CDN Lab Newsletter

Spring 2010 -- Cognitive Developmental Neuroimaging Lab

Research Projects

Hello from the CDN lab!

We would like to thank all the children, adults, and families who have participated in our research studies!

Here at the Cognitive Developmental Neuroimaging Lab (CDN Lab), we are interested in the development of attention, executive function, learning, and memory from infancy through adolescence. We use three main techniques to gather our data: MRI, EEG, and behavioral testing. With magnetic resonance imaging (MRI), we are able to see the structure of the brain, as well as which parts of the brain are working hardest, when completing cognitive tasks or games. EEG allows us to monitor the electrical signals our brain produces when challenged by the games. The behavioral testing tells us how quickly and accurately participants are responding while playing the games.

In our newsletter, you will find all of the studies we have been working on in the past year. We couldn't have done it without all of you, so thank you for all your help!

If you have any questions about our research, would like to see continued updates on our studies, or want more information on how to participate in our current projects, you can visit us at http://cehd.umn.edu/icd/CDNLab or call us at 612-624-0075.

To add or remove a child from the Institute of Child Development's list of potential participants, please contact the Infant Participant Pool at IPP@umn.edu.

Attention and Learning during Infancy



In our series of infant experiments we are exploring how infants learn about the world during the first year of life. Given that infants are faced with a massive amount of information in their surroundings, we are especially interested in how infants identify what information is most interesting or important to learn. This is especially intriguing since young infants cannot simply be told to pay attention to specific items. With our Baby Shapes studies, we are trying to understand how developing attention skills might contribute to infants' ability to learn about their world, and how the relationship between attention and learning might vary for individual infants.

During the past year the Baby Shapes project has included two related studies. The first study examined whether 7-month-old infants can learn predictable relationships between pairs of shapes. For this study, infants watched a short movie with pairs of brightly colored shapes appearing in multiple locations. Certain shapes consistently appeared together. For example, every time a green heart appeared it was paired with an orange diamond. We wanted to know whether the infants understood that these shapes "belong" together as a unit. At the end of the movie we showed infants the shape pairs that they had already seen and some shape pairs that were new combinations. We were able to determine whether the infants learned about the original shape pairs by measuring how long they looked at the new combinations.

We found that some infants spent much more time looking at shape pairs that were familiar to them, while other infants showed a preference for the new shape combinations. However, in both case the infants could tell the difference between the old and new shape pairs, suggesting that they had successfully learned the original shape combinations.

Currently, we have added a new element to the movie to determine how early attention skills influence this learning effect. Specifically, the movie now also includes a bright yellow circle (known as the cue) that briefly flashes in the same location where a shape pair will later appear. Even though the cue appears for a very short time, it still influences where infants attend when the shape pairs appear. We call this an "attention bias" because infants' attention is directed to the location where the cue appeared. We believe that this attention bias may have a strong effect on infants' learning of the predictable shape pairs. In particular, it seems likely that infants will learn the shape pair that appears in the cued/attended location to a greater extent than the shape pair that appears in locations that have not be previously cued. We are continuing to collect data using this updated movie and are eager to begin data analysis. If we do see the expected effect of attention on infants' learning of the shape pairs, it will demonstrate that perceptual information in the environment can have an important effect on both infants' attention *and* learning.

The second study we have been working on during the past year also examines the relationship between infants' developing attention and learning processes. In this study, however, we focused on patterns of behavior that are unique to individual infants. The question we addressed is whether individual infants consistently show the same attention behaviors at different points in time. To examine this question, we invited infants to the lab for three separate sessions between their 7- and 8-month birthdays. At each session the infants viewed a movie in which brightly colored shapes appeared in various locations. As in the movie described above, this movie included a bright yellow cue that briefly flashed in the same location where a shape later appeared. In general, some infants are very sensitive to this cue and show a large attention bias towards the cued location, while others are less sensitive and show a weaker attention bias. By having infants view the same movie on three separate occasions, we could determine whether individual infants *always* show a strong/weak attention bias, or if the size of infants' attention bias varies depending on the day.

Preliminary Results

Our preliminary data suggest that there is some stability in infants' attention biases, but it is far from complete consistency. Approximately 20% of the infants we saw showed a strong attention bias at all three sessions, while about 30% showed a strong attention bias at the first and second sessions OR the second and third sessions. We plan to look at each individual infant's pattern of stability more carefully to gain a better understanding of why some infants show consistent attention behaviors while others do not.

There are several factors that may contribute to differences in the stability of individual infants' attention behaviors. One possibility is that some infants are generally more sensitive to environmental/perceptual influences. We assessed this sensitivity by developing additional tasks that measured infants' sensitivity to novel information. In one task, infants played with an assortment of toys, including some that we expected would be relatively novel for the infants. We measured each infant's style of play with these toys, including how quickly they began to play with the toy, their displays of positive emotions, the extent of their focused play, and their various exploration strategies. In the second task, infants' viewed another movie in which they repeatedly saw a smiling female face. After several repetitions, this face became relatively familiar to the infants. At the end of the movie they saw both the now-familiar face and a brand new face. We measured infants'

(continued) interest in these two faces and determined whether each infant had a preference for the familiar face or the novel face. We also asked parents' to complete a questionnaire that can identify patterns in their infants' daily behaviors. For example, this questionnaire can tell us whether an infant tends to be wary of new situations or if they tend to get very excited by highly stimulating toys.

Finally, we also collected DNA samples to determine whether biological factors also contribute to differences in individual infants' responses to novel information, and/or the strength of their attention biases. We are interested in specific genes that influence the dopamine chemical system in the brain, which is involved in both attention and learning. Though every human has these dopamine genes, there are normal differences in the construction of these genes that may influence different patterns of behavior across individuals.

By assessing a wide range of factors that may be related to sensitivity to environmental, perceptual, and/or novel information, we hope to identify consistent, coherent patterns of behavior for individual infants. We believe that infants' consistent responses to information available in the environment, particularly novel information, will be related to their attention behaviors. As any parent knows, no two infants are the same – even when they are the exact same age! Understanding the factors that influence individual differences in attention behaviors will help us explore the subtle differences in the relationship between attention and learning for different infants.

Novel Toys

Faces Task

The Role of Experience and Maturation in Attention Development

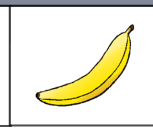
As part of our interest in attention and learning development during early infancy, we have conducted a related study investigating how early experience in the environment and maturation of the brain contribute to attention development in infants.

In this study, we are interested in the development of a very specific attention skill during early infancy: inhibition of return. Inhibition of return is the ability of an infant to be sensitive to perceptual cues in the environment; infants exhibit inhibition of return when their eye movements to objects and locations in the environment are guided by previous visual cues. The development of this attention-shifting ability is highly related to the maturation of several specific brain areas: the superior colliculus, frontal eye fields, and parts of the parietal cortex.

We investigated the development of inhibition of return in both full-term and preterm infants at 7- months of age. From previous studies we knew that full-term babies typically show inhibition of return by 7-months of age. However, no studies have investigated the development of this ability in preterm infants. We wondered if preterm infants would need extra time to catch up and show this attention skill, or if perhaps their extra visual experience in the environment would facilitate the development of the brain regions that support this attention ability.

Like in our other infant studies, we had infants sit on their parents lap while watching a short movie containing different brightly colored shapes. In addition to the shapes, the movie also contained a bright yellow circle, known as the cue, which appeared briefly in locations on the screen. To assess if infants oriented their attention based on the location and timing of the cue (i.e. showed inhibition of return) we recorded infant eye movements to track where and how quickly they looked at the different shapes. We found that by 7-months, both preterm and full-term babies successfully shifted their attention in response to the cue; this suggests that by 7-months, in this area of visual attention, preterm infants have already caught up to full-term babies! However, we are still curious to see if babies born prematurely might show this attention ability even before we would expect, because they have had extra time and visual experience in the world. Thus, we are currently conducting a follow-up study with 4 to 7-month old full term infants (these full-term infants are matched to the corrected-ages of our preterm group) to see when the development of this attention shifting ability emerges. Data for this project was presented as a poster in March 2010 at the International Conference on Infant Studies and is available on our website in the publications section.

Paired Associates Memory Study



Paired-Associates Behavioral Study

In the Paired-Associates Memory study, we were interested in how children of different ages memorize pictures of two objects together and form an association. We also wanted to find out how the ability to recall in the presence of a cue changes across development.

We asked 8-year-old and 12-year-old children to play a memory game on the computer. In this game, children watched pictures of objects (a total of 160) on the computer screen presented to them in pairs every four seconds. For example, we asked them to memorize that a *telephone* was paired with a *banana*. Then, during the recall part, we showed them one of the objects (e.g., the telephone) as the cue, and asked them to remember the second object that it was paired with earlier (e.g., the banana). We first asked them to silently remember the second object and press a key if they remembered. In the last part, we asked them to verbally tell us if they remembered the second item of the pair.

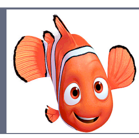
We have tested forty 8-year-old children and forty 12-year-old children for this study. As we predicted, older children remembered more --about twice as many -- of the pairs than the younger children. We don't know yet if this is because older children learn new information better, or if it is because older children are better able to retrieve from memory what they had learned, or both.

Paired-Associates fMRI

Some of the children who participated in the Paired-Associates study were also asked to come back and participate in another study about memory and the brain that used functional resonance imaging (fMRI).

In this study, we were interested in what the brain does as children tried to memorize the picture pairs and then later tried to recall them. Previous studies with adults have suggested that a structure in the brain called the "hippocampus" has an important role in learning new information, particularly associations between new pieces of information. We wanted to test whether this region is also as active in children because we think that this structure continues to develop across childhood. We also wanted to examine whether the hippocampus is equally active in younger compared to older children. Children played the same paired-associates memory game described above in the MRI scanner.

We have tested eighteen children ages 8 & 9 years and twelve children ages 12 & 13 years. We are still in the process of recruiting additional participants and analyzing the imaging data. We are interested in examining brain activation patterns for pairs children later successfully remembered versus those they later failed to correctly remember. We will keep you posted on the results of this study!



Executive Function Study

In this study, we are examining the executive functioning of preschoolers who were born moderately premature (34-36 weeks gestation) and those who were born full-term. Executive function is a collection of abilities related to planning, cognitive flexibility, selective attention, and inhibitory control. Executive functioning develops gradually across childhood and adolescence and impacts not only children's school performance, but also their social relationships. We know from research that children who had been born before 32 weeks gestation show more difficulties with executive function later in childhood compared to those who had been born at term. Little is known, however, about executive function in preschoolers who had been born moderately- to late-preterm. It typically has been assumed that cognitive development of late preemies looks just like their full-term peers, but few studies have followed these children into the preschool years, a time of important changes – both neurological changes and changes in children's experience in the world – that can affect executive function.

Study Opportunity: We are currently conducting a study on the development of executive function preschool-aged children. There are two groups of 4-year-olds in this study, those born prematurely (32-36 weeks gestation) and those born at term (37-41 weeks gestation).

The study requires one visit to the Institute of Child Development at the University of Minnesota. During this visit, we would ask your child to complete four interactive games and four computerized games. In addition, we would give your child a brief intelligence test. While your child is completing the games, we would ask you to complete two questionnaires. We would also ask your permission to obtain your child's medical records from his/her birth hospitalization. The total visit would take approximately two-and- one-half hours. As a thank you for participating, we would compensate your family $10 for your travel to the University and give your child a small book in appreciation of his/her efforts on the games. If you are interested in this opportunity, please contact us at the Cognitive Developmental Neuroimaging Lab at 612-624-0075.
www.cehd.umn.edu/icd/CDNLab/ResearchParticipation.html.

Implicit Learning Studies

Introduction to Implicit Learning Studies

As part of a large project over the past several years, we have been examining how learning changes with practice across the lifespan. The specific type of learning we are studying is called implicit learning; implicit learning is your ability to learn about patterned information in the environment, without necessarily being aware of the fact that you are learning.

In studies examining implicit learning, we ask both adults and children to visit our lab and play simple computer games with cartoon characters. In these games participants are asked to press buttons on a button box or the spacebar on the keyboard to tag certain cartoon characters that appear on the computer screen. Sometimes the cartoon characters show up in a hidden, repeating pattern, but other times they only show up randomly. To see if people have learned about the hidden pattern, we look to see if participants are faster at tagging the characters during the patterned parts of the game than when there are no patterns. Interestingly, almost all children and adults show evidence of learning these patterns, even though we don't tell participants to look for a pattern.

We are interested in implicit learning because it is a basic form of learning that is available early in the lifespan (even infants can learn about patterned information), which helps us constantly track and learn new information about our environments. In the past year we conducted two separate studies that examined the development of implicit learning during childhood:

Role of Eye Movements in Learning Spatial Information

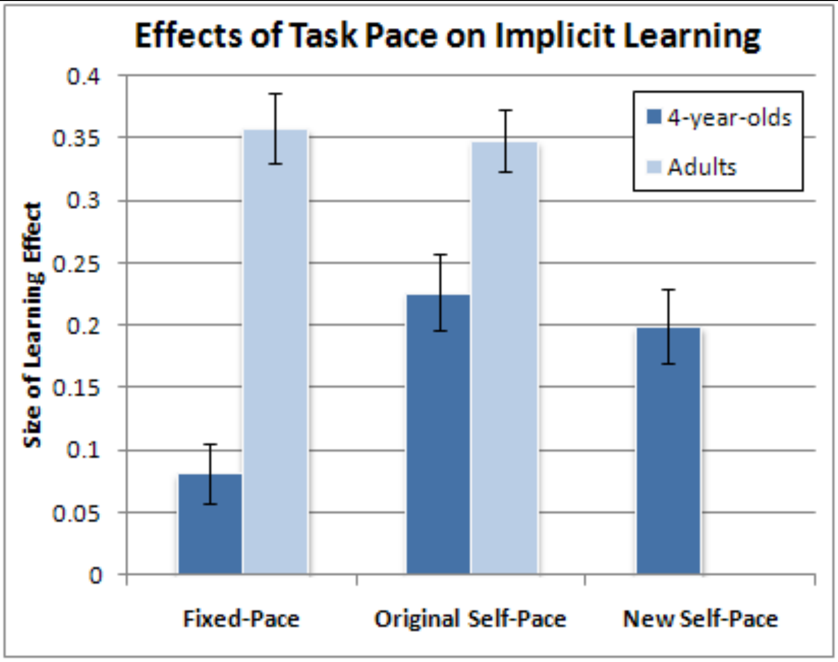
In a previous study in our lab, we had examined whether learning about patterns is easier or harder depending on whether the hidden pattern is based on spatial information (e.g. pattern is based on where the cartoon characters show up in the game) versus object identity information (e.g. pattern is based on who the cartoon characters are in the game). Findings of this study suggested that while adults can learn both spatial and object identity patterns equivalently, 8-year-old children are much more successful in learning spatial patterns.

We hypothesized that the reason that 8-year-olds might be better at learning the spatial patterns is that they might be moving their eyes around the screen to follow the pattern of locations. This might give the brain extra information about the presence of a pattern. To test this hypothesis, we conducted an experiment with both 8-year-olds and adults where participants were asked to tag Scooby-Doo as he showed up in various locations on the computer screen (sometimes following a pattern, sometimes not) without moving their eyes from the center of the screen. We found that while adults can still learn about the pattern even without moving their eyes, 8-year-olds did not show evidence of learning the pattern unless they were allowed to make eye movements. This suggests that implicit learning abilities change across development; at a younger age, children may need multiple sources of information (the actual sequence and simultaneous eye movements) to successfully learn patterned information. These data were presented in a poster at the April 2009 Society for Research in Child Development conference and is available on our website in the publications section.

Role of Task Pace in Learning Patterned Information

In a separate implicit learning study in our lab we investigated how the pace of information presented impacts learning of hidden patterns. Previous studies within our lab had suggested that 4-year-olds learn less about patterned information than do 8-year-old children and adults, but we wondered if preschoolers' learning might improve if we changed our task to adapt to the participant's own speed/pace.

In this study, 4-year-old children and adults played a computer game of tag with Elmo and his friends by pressing buttons in response to seeing the different Sesame Street characters appear on the computer screen. Like the other implicit learning studies, sometimes these characters appear in a sequence pattern of locations, while other times they appear randomly. Preschoolers and adults played 1 of 2 versions of the Elmo game: a version in which the characters appear at a predetermined speed (the fixed-pace version) or a version in which a new character does not appear until the previous character was correctly tagged (the self-pace version). We found that the pace of the game does not seem to matter for adults, as they seem to learn the same amount about the hidden pattern in both versions of the game. However, for 4-year-old children, the pace of the game matters a lot! Preschoolers learned much more about the pattern (and were more accurate at tagging the characters) when they played the game at their own pace. This part of the study was presented in a poster at the April 2009 Society for Research in Child Development conference and is available on our website in the publications section. However, we were still curious as to why 4-year-olds performed so much better on the self-paced version of the task. Although the timing of the task was probably important, we wondered if the fact that there was also accuracy feedback on this task (and not in the fixed-pace game) might have made the task more motivating for 4-year-olds. We conducted a follow-up



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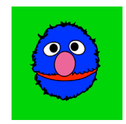
study with 4-year-old children using two different self-paced versions of the Elmo game: a version in which the new character did not appear until the previous character was correctly tagged (the self-paced, accuracy feedback version) and a version in which a new character appeared as soon as any response was made (the self-paced, no accuracy feedback version). We found that 4-year-old children learned an equivalent amount of information on these two tasks; this suggests that the critical difference between the original self and fixed paced tasks in our first study was the timing of the game. At this point it seems that for preschool-aged children, being able to take in information at a developmentally appropriate pace can substantially facilitate implicit learning.








Attention and Emotion in the Adolescent Brain

In everyday life, we are faced with the cognitive challenge of ignoring distractions. This may be more difficult for teenagers than adults and it may be especially difficult when distracters evoke emotions. In this study, we are interested in how easily teenagers and adults are distracted by emotional images.

Adolescents and adults, aged 11-22, completed two behavioral tasks in which they were asked to respond to stimuli that are presented with a variety of emotional images in the background. Images include neutral ones such as a spoon, positive ones such as a puppy, and negative ones such as a snake. The two tasks require that participants ignore the emotional information while maintaining attention on the task. While one task primarily tests the ability to hold back a response once you have built up a tendency to respond, the other tests the ability to maintain and update information in ones memory.

Results thus far have shown that while negative images capture attention and produce slower responding in all age groups, teens around the age of 13-14 years are particularly likely to make impulsive errors when negative distracters are present. This effect was also found in 15-16-year-old girls but not boys of the same age.

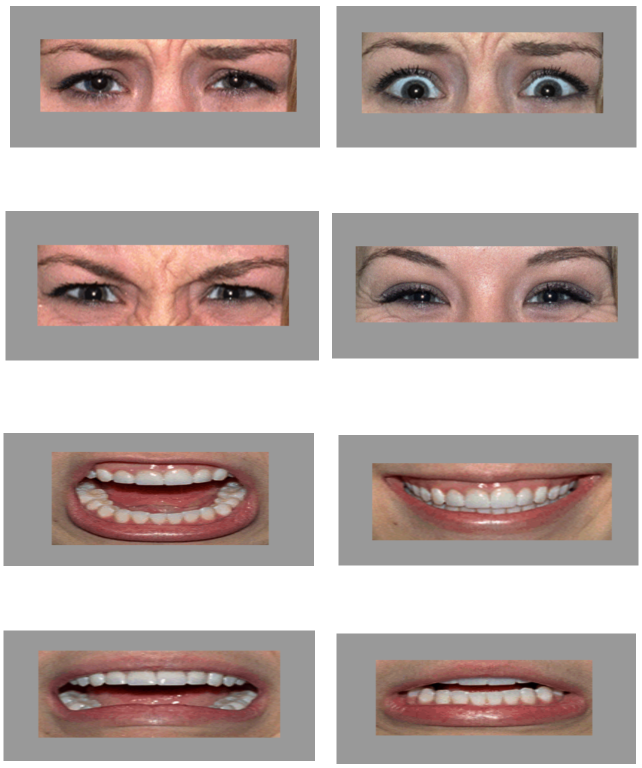
MRI data have been collected from a sample of adults (ages 20-22 years) and adolescents (ages 13-14 years) in order to explore differences in brain structure and activity that might account for the performance differences between the two groups. These data are currently undergoing processing and analysis.

In a separate sample, behavioral data have been collected from a group of young teens who were internationally adopted after spending time in an institutional care facility. These data will help our understanding of how early life stress can influence the ability to cope with emotional distracters later in life.

Data are currently being collected for the memory task along with measures of heart rate and skin conductance (small changes in sweat levels that are related to emotional responding), as well as subjective ratings of the background images. With these data, we aim to answer questions regarding how specific the emotion-cognition effect is to a particular cognitive task. It will also provide new information about how much of these effects is due to initial emotional responding to the images versus attention or self-regulatory abilities.

Understanding Faces Study

Humans rely on social interaction to learn about the world. We look to others to help us judge whether situations or events are positive or negative, whether we should be happy. The ability to read the social cues and emotional signals of others is a critical skill that we use even in infancy but continue to develop across childhood and into adulthood.



In the face emotion study, we asked how well eight-year-olds understand human facial expressions by asking them to identify facial emotions when only some of the facial features were available. When children were given only the eyes from a face, they were quite good at identifying angry expressions, but not as good at identifying happy or sad emotions. In contrast, when we gave children only the mouths from different faces, they were extremely good at identifying happy expressions, but not very good at identifying angry or scared expressions. In general, 8-year-olds do not identify the emotions in the same way that adults do.

For some of the children, we also measured brain activity while they looked at different facial expressions. We found that a region of the brain called the amygdala responded differently for children than we had previously seen for adults. Our data suggest that this part of the emotion processing network in the brain is still developing and is not very adult-like at 8 years of age.

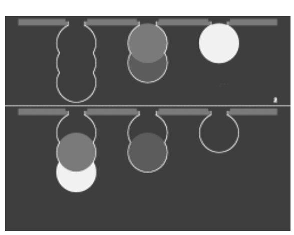
We also measured a naturally occurring gene variant (serotonin transporter gene) and its relation to emotion processing. We found that children with the long form of the gene (60% of children) performed somewhat better when matching faces by emotion than children with the short form of the gene (40% of children). In adults, the amygdala has been shown to be more reactive in individuals with the short form of the gene, but we found no difference in amygdala activity in children based on genes. One possibility is that this genetic difference emerges over time, perhaps with the transition to adolescence or even adulthood.

Learning and Memory Study

Over the past nine years a group of children have been involved in an ongoing study of learning and memory. In the past we studied their memory for objects and events of their lives, including recognition of mom's face and voice in infancy. Now that these children are nine and ten, we are interested in their thinking and planning abilities as they proceed though the school-aged years.

These children were asked to play several computer games. In one game, children had to arrange three colored balls to match an arrangement displayed on the computer screen. The task

During the easiest part of the game, everyone was able to correctly move the colored balls to the right places. But when the game got harder, everyone took more tries trying to get the balls to the correct places.



We are currently examining the connection between the structure of particular areas of the brain, performance on the games, and parent's report of child personality and behaviors.

An exciting aspect of this study is that we have lots of information about the children from throughout their lives. We are able to look for connections between physiological measures from when the children were infants and the way they approach the game as 9-year-olds.

Currently, members of our research team have been working hard on analyzing all of the data from the last few years of this longitudinal study and will present it at the Human Brain Mapping conference in Barcelona, Spain this summer. The presentation poster will be available on our website in the publications section this June.

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