered whether beginning walkers, 14-month-olds, would perform differently in the same reorienting task. We speculated that 24-month-olds could have learned to use geometric cues over several months of walking experience that may have taught them to navigate using, for example, the shape of rooms found in their environment. Perhaps younger children with little walking experience might be more likely to notice and use all sorts of cues, including featural information. Thus, we invited 14-month-olds who had recently learned to walk, to perform our orienting task in a room with three white walls and one blue wall. The youngsters' lack of experience did not affect their search performance: 14-month-olds also used the room's geometry to reorient. These findings seem to provide support for the theory that children have a specific area of the brain, or module, that uses only geometric information to help them reorient. (Adults use more than this module, which makes them successful in reorienting tasks). Researchers who proposed the geometric module theory believe this module is present at birth; thus they would predict that 14-month-olds should use geometry, even though they have little experience reorienting or navigating while walking.

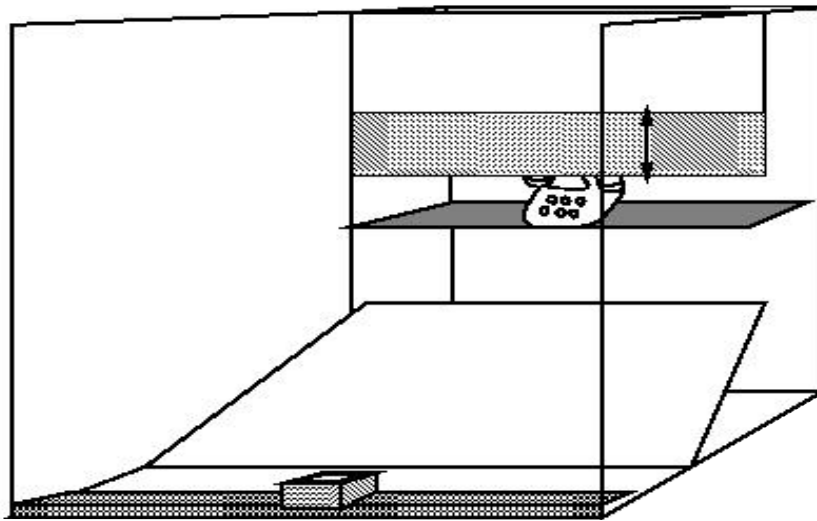
Since walking experience does not seem to impact toddlers' orienting abilities, we are now testing 24-month-olds in the same orienting task but now in a room without geometry. The new room is completely circular and white, with one section of blue wall. Children are asked to find the toy in a hiding tube that extends around the circumference of the room. A search will be considered correct if the child searches the hiding tube in the quadrant of the room that contains the toy. If a reorienting module does exist, then even in this circular room without geometry toddlers' should not be able to use the blue wall to reorient and should be completely at chance finding the toy, searching all quadrants equally. However, the reorienting module theory would be in question if toddlers use the blue wall to reorient and search the quadrant containing the toy more often than they would by chance. This type of search would indicate that toddlers can and will use features to reorient if a geometric cue isn't available. Regardless of how toddlers search we will be learning more about what sorts of information is used by young walkers to figure-out where they are and where they want to go!

Problem-solving Babies

Can babies solve problems?

As reported in our previous newsletters, 7-month-old infants can learn to solve problems by acting on one object to get another object. For example, with their parents' help, 7-month-old infants learned to push a button to retrieve a distant toy (see picture below). Pushing the button caused the shelf supporting the toy to drop, so that the toy slid down a ramp to within infants' reach. Infants faced this task after a transparent or an opaque screen was lowered between them and the toy, so that the toy either remained visible or became hidden. Infants also saw sometimes that no toy was presented before a screen was lowered. Infants pushed the button most for visible toys and least when they could see there was no toy. They pushed the button at an intermediate level when they could not see what was on the shelf, whether or not a toy was present. Thus, infants appeared to learn the appropriate problem-solving skills for retrieving toys, but they could only carry out these skills with visible toys.

We next explored whether infants could learn problem-solving skills that allowed them to solve problems in new situations. Seven-month-old infants first learned one way to solve a problem and were then presented with a problem requiring a new solution. Infants were presented with the same button set-up we used in our earlier studies. With their parents' help, they learned to pull down on a yellow plastic ring to retrieve a distant toy. The ring was attached to the button, and pulling down on the ring caused the button to lower, dropping the distant shelf so that the toy on it slid within infants' reach. The ring was then removed from the button, so that infants needed to push the button to retrieve toys. This was a new behavior that they had not been taught. Despite this, infants showed the same pattern of button-pushing as infants in the earlier studies who had been taught directly to push the button. That is, these ring-pulling infants went on to push the button most for visible toys, least when they could see there was no toy, and intermediately when they could not see whether a toy was present. Infants thus showed remarkable flexibility in their problem-solving skills. They were able to carry out new problem-solving skills as required by the situation, even though they had not been taught those specific skills. These flexible-problem-solving skills may come in handy for infants to get what they want, such as distant toys or bottles!



Milestones

Just as children continue to develop each day, so does the Cognitive Development Center. In the past year, there have been many accomplishments for individuals as well as the center itself. Below are highlighted events that have positively changed lives and in turn, benefited the lab tremendously. We are proud of all of the achievements and look forward to many more in the future!

- Dr. Yuko Munakata was awarded the Boyd McCandless Young Scientist Award, from the American Psychological Association for her distinguished contribution to developmental psychology.
- Dr. Jeanne Shinskey and Jennifer Stedron were both awarded National Research Service Award grants.
- Ben Yerys defended his Master's thesis this past March.
- Dr. J. Bruce Morton accepted a position as an assistant professor at Western Ontario University in Ontario, Canada.
- Four of our undergraduate researchers have graduated from the University of Denver, with three of them continuing their education at medical school: Lindsey Hackett, Laura Landgraf (Johns Hopkins), Eric Flyckt (Stanford), and Jennifer Huddleston (CU Boulder).
- In the last 3.5 years we've produced 22 publications and 18 conference presentations! Below is a selection of some of the work:

Shinskey, J.L. & Munakata, Y. Are infants in the dark about hidden objects? *Developmental Science*.

Stedron, J.M., Munakata, Y., & O'Reilly, R.C. (2000). Spatial reorientation in young children: A case of modularity? Poster presented at the 2000 meeting of the International Conference on Infant Studies, Brighton, England.

Munakata, Y., & Yerys, B.E. All together now: When dissociations between knowledge and action disappear. *Psychological Science*.

Morton, J.B. & Munakata, Y. Are you listening? Exploring a knowledge action dissociation in a speech interpretation task. *Developmental Science*.

Munakata, Y., Bauer, D., Stackhouse, T., Landgraf, L., & Huddleston, J. Rich interpretation vs. deflationary accounts in cognitive development: The case of means-end skills in 7-month-old infants. *Cognition*.

Shinskey, J.L. & Munakata, Y. Detecting transparent barriers: Clear evidence against the means-end deficit account of search failures. *Infancy*.

Munakata, Y. Graded representations in behavioral dissociations. *Trends in Cognitive Sciences*.

Shinskey, J.L. Object concept, development of. In J.H. Byrne, H. Eichenbaum, H. Roediger, III, & R.F. Thompson (Eds.), *Learning and Memory* (2nd ed.).

Munakata, Y. and Stedron, J.M. Memory for hidden objects in early infancy: Behavior, theory, and neural network simulation. In J.W. Fagen & H. Hayne (Eds.), *Advances in Infancy Research*, Volume 14.



Cognitive Development Center

We hope you've enjoyed reading about all the discoveries the Cognitive Development Center has made in the past year. This would not be possible without parents like you who offer your time to contribute to the advancement of developmental science. Thank you! We hope your experiences with the center have been as exciting for you as they have been for us.

