At the Cognitive Development Center, our goal is to understand thinking and how it changes with development. We work with infants and children to explore the basic building blocks of how they control their thoughts and actions. How do they choose their words? How do they learn to plan ahead? How do they stop themselves from doing things they’ve been told not to? How do they switch from one activity, or one set of rules, to another? How do social and genetic factors relate to choosing rewards? In our center, we use simple games to explore these building blocks. Learning how these abilities develop helps us understand not only how infants and children think, but also how we come to think as adults.

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**Cognitive Control: How children control what they do**

Cognitive control refers to a variety of abilities, including choosing from among multiple possible options, switching between activities, planning ahead, stopping certain actions, and waiting for a reward over time.

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### What if I get ready now?

**Leaders:** Nic, Shaina and Krystin  
**Age:** 5- and 10-year-olds  
**Dates:** February 2012-November 2012  
**Game:** Children are notoriously reactive; they often respond to situations without planning ahead. We wanted to explore the possibility that children could learn to plan ahead and not just react in the moment. We compared five- and ten-year-olds’ ability to prepare for future events by having them complete a computerized task that encouraged them to plan ahead in some instances. Children were asked to wear an EEG cap and have their pupil diameter tracked, which allowed us to see whether children exerted the most mental effort before or after they were encouraged to plan ahead.

**Major Findings:** Five-year-olds could be encouraged to plan ahead for future events, but they didn’t often choose to do so on their own. Conversely, ten-year-olds tended to plan ahead by choice as well as when encouraged to do so. This suggests that five-year-olds might be able to plan for future events if given the right type of practice or encouragement.

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### Quick! What’s that picture?

**Leaders:** Hannah and Allison  
**Age:** 5- to 6-year-olds  
**Dates:** July 2010- June 2012  
**Game:** Children were asked to name a set of pictures on the computer. These pictures always fit into a broader category (for example, food), but could also be split into more specific categories (like fruits and vegetables).

**Major Findings:** All the pictures could be easily named, but children slowed down as they named such pictures over and over again. (Adults do the same thing). We think this happens because so many words become active in their minds that choosing the right one becomes more difficult.

Providing different category labels can affect children’s ability to name pictures. With some children, Allison pointed out attributes of the pictures that made them seem less similar; for example, she said that an apple was a fruit and a carrot was a vegetable. Pointing out these different attributes made pictures easier to name.

So, we wondered what would happen if Allison were to point out the similarities between pictures. For example, if she said that an apple and a carrot were both foods, would this make the pictures easier or harder to name? On one hand, children would be given more information about the pictures; on the other hand, this information could make the pictures seem more similar.

After playing this version of the game, we saw that it was a little bit of both. When Allison pointed out attributes of the pictures that made them seem more similar, children were faster to name the pictures at first, but then slowed down as they named more pictures. We think this happened because choosing our words is more difficult when the words seem more similar to one another.
### Inhibition: How do children stop themselves?

Young children often have trouble stopping or inhibiting automatic actions. Even when they seem to know the rules, it may be difficult for them to avoid doing something that they have a strong, natural tendency to do. For example, children might yell out an answer in class even though they have been told that they must raise their hand. We are interested in how children learn to stop their actions, and what factors might improve their ability to do so.

### Stop! Don’t feed George brown bananas!

**Leaders:** Chris, Yetunde and Lindsay  
**Age:** 5.5- and 6.5-year-olds  
**Dates:** March 2010 – September 2011  
**Game:** Children played a game with George the monkey and were asked to feed him yellow bananas and to try not to feed him bananas that turned brown. Sometimes George helped the children by pointing to the bananas that might turn brown.  
**Major Findings:** Children were able to use two different kinds of stopping. They could either stop everything they were doing (global stopping), or they could select to stop only a portion of what they were doing (selective stopping).  

Global stopping is faster but less precise. Selective stopping is slower, but results in the ability to stop one action while continuing another. Learning more about how and when children use these different types of stopping will give us insight into the development of inhibition.

### Should I press that button?

**Leaders:** Nic, Kristen and Kate  
**Age:** 7- to 9-year-olds  
**Dates:** October 2011-Ongoing  
**Game:** Children received one of three different types of practice before they played a game to gather bananas for George the monkey. In the first type of practice, children pressed a button one time to collect yellow bananas for a monkey and two times to make a banana that turned brown go away. In the second type of practice, children watched a plane fly across the screen. If the sky stayed blue they pressed a button one time to have the plane land, but if the background turned stormy they had to refrain from pressing a button to keep the plane from landing. In the third type of practice, children pressed a button one time to collect yellow bananas but if a movie character appeared they waited and did not press any buttons. The final game, which every child played, required children to gather yellow bananas for George the monkey by pressing a button one time and to refrain from pressing the button if the banana turned brown.

**Major Findings:** Two types of practice helped children inhibit, or not gather brown bananas, in the final game: when children practiced looking for changes in the banana color by watching it turn brown (the first type of practice) and when children practiced stopping by not letting a plane land in stormy weather (the second type of practice). However, in the first type of practice, children seemed to adopt different strategies to watch for a color change, and only the strategies that closely mirrored the final game seemed to help. This suggests that children can learn strategies for inhibiting that can be generalized to new situations and that some strategies may be more helpful than others.
Don’t open that box!

**Leaders:** Jane and Emma  
**Age:** 3- to 4-year-olds  
**Dates:** June 2012 – Ongoing  
**Game:** Children opened boxes that had different shapes on top. In the basic game, children were instructed to leave red triangle boxes closed, and to open boxes with blue squares to find stickers. In another game, children had to wait a short amount of time before the shape was placed on the box, and were reminded not to reach too quickly. In the last game, Jane included an additional reminder of the rules and pointed to the shape as soon as each box was revealed.  
**Major Findings:** So far, children are more likely to stop themselves from opening a box when Jane points to the shapes on top of the box or says the rules again. In a previous version of the game, children were more likely to stop themselves when they had to wait a short amount of time before they opened the box, but those children may have been helped more by the additional reminders they received over the delay than by the delay itself. ⭐

Cognitive Flexibility: *How do children switch from one activity to another?*

Cognitive flexibility is the ability to change routine behaviors to meet the needs of changing circumstances in the environment. For example, you might typically use a chair as a seat, but if you need to reach a vase that is located on a high cabinet, you could use the chair in lieu of a ladder. Some projects explore this skill and how it develops across the lifespan.

Look at those lines and pick the odd one out!

**Leader:** Maria  
**Age:** 3-year-olds  
**Dates:** September 2010- August 2011  
**Game:** Children played a card sorting game where they first had to sort picture cards by color and then switch rules to sort by shape. After this game, children were shown four pictures of lines and were told to pick the one that was oriented differently than the other three, or to pick the “odd one out”. For example, three of the lines may have been oriented vertically and the fourth oriented horizontally.  
**Major Findings:** Children who switched between shape and color on the card-sorting game were more likely to pick the line that was oriented differently. This could suggest that as children develop cognitive flexibility, they begin to pay more focused attention to distinguishing characteristics of items (such as, shape, size, color, orientation) and use this information to better follow rules or make decisions. ⭐
Do labels help or hurt?

Leaders: Laura and Lena
Age: 3- to 4-year-olds
Dates: July 2011 - Ongoing
Game: Laura played matching games with 3 and 4-year olds.

In the “labeled-picture” games, Laura labeled the way that a set of pictures went together (for example, in one game a picture of a large red shoe and a picture of a large blue shoe could go together because they are the same shape). Laura explained why she had picked the pictures in a certain way, and told children, “I pointed to this picture and this picture because they are both the same shape”. Then, she would ask the children to show her another way that the pictures could be grouped together, for example, two pictures could go together because they were the same color.

Conversely, in the “non-labeled-picture” games, Laura would say that two pictures went together but would not explain why.

Major Findings: Telling 3-year-olds specifically how pictures could be grouped together (for example, by size), made them less likely to group the pictures in another way (for example, by shape). On the other hand, telling 4-year-olds specifically how pictures could be grouped together helped them to group the pictures in another way. This suggests that there is a developmental change between 3 and 4 years, during which children learn to use language to guide flexible behavior.

Which lid should I pick up?

Leaders: Jane, Katye and Julia
Age: 10.5- to 12-month-olds
Dates: July 2008 – Ongoing
Game: In the A-not-B game, infants reached to a toy in one of two hiding locations: A or B. At first, Jane hid the toy several times in location A. Infants were encouraged to reach for the toy. After this, Jane took the toy and hid it in location B, while the infants were watching. Infants often continued to reach to the first location, A, instead of switching to reach to the next location, B. In the next part of the game, infants were seated when Jane hid the toy, but then moved to standing when they had to find the toy. This posture change was intended to help us explore how infants reach when the situation changes.

Major Findings: This game has been restructured a number of times. Infants have been encouraged to reach to new hiding locations to find a toy, but they have also been encouraged to reach for lids without toys being hidden; however, infants often reached for both lids and found that they could clap the two lids together! Currently, we are trying to find the right balance between keeping infants interested in looking for a toy while continuing to add a change of posture to the game. We hope that future projects will inform us about when and how habits are disrupted, and how different individuals may handle this kind of disruption.
**Now or (maybe) later?**

**Leaders:** Laura, Rachel and Layne  
**Age:** 3- to 4-year-olds  
**Dates:** January 2011 – May 2012  
**Game:** Children watched some interactions between adults. These interactions were meant to either make the child trust or distrust Laura. For example, if Laura ripped up another person’s drawing and lied about it, she could be seen as untrustworthy. On the other hand, if she apologized for accidentally ripping it, she could be seen as trustworthy. After watching the interactions, children were given a series of choices. For instance, they could choose if they wanted a smaller amount of candy now or a larger amount of candy later. We were wondering if the interaction that they watched would influence whether they chose a larger reward for later.

**Major Findings:** Children seemed surprisingly willing to delay gratification, regardless of whether Laura seemed trustworthy or untrustworthy. Children who participated in this project may have had an unusual amount of experience with delaying gratification (for example, by saving money), or advanced impulse control. Another possibility is that children may have focused only on the magnitude of the delayed reward (for example, 6 fruit loops compared to 1), and ignored the time difference. We are working on some changes to this project to better understand the role of trust in delay of gratification, and what makes children view individuals as trustworthy or untrustworthy. 

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**Social, Emotional and Genetic Factors:** The basic building blocks of children’s cognitive control may be shaped by a variety of factors, including social, emotional and genetic factors.

**Does trust influence delay of gratification?**  
Delaying gratification (waiting for something rewarding) can be difficult for everyone, especially children. Children often prefer to indulge in activities that are immediately satisfying, such as getting a cookie right away, as opposed to activities that require delaying gratification, such as waiting to receive a cookie until they have finished all their vegetables at dinner. The ability to delay gratification slowly improves across childhood and adolescence, but even adults occasionally struggle to delay gratification in the presence of a tempting immediate reward. One interesting facet of waiting for a reward is how social factors, like the relationship you have with the person providing the reward, may influence your ability to wait. Does a feeling of trustworthiness make it easier to wait?
**Genetic Differences: What helps me wait?**

**Leaders:** Lindsay, Kate, Amanda, Grit, Chris and Laura  
**Age:** 6- to 7-year-olds  
**Dates:** November 2011- Ongoing  
**Game:** We asked children to give us a saliva sample so that we could look at a gene that relates to an oxytocin receptor. Oxytocin is a chemical in our bodies that might explain some differences in how people trust. Children were also asked to play four different games to delay gratification (with either fake candy or real pennies, stickers and treats), and remember Caucasian or Chinese faces.

**Expectations:** Differences in responsiveness to oxytocin may be a factor that affects how people trust one another, remember faces, or bond in social situations. We hope to further understand how our genetic make-up relates to trust, cognitive control, and memory.

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**Differences in Free-Time: Are you a busy bee?**

**Leaders:** Lindsay, Andrei, Eden, Laura and Jane  
**Age:** 6- to 7-year-olds  
**Dates:** October 2011-Ongoing  
**Game:** Children played three computer games: 1) a preference game with SpongeBob and Blue, 2) a game with fish swimming in different directions and 3) a copycat number game. Children also played two vocabulary games. While children were playing these games, parents filled out a survey of how their children spent their time in the previous week. Children were also asked to give a saliva sample at the end of this project.

**Expectations:** This project is looking at a wide variety of social and emotional situations and their relationship to development. Specifically, we are trying to get a better idea of how children spend their time and how this might relate to cognitive control. One question we are particularly interested in is how does the amount of time children spend in structured activities (versus self-directed play time) relate to cognitive control and their ability to plan ahead? Answering these kinds of questions may ultimately inform debates about how parents structure their children’s time and how this may contribute to differences in cognitive control.
Have friends who would like to participate? Recently moved or welcomed a new family member? Please contact us! (303) 492-6389 or cogdevctr@grey.colorado.edu

For a sampling of our recent publications, awards/grants, and other information on the Cognitive Development Center and ways to support us, visit: http://psych.colorado.edu/~cdc/