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Teaching Ten

Rebecca Distefano and Yeshim Iqbal, Lab Coordinators;
Monika Glowacki, Research Assistant

Previous research shows that children learn how to count before they understand what the individual number words mean. For example, if there are 10 animals on a card, an adult, without counting, can estimate that there are 10 animals. In contrast, a young child, who can count to 10, may not know what it means to be 10 quite yet. We would like to better understand how children construct the meanings of number words. To do so, our task attempts to teach children what ten animals look like when contrasted with another number of animals (e.g. 10 cats vs. 5 cats, or 10 horses vs. 20 horses). We are interested in knowing whether children will be able to understand the number 10 in this context, where we use approximations, to teach the number word.

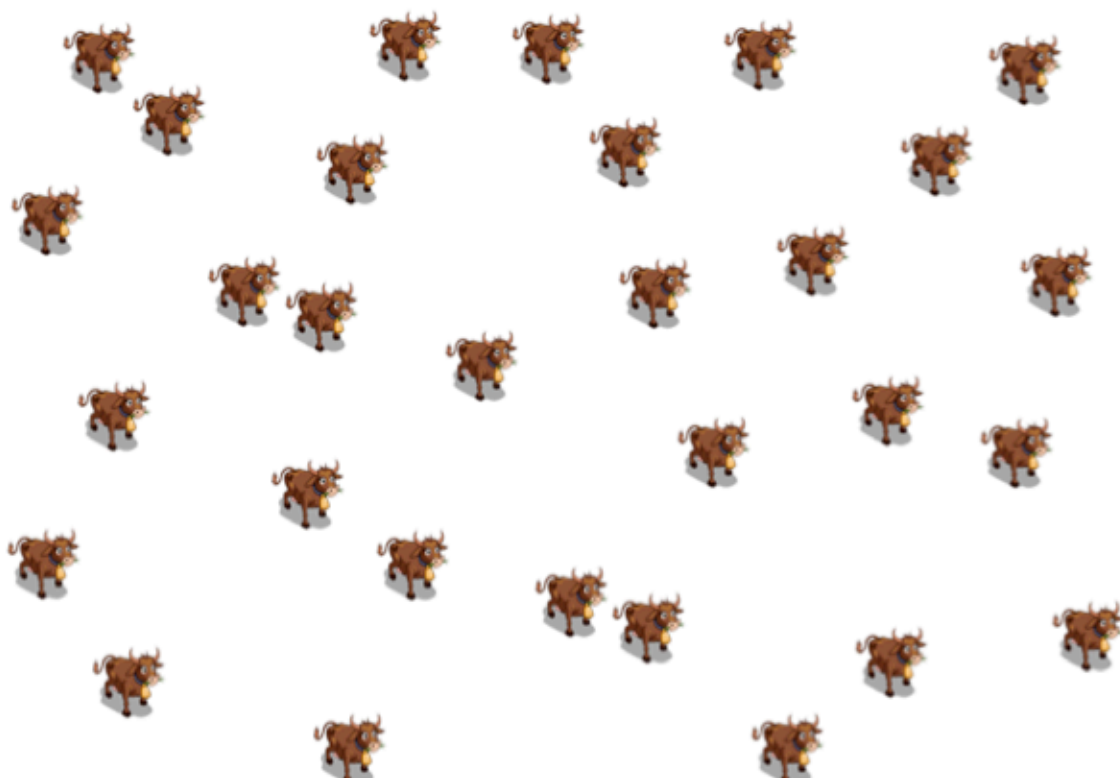
First, the child participates in a training session. In the training sessions, the experimenter shows the child two cards with animals on them. One card is the target card, which has 10 animals. The other card is the comparison card, which either has 3, 5, 7, 15, 20, or 30 animals. During the training session, the experimenter tells the child which card has 10 animals, the number of animals on the other card, and again which card has 10 animals (e.g. “this card has 10 cows; this card has 30 cows, but this card has 10 cows”). After the training session, the child completes up to three practice sessions. The practice sessions use the same cards as the training session, but the experimenter asks the child to pick the card with 10 animals and provides the child with feedback (e.g. “Great! That card does have ten!” or “Good try, but the other card has ten.”). In the testing session, the experimenter shows the child cards with new animals and asks the child to pick the card with ten. In the testing session, the experimenter provides no feedback.

Three-year-olds almost always succeed on the 10 vs. 3 and 10 vs. 5 ratios, but they do not succeed on any of the other number ratios (10 vs. 7, 15, 20 or 30). The children succeed on the smaller ratios because these are numbers that the children already understand and they are failing at the larger ratios because they are not actually learning what the number ten means. This gives us insight into how children construct the meanings of number words because it shows that they cannot learn simply by using approximations.

In an additional task, we show children cards with circles on them and ask them to guess how many circles are on the card without counting. Children who say higher numbers for when they see more circles are called mappers. We are interested to see if there is a difference in performance between mappers and non-mappers on the teaching ten task. We are still collecting data from children who are mappers and will keep you posted!



Which one has ten?



Strategic Reciprocity in Young Children

Carla Sebastian, Visiting Graduate Student

Most social relationships that we build throughout our lives are based upon reciprocal exchanges of resources, support, and help. We expect people who benefit from us to return the favor, and we feel obligated to return the kindness to those who have been generous with us. Reciprocity is considered to be a key feature of prosociality in adults: we are more likely to be willing to give resources to a person who is able to reciprocate than to another who cannot. Imagine that you have a plate of broccoli and your partner has a delicious cake. You may generously share your broccoli with her with the assumption that you will receive yummiier food in return. This example represents a more elaborate form of reciprocity because it requires one to consider the future before making a decision (planning abilities). Furthermore, this situation asks one to delay an immediate reward in order to obtain something better later (delayed gratification).



In this study, we were interested in whether young children share with others strategically, considering what others could do for them in the future. We studied this by presenting three- and five-year-olds with a game situation where they interact with a Puppet as their partner. Each player receives the same amount of toys, but the Puppet receives high-valued toys while the child gets lower valued ones. Both players engage in a turn-taking game in which they are given the opportunity to share their resources during each turn. Children always decide first and the Puppet mirrors the child's actions. If children understand that they can gain access to the higher-valued resource through strategy (meaning being nice to the Puppet), they will share more in this situation than in another condition (control condition) an amount of resources that they could use to play with a low attractive toy immediately or a high attractive toy later. The planning task consists of making a puzzle in two steps. Children can choose between two sets of incomplete puzzles (e.g., the incomplete body of a giraffe or the incomplete body of crocodile), taking into account which piece would be available in the following step (e.g., the head of a crocodile).



We found that five-year-olds shared more resources when the Puppet had attractive toys and when she was able to reciprocate them, than when she had no resources. However, three-year-olds shared at very low rate, regardless of whether the Puppet had resources or not. This developmental pattern was also found in the delay of gratification task (older children save more resources for a delayed but more attractive toy than younger children) and in the planning task (five-year-olds outperformed three-year-olds). Interestingly, children of both ages who saved more resources for the delayed but more attractive toy also shared more resources with the Puppet. Furthermore within the three-year-old group, children who were better in planning ahead also shared more with the Puppet. These findings suggest that there are dramatic improvements between the ages of 3 and 5 in children's ability to consider and anticipate the future when they act in the present, and that these skills are somewhat related to this elaborated kind of reciprocity: the strategic reciprocity.



Bribery

Carla Sebastian, Visiting Graduate Student

When we hear about bribery, concepts of corruption and other undesirable behaviors immediately come to mind. However, bribery is not necessarily tethered to the concept of morality. It can also be defined as the act of giving a resource to someone in order to alter his or her behavior. In accordance with this definition, bribery is strongly related to reciprocity as long as the recipient favors the donor in some way. This research deals with this phenomenon. In a previous study examining strategic reciprocity, we found that five-year-olds shared significantly more with a partner who had higher-valued resources than with another who didn't. But do five year olds understand that acting prosocially toward the correct person can tip the scales in their favor? Previous research shows that children in middle childhood (around seven years of age) begin to use strategies in order to alter another's view of them towards a more positive one. For example, they can enhance some aspects of themselves while downplaying others to convince other children to pick them as a partner for a game (self-presentation). So in this study we were interested in whether five and seven-year-olds would favor another person with the intention to trigger preferential treatment from that person.



Children played a triadic game with two adults (players A and B) that consisted of two steps. In the first step (giving game), the child received two stickers (a high-valued and a low-valued sticker) and was told to distribute them between players A and B. The child could decide who got the better sticker and who got the worst one. In the second step (two-player game), player A chooses a partner, either the child or player B, to play a game with. The crucial component of this task was that children knew in advance that player A was going to make the decision about who he or she wanted to play with in the second step. If children understand that they can influence

the second step. If children understand that they can influence player A's decision by being nice to her, they will give the best sticker to player A. Alternatively, children may favor player A over player B just because they prefer the 'lucky' or 'privileged' people. In light of this possibility, we presented another situation in which player A had no chance to choose a partner for a game. In this condition (control condition), the two-step game remained the same with one exception: in the second step, player A doesn't need a partner to play the game because it is a one-person game. Therefore, if children are not biased towards privileged people, they will give the best sticker to player A as often as to player B.

Data collection for this study is ongoing, and we look forward to sharing the findings with you very soon!

Responses to Goal Completion

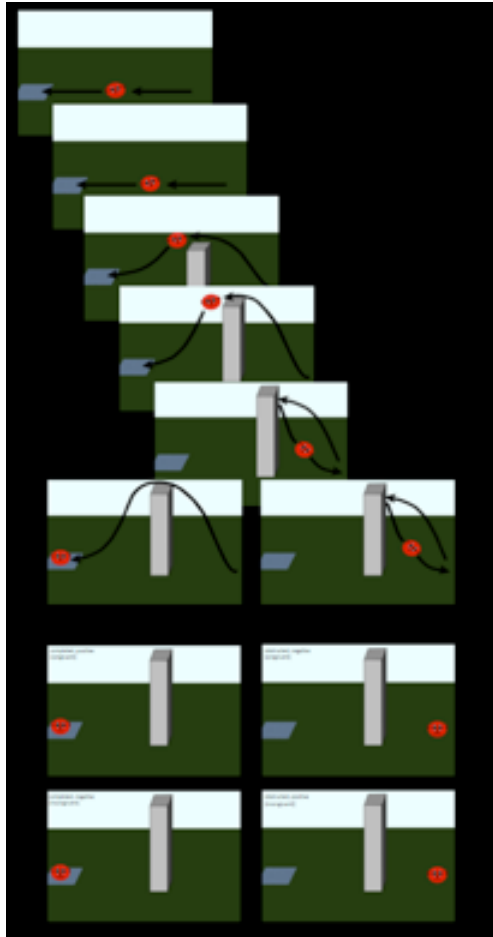
Amy Skerry, Graduate Student

Human infants are sensitive to the emotional expressions of others. They can discriminate facial expressions associated with different emotions and match congruent facial and vocal signals (i.e. a sad face to crying sounds, a happy face to happy vocalizations). Infants are also able to use the emotional expressions of others to learn about the world. A nine-month-old infant, for example, will use its caretaker's emotional reactions towards an object to guide its own behavior with respect to that object.

However, in these studies, infants rely on cues that are directly observable in a facial expression or vocalization. We were interested in finding out whether infants this age are also able to infer the emotional state of an individual in the absence of any observable affect. As adults, we understand emotions not only as observable communicative signals that tell us about objects or events in the world, but as expressions of internal states that a person might experience in response to various outcomes. Do infants understand that there are certain situations that make others feel happy, and situations that make others feel sad?

In one study, we present 8 and 10-month-old infants with an animated shape that attempts to jump over a barrier to a particular location. The shape either succeeds and makes it over the barrier, or fails and tumbles back down. The shape then gives an emotional response that is congruent or incongruent with the outcome. We compare infants' looking time to these four events (success+happiness, success+sadness, failure+happiness, failure+sadness). If infants expect the shape to be happy upon completing its goal and sad when it falls back to the bottom, this might be reflected in increased looking time to emotional reactions that are incongruent with the observed outcome. So far, we are finding that infants do distinguish between congruent and incongruent emotional reactions, and look longer at the crying expression when it follows a completed goal than they do to any of the other events. Ongoing studies are aimed at replicating this finding, and determining which exact cues drive these expectations.

An additional study with 18 month olds investigates whether these expectations depend purely on the match between the outcome and the reaction, or whether infants might take into account the agent's beliefs about the outcome. In this study, an agent sometimes holds a false belief about the location of a toy, and therefore thinks she has obtained her toy when she hasn't, or thinks she has lost her toy when it is in fact still present. The person expresses an emotion that is congruent with the actual state of the world, or congruent with her beliefs about the world. This allows us to test whether infants' expectations are driven by the mismatch between the actual outcome and the reaction, or the agent's subjective belief about the outcome.



Stimuli for Responses to Goal Completion study

Sticky mittens studies (3-4 months)

In these studies, we are interested in how infants' experience producing actions affects their ability to infer the goal of another agent's action (i.e. reaching for a ball). Recent research suggests that first-person experience manipulating objects leads 3 month olds infants to perform more like older infants on tasks assessing understanding of goal directed action. Based on these findings, some have concluded that the basic ability to interpret actions in terms of underlying goals or intentions is acquired from first person experience producing actions. In several studies, we seek to understand both the initial assumptions infants have about goal-directed actions, and the additional information that might be available in first person action experience to support making sense of particular actions performed by others.

In these studies, we give infants velcro-covered mittens and allow them to interact with velcro-covered objects, which they can lift and slide due to the velcro. We then use a looking time paradigm to assess their expectations about goal-directed action events. In one study, we found that infants given action experience looked longer at events in which an agent took a longer than necessary path to the goal. Sensitivity to the efficiency of actions is a standard signature of goal understanding in older infants, and we found that infants given the velcro-mittened training demonstrated this effect, but that infants in a no-velcro control condition did not. In ongoing work, we are replicating this finding and running a further condition to determine whether this effect occurs only when infants are familiarized with efficient actions. We are also running a follow-up study to explore one hypothesis about what infants learn in the velcro-mittened condition. In this study, we examine whether the velcro-mittened experience shapes infants expectations about basic properties of causal entraining events (i.e. that one ball will set another ball into motion only upon contact).

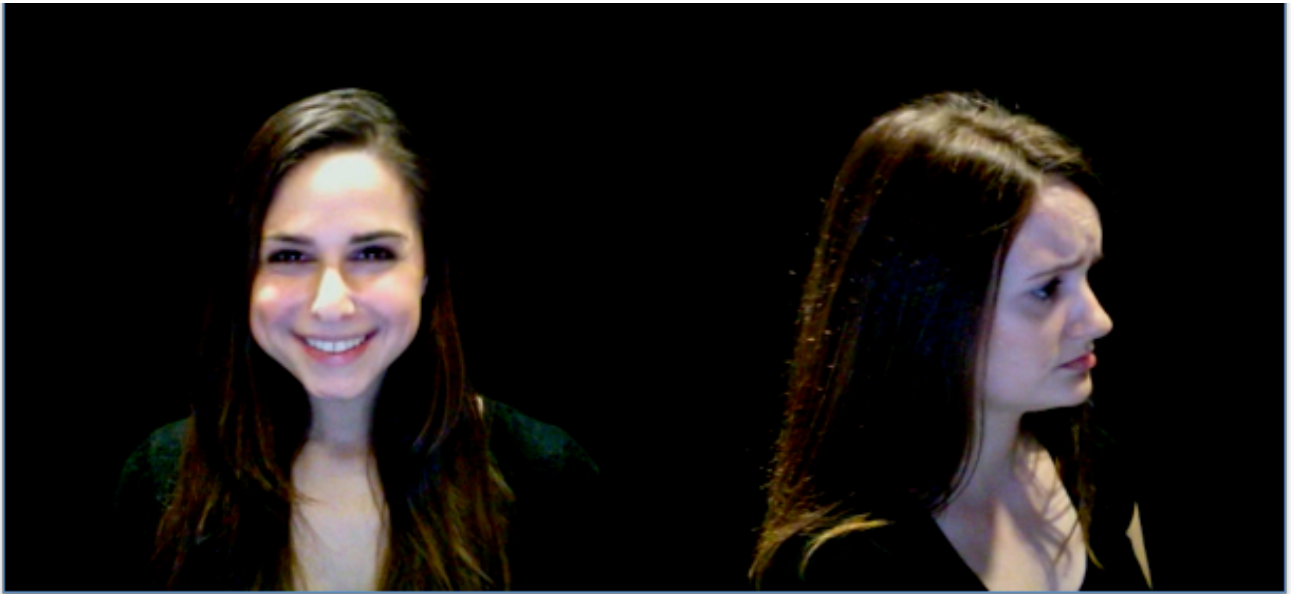


Stimuli for Sticky Mittens study.

Emotional Congruence (11 months)

In the Responses to Goal Completion study, we found that infants had expectations about how another agent would react to completing or failing to complete a goal. In a second line of studies, we are asking whether infants have expectations about emotional reactions in a social context, and exploring the factors that shape their expectations about emotions in these situations. In one study, we presented infants with a target who became happy or sad and a second individual (shown to be friendly with the target) who reacted with congruent or incongruent emotion. We predicted that infants would look longer at the incongruent emotional reactions. Of course, infants might look longer at incongruent trials simply because the perceptual features were more similar across the two individuals in the congruent case. However, if infants possess a more abstract understanding of emotions, they might expect congruent emotional expressions only when the person reacting has visual access to the target. So we contrasted the condition described above with a condition in which the second individual is oriented away from the target. In this condition, the incongruent emotion is less surprising, since it is not a clear response to the target's emotion.

In the first study, we found the predicted result wherein infants look longer at the incongruent trials when the observer is oriented towards, and thus reacting to, the target's emotion, but not when the observer was oriented away. This suggests that infants' expectations about emotional reactions are not driven by greater perceptual homogeneity in the congruent trials. It also suggests that, rather than being driven by the simple mismatch in valence of the incongruent expression, infants' expectations depend on conceptually relevant variables like perceptual access. In a second study, we are replicating this finding and investigating other factors that affect infants' expectations about emotional congruence, such as the two individuals' interaction history (competitive vs. affiliative).



Stimiuli for Emotional Congruence study



Action Understanding in the Infant Brain

Dan Hyde, Post-Doctoral Fellow

Infants show great interest in and attention towards people and their actions. This natural interest in others is thought to facilitate and drive learning from early in life. Recent work in developmental psychology suggests that infants' understanding of others' actions may be deeper than previously thought. For example, under some conditions, young infants may even be able to infer the preferences, goals, and thoughts of others. Work with adults and older children have identified regions within the temporal lobe of the brain that are particularly important to this deeper understanding of others. More specifically, in the mature brain, different regions of the temporal lobe may play distinct roles in social understanding. In our study, we were interested in the function of these brain regions in pre-verbal infants. In particular, we asked whether the same functional divisions seen in adults are present in 6-8 month old infants. To do this, we presented infants with video clips of people reaching for objects. Sequences of four clips, the first three being the same person reaching for the same object and the fourth being the same clip again (no change), a clip of the person reaching for a different object in the same location (new goal/same movement), or a person reaching for the same object in a new location (new movement/same goal), were shown to the infants. We measured the brain response using near-infrared spectroscopy (NIRS) over the right side of the head, including the temporal lobe, as infants watched these clips. NIRS uses light emitters and detectors to estimate changes in the amount of brain activity over time. With this technology, we asked if regions along the temporal lobe responded to the clips of changes compared to the clips containing no change and if different regions responded selectively to different types of changes. Preliminary results suggest that widespread temporal regions of infants, like that of adults, are sensitive to changes in the actions of others. However, the divisions of the temporal lobe may not be as selective as those seen in adults, suggesting social experience and brain development refine divisions for thinking about others' actions over development.



Learning to Count with Us

Dan Hyde, Post-Doctoral Fellow

Our lab has a rich history of studying numerical and mathematical development. We have used this knowledge to develop a large scale training study designed to learn about the particular skills and mechanisms that allow young children to learn to count.

In the first part of the study, 2-5 year old children came into the lab and completed a large battery of tasks examining pre-elementary school numerical and mathematical skills, such as counting, one-to-one matching, adding and subtracting objects, numerical labeling, estimating, and comparing. In addition, we measured the spontaneous brain response to numerical quantities using the event-related brain potential technique (ERPs). Preliminary analysis suggests that individual differences in counting ability are related to individual differences in one-to-one matching tasks and tasks requiring tracking small numbers of objects. Individual differences in estimating and comparing appear to be related to individual difference in spontaneous brain processing of quantities.

We invited a subset of the children that were on the verge of mastering counting to participate in a home program in an attempt to improve counting abilities. Each child in the training portion of the study borrowed a small laptop from us, practiced a counting game at home, and returned 2 weeks later to complete the same tasks as in the first visit. Importantly, each child was randomly assigned to 1 of 5 training programs aimed at improving counting. All training programs presented a number of problems that required the child to choose the greater of two quantities. Each of the 5 training programs was designed to improve counting in a different way: comparison of larger approximate quantities, exact comparison of smaller quantities, matching using a visual-spatial abacus, verbal counting, or verbal addition. Our preliminary analyses suggest that, on average, most children made improvements on the counting assessment after practicing for only two weeks. We are still in the process of seeing which type of program worked the best and incorporating parental suggestions and feedback into new, more exciting versions of the computer game for the second round of testing. In the end, we hope to identify the types of experiences that facilitate and improve counting and to identify the brain developments that occur as a result of learning.



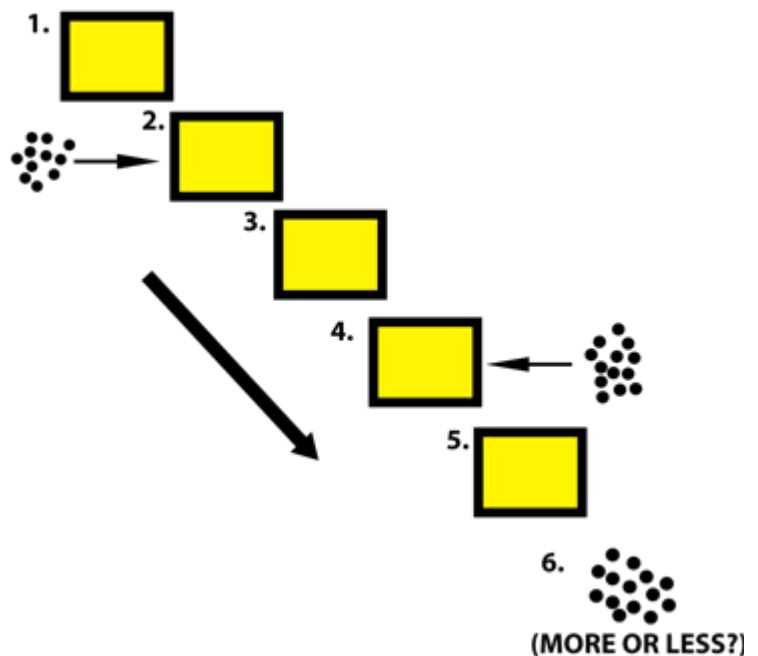
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Infant Arithmetic

Dan Hyde, Post-Doctoral Fellow

Previous studies have shown that even young infants have some basic intuitions about arithmetic. For example, if you show an infant an animated display with one collection of objects moving into a box, and then another collection of objects moving into the same box, they look reliably longer (meaning they are surprised) when the box opens up to reveal way too many or way too few objects. In other words, infants are able to track the approximate number of each set and combine those approximations to form an expectation about how many total objects went into the box. In our study, we were interested in knowing how this ability is related to arithmetic performed by educated children and adults. To test this, we brought adults and 6-7 month old infants into the lab and showed them animated addition problems as we recorded event-related brain potentials (ERPs) from the scalp. Infants simply watched the animations while sitting on a parent's lap. Adults, in contrast, were asked to add the first two arrays and make judgments as to whether the outcome of the animated addition problem was more or less than the actual sum. We found both commonalities and differences between adults and infants in response to animated addition problems.

Both groups showed posterior parietal brain activity that was sensitive to the difference between the outcome array and the actual sum. This suggests that infants and adults were processing the animated addition problems using similar brain regions in a similar way. These results also suggest that infants were actually computing the sum in their mind, since the brain response was sensitive to the actual sum that was never shown. However, the infant brain response was much slower (adults ~200 milliseconds/infants ~500 milliseconds) and required larger differences between the outcome array and actual sum to be detected. Together these results tell us that infants have a basic brain system for arithmetic that increases in precision and efficiency over development. One open question is if these developments happen solely as a result of brain maturation or if they are driven by experience or education. Furthermore, education may benefit from incorporating early arithmetic intuitions into teaching symbolic arithmetic.



The Development of First Impressions from Faces

Emily Cogsdill, Graduate Student

Previous research has shown that adults use facial characteristics to attribute personality characteristics to other people both rapidly and with a high amount of agreement. However, although research suggests that children begin to attribute personalities to other people starting at around age 7, little is known about how and when they use physical appearances to make such judgments.

In this study, we looked at the developmental origins of face-based personality attributions. In particular, we were interested in learning when children begin to attribute qualities like “Mean” or “Nice” to people based on their facial features in the same way that adults do. One possibility is that the tendency to make these judgments develops gradually, perhaps as a result of exposure to media and other social influences. Another possibility is that adult biases are rooted in natural tendencies that are either present at birth or learned rapidly in infancy and early childhood. By discovering when children begin to make face-based personality attributions, we hope to learn about how these personality judgments develop in the first place.

To test this, we showed children ages 3-12 pairs of faces that had been rated by adults to appear either high or low in one of three different traits: Trustworthiness, Dominance, and Competence. Each pair of faces consisted of one “high-trait” face (e.g. Trustworthy) and one “low-trait” face (e.g. Untrustworthy). We then asked children to either attribute a behavior to one of the faces (e.g., by asking, “Which of these people always tells the truth?”), or to attribute a trait to one of the faces (e.g., “Which of these people is very nice?”). We also had a sample of adults make these same judgments for comparison.

Our results suggested that adults and children of all ages made reliable personality attributions based on facial features. Consistent with prior research on children’s personality inferences, we found that children ages 7 and older reliably attributed traits to faces in the same manner as adults. However, we were surprised to find that even children ages 3-6 made reliable trait inferences as well, particularly in the domain of Trustworthiness.

We will soon be conducting follow-up studies to learn more about the nature and development of younger children’s face-based personality attributions. For example, we are interested in learning whether different trait judgments correlate with one another (e.g., if Trustworthiness correlates with Dominance), and also whether certain types of personality judgments (e.g. Trustworthiness) tend to emerge earlier in development than others.



Third Party Intervention

Jillian Jordan, Research Assistant

How do children develop a sense of fairness? Previous research from our lab has revealed that children prefer equal to unequal distributions of candy between themselves and another child. Specifically, around age four, children begin to dislike “disadvantageous” unequal distributions in which they receive less candy than a peer child, and are sometimes willing to sacrifice their own candy to prevent getting a bad deal. Around age eight, children also begin to dislike “advantageous” unequal distributions in which they receive more candy than another child, and are sometimes willing to sacrifice their own candy to prevent another child from getting a bad deal. In the present study, we were interested in understanding if third-party children dislike unequal distributions of candy between two other children. Might children be willing to intervene to prevent another child from getting a bad deal, even if they are not personally affected by the distribution?



In our study, children come into the lab and are told that their job is to make decisions on behalf of two third-party children that came into the lab yesterday, Jane and Annie. They are told that Jane’s job was to be the divider, and that Jane wrote down how she wanted to divide skittles between herself and Annie. Then, they are shown a set of distributions of candy that Jane proposed, and have the option to accept or reject each distribution. If they accept the proposed distribution, they are told that it will be enacted: the skittles that Jane wanted to keep for herself will go to Jane’s bag, the skittles that Jane wanted to give to Annie will go to Annie’s bag, and Jane and Annie will come in to collect their skittle bags at the end of the day. If they reject the distribution, however, they are told that the skittles will be thrown out and nobody will get to take them home. Then, children have the opportunity to accept or reject twelve distributions, six of which are fair (three for Jane and three for Annie), and six of which are unfair (six for Jane and none for Annie).

Children receive their own bowl of skittles at the beginning of the game, and in one version of the game, children have to give up some of their own skittles if they want to reject. Thus, in this condition, it is costly for children to intervene against unequal distributions. However, in the other version of the game, there is no cost to rejecting.

Preliminary results show that six-year-olds do prefer equal to unequal distributions of candy between two other children: participants in our experiment reject more unequal distributions than equal distributions! Additionally, our results suggest that children are motivated to get as many skittles for themselves as possible: participants reject fewer distributions in the condition where rejection is costly. Nonetheless, even in this condition, children reject a fair number of unequal distributions, suggesting that six-year-old children are willing to sacrifice candy in order to intervene against inequality between two other third-party children. Thanks so much for your help with this study!



Can 3 year-olds “Read” a Person’s Mind?

Alexander Bardis, Research Assistant

By the age of four children are able to understand when another person has a thought or a belief that is wrong – that is, if another person has a “false belief.” For example, in a situation where one person leaves their favorite toy in box A, and then in their absence their favorite toy is moved to box B, 4 year olds understand that when that person comes back looking for the toy they will look in box A, whereas the toy is actually in box B. In that context for example, that person has a “false belief” that their toy is in box A. By contrast, a 3-year-old would say that the person would look in box B for their favorite toy, which means that they do not have a robust false belief understanding.

However, previous research has shown that infants, like adults, can keep track of other people’s knowledge and use this information to guide their own actions. For example, if someone is looking for a toy in the wrong place because they don’t know it has been moved, 18-month-olds will help that individual by retrieving the toy from its actual location. However, infant and toddler performance in these kinds of helping situations contrasts starkly with their inability to talk and reason about knowledge and beliefs. Indeed, it’s not until about age four that children can accurately discuss behavior guided by false beliefs, like that of the individual searching for the toy in the wrong spot.

We are interested in understanding this discrepancy between toddlers' ability to act on information about "false beliefs" and young preschoolers' inability to discuss such false beliefs. One possibility is that talking about beliefs involves the development of additional cognitive resources that aren't available to toddlers. Another possibility, though, is that preschoolers may fail both tasks requiring them to discuss others' beliefs and measures like the helping task designed for toddlers because they are operating under a different and mistaken understanding of beliefs and knowledge.

In our study an experimenter hides an object in one box, then in the absence of that experimenter, a sneaky confederate switches the object to another box. We are interested to see if when the experimenter returns, the participants will give an indication that the toy has been moved. This need to inform the experimenter is interpreted as an understanding of the experimenter's false belief.

We are right in the middle of data collection, but keep an eye out for the next newsletter so we can tell you what we find!

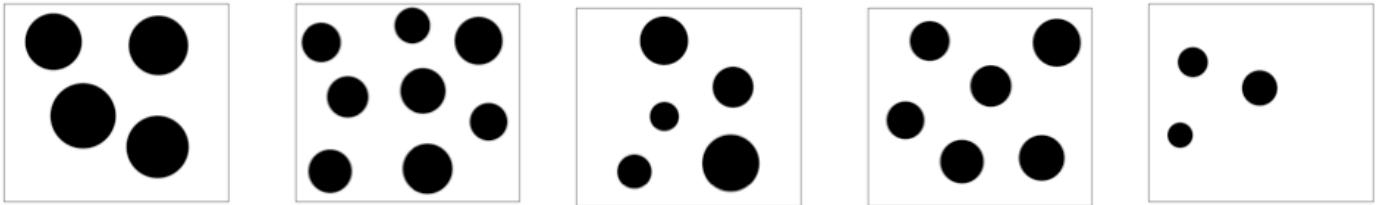


The experimenter doesn't know that the toy has been moved to the other box. Will 3-year-olds help him?



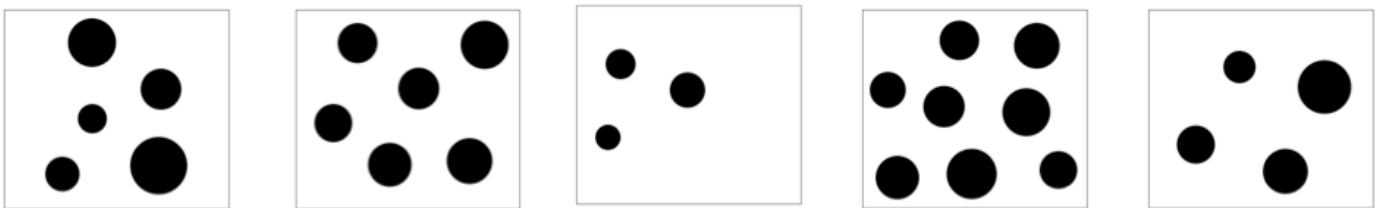
Seeing Sets

Arin Tuerk, Graduate Student



Previous research with adults shows that when we look around the world we are constantly grouping arrays of objects together and encoding them efficiently as “sets.” Given the fact that our visual system is severely limited in the number of objects it can represent in parallel, encoding sets of objects instead of individuals allows us to remember information about more total things. For example, when we look at the leaves on a tree, although each leaf is a little different in color, length, width etc., we tend to represent the average properties of those leaves, averaging across the variation on each dimension. While we can’t report whether the longest leaf on the tree was also the greenest, we can make general statements about how long and green the leaves were on average. Instead of attending to each member in the set, we save ourselves the extra cognitive load and represent the gist. In more controlled studies, we have seen that when adults are quickly shown an array of circles of varying sizes, they are actually more accurate at estimating the average size of the set of circles than the size of any one circle in the set. Our question is whether infants also engage in this type of perceptual averaging and efficient representation.

During this study, 6-month-old infants are habituated to cycles of dot arrays that differ in number of dots, individual dot size, and spatial arrangement - but all arrays share the same average dot size. We next present the baby with test arrays that have either the same average dot size as the habituation arrays or an average dot size that is 2 times larger or smaller. We then measure which of the test arrays the baby finds more interesting, or spends more time looking at. We know that infants tend to look at things that are new or different, so if he or she spends more time looking at the arrays with the novel average size, we will know that he or she has encoded the common average size of the habituation arrays. We are still in the early phases of data collection on this project, but it appears that babies’ visual systems may already be capable of this sort of efficient computation!



Picture Paternalism

Christina Wong, Research Assistant

If you ask most children whether they want to eat a chocolate bar or a granola bar, they would probably pick the chocolate bar. However, what happens one child is asked to pick a snack for another child? We know that adults—when picking for children—will usually choose the healthier option, citing that even though the child wants the chocolate bar, a young child does not realize the unhealthy consequences, and so the granola bar is a better choice. This is an excellent example of paternalism, when someone makes a choice for someone else—overriding that person's desires—because the chooser feels that he/she knows better than the person he/she is making the decision for. In this study, we were interested in exploring whether children exhibited paternalistic tendencies when making decisions for other children. We researched this by asking six and nine year olds to pack a lunch and a backpack for another child who was going on a trip the next day.

Each child was first introduced to a fictional child, named either Alex or Alice depending on the participant's gender. They were told that Alex/Alice was the same age as them and was going on a trip the next day but forgot to finish packing! During the course of the study, a drawing of Alex or Alice was kept on the study table so that participants remembered they were packing for someone else. Each participant then packed a total of four things for Alex/Alice: two snacks and two items of clothing. In every trial, participants were given two choices, and they listened to a "phone message" from Alex/Alice that sounded something like this: "I know that the chocolate bar will give me a stomach ache, and I know that the granola bar will make me feel good. But I want the chocolate bar, I don't want the granola bar." The child then packs whatever he/she wants to give to Alex/Alice while the researcher is doing something else, and therefore not watching. In other trials, the child is asked to choose between water and soda, pants and shorts, and boots and sandals. Based on our previous research in which children recommended whether characters in a video should make paternalistic choices or not, we expected to find that six year olds would be less paternalistic while nine year olds would be more paternalistic. However, we found that the chances of six year olds and nine year olds making paternalistic decisions or not were both roughly 50%, so it currently seems like there is no developmental trend that predicts paternalism in children.

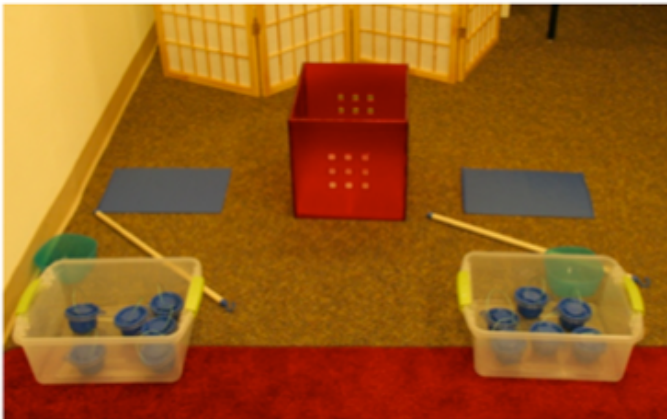


Children Share Based Upon Merit (Equity Sharing)

Patricia Kanngiesser, Visiting Graduate Student

Young children often make selfish decisions when asked to share things with others. Recent studies, however, have found that children will share rewards equally when they worked with someone else to complete a task. But do they also acknowledge differences in the amount of work someone contributed to a task? The idea that one's contribution should determine one's reward is an important fairness principle (called the "merit" principle) that is applied in many everyday situations. Yet, we know little about when children first begin to use this principle when sharing things with others.

We investigated whether three- and five-year-old children will use merit when sharing rewards with a partner. Children participated in a game with a puppet-partner, in which they had to fish for coins that were later traded for stickers. In the different rounds of the game, we varied how much work the puppet contributed to the task by having the puppet either find more or less coins than the child. At the end of each round, we asked the child to divide the sticker rewards between himself/herself and the puppet.



Children as young as three years of age gave the puppet more stickers in situations in which it had contributed more than in situations in which it had contributed less. Most children, however, struggled to give away more than half of their stickers. Young children thus begin to apply the principle of merit when sharing rewards with others, but still show a tendency to focus on their own benefit. It is probably not until six to eight years of age that children will overcome this tendency and give more than half of the stickers to a partner.



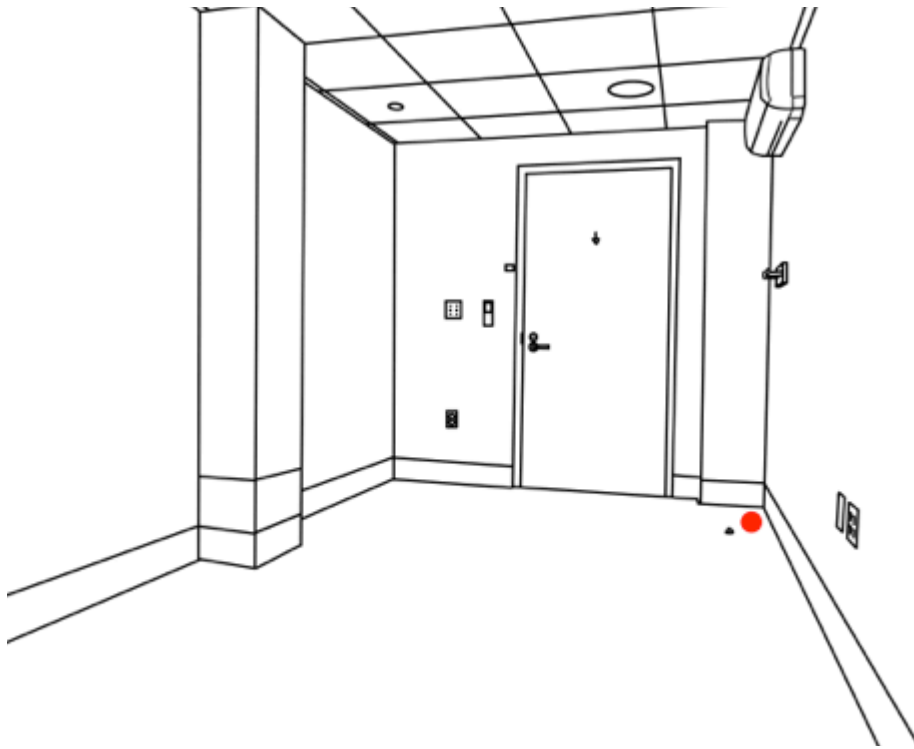
Developing Interpretations of Maps and Line Drawings

Moira (Molly) Dillon, Graduate Student

Adults across human cultures use maps and drawings to represent the spatial world. However, it is unclear how humans acquire the knowledge to create and interpret these maps and drawings. We hypothesize that this “symbolic” spatial knowledge is built from our ability to navigate the surroundings and to recognize objects in the environment.

In this study, we examined how tightly linked navigation and object recognition were to using maps and line drawings during the critical point in development where children are starting to understand that maps and drawings represent real spatial entities.

We tested more than 50 four-year-old children on a number of different tasks including sticker-finding games, map games, a line drawing game, a computer game, and a picture naming game. Our participants were very dedicated: they completed all of these tasks during two separate visits to the lab.



An example line drawing from the experiment.

Our results indicated that the ability to navigate and to recognize objects each contributed differentially to the ability to interpret maps and drawings. Critically, as children develop these spatial skills, they seem to rely on the information available in the environment. For example, children's ability to navigate seemed to be engaged when they were presented with line drawings of scenes. Though the drawing itself could be considered an object, it depicted a scene, or a navigable layout, so the children used their navigational skills to interpret the drawing.

We are excited to delve deeper into children's understanding of drawings and hope to uncover more information about how children's early emerging spatial abilities give rise to their later, more complex spatial understanding.

Mr. Gorilla



Mr. Gorilla, our favorite companion!

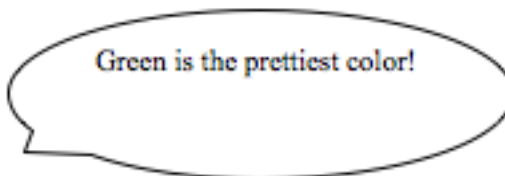


Beliefs and Practices

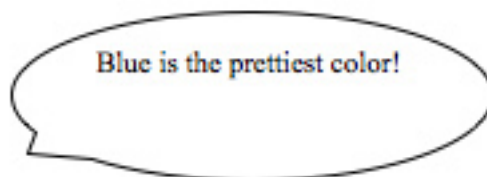
Larisa Heiphetz, Graduate Student

One of the studies conducted in our lab last year showed that children prefer those who share their beliefs in a variety of domains (e.g., factual, preference-based, and religious beliefs) but only attribute more positive rather than negative behaviors to those who share their own religious beliefs. In this study, we were interested in whether beliefs matter more or less to children than the behaviors that another person does.

We asked 6-10 year old children about their own beliefs and activities, and then we showed them pairs of different characters. In each pair, one character shared the child's belief but did a different behavior, and the other character shared the child's behavior but believed something different. For example, if a child told us that she thought green was the prettiest color and liked to watch Sponge Bob, we would say that one character thinks green is the prettiest color but does not watch Sponge Bob, while the other character watches Sponge Bob but does not think that green is the prettiest color. Then we asked questions about the child's preferences (e.g., "Which of these children do you think you would rather be friends with?") and which character the child thought did a good or bad behavior.



We found that children did not show a preference for either character. That is, about half the time children selected the character who shared their beliefs when asked whom they would rather befriend, and the other half of the time children selected the character who shared their behaviors. However, children attributed more positive rather than negative behaviors to the character who shared their religious beliefs.



Helping in Absence

Kerrie Pieloch, Lab Manager

A number of studies have shown that during children's second year of life, they begin to act prosocially in a variety of ways, including acts of helping, comforting, and sharing. However, most of the past research showing prosocial behaviors in young children used scenarios in which the recipient provided overt cues about the problem. For example, the experimenter is desperately reaching for an object or is struggling to open something, making sounds of effort or even asking the child for help directly. But do children really need all these cues that the helpee provides in order to realize that help is needed? Perhaps they can infer that from the situation alone.

In this study, we tested whether young children (aged 24 to 30 months) would help another person proactively, that is in the absence of behavioral cues from the experimenter. To do this, we created a situation in which an actor doesn't notice that an accident occurred (in this case, a can drops on the floor while the experimenter is turned away, engaged in another task). This was contrasted with a control condition in which a can falls on the floor, but the child had previously seen the can fall and the experimenter purposely left the can on the floor. We then analyzed the results to see how often children helped by picking up the fallen can.



We found that children in the experimental condition were more likely to help by either lending a hand and picking up the can or informing the agent about the problem, and children in the control condition were less likely to do so. These results suggest that explicit behavioral and communicative cues are not necessary in order to elicit help from children, and that instead, children aged two years and older help proactively, not only reacting to another person's expression of need.



Desire, Understanding, and Helping

Kate Hobbs, Graduate Student

By about 14-months, infants seem to be genuinely helpful creatures. They often bring us toys and things to show us and will even help us when we can't reach an object. Of course, many parents report this all changes when the "terrible twos" roll around! But even if infants don't want to be helpful they still may know how to be helpful. This study begins to explore what infants know about others' emotions and how to be helpful.

One thing that is required to be most helpful is to consider what your social partner's preferences are. If your friend is hungry and prefers goldfish crackers to broccoli, giving her broccoli is nice enough, but not as helpful as it would be to give her some goldfish. To be helpful one must both understand this principle and be able to figure out what a social partner's preferences are. Previous research has shown that by 18 months of age infants can figure out which of two food items someone likes based on her emotional responses to each, and will give the person her preferred food.

Our study seeks to explore the extent to which children can read others' emotions to figure out what their preferences are and help accordingly. Ultimately we may compare children's helping responses when they are given emotion information about someone's preferences versus action information about preferences. To date we've run two conditions with infants between 23 and 25 months.

In the positive-neutral condition, infants saw an actor show a preference for one of two toys by reacting neutrally towards one and very positively towards the other. Specifically, the actor showed a neutral facial expression while holding one object and said, for example "oh, hmm. A ball. Yeah, I like this one okay" in a flat tone of voice. With the preferred object, however, the actor smiled at the toy and said, "oh, wow! A block! I really like this one!" in a positive tone of voice. In the test trials the actor clumsily knocked both toys off of the table and out of his reach, necessitating help from the child.

The other condition, positive-negative, is very similar but employs an even stronger contrast between the emotions displayed. In this condition the actor displays positive affect and language towards one object, as in the positive-neutral condition, but then displays negative affect towards the other object, frowning in disgust and saying, "ew, yuck! A block. I don't like this one!" We've found that 2-year-olds, though helpful generally, still help randomly without considering the actor's specific preference, even when the contrast between the two emotions displayed is even starker.

So while two-year-olds seem to have very helpful motives (at least with new people!), they don't always seem to know the best way to be helpful. Some of our ideas for follow-up studies include giving children action evidence of an actor's preference (which object do they pick up intentionally?) to see if kids will help differentially, as well as testing older children in the experiments described above to see when this understanding of helping begins to mature.





Infant Desire Understanding

Kate Hobbs, Graduate Student

Infants know a surprising amount about people and in particular their intentional or goal-directed actions. For example, from about 5 months and perhaps even younger, infants reason about people's actions in terms of goals like objects as opposed to just random movements through space. Previous studies in our labs have asked whether infants can read others' actions and use this information to help them appropriately. That is, having seen an adult like one toy better than another, will an infant give the actor the one she likes best when she needs help? We have found that while 14-month-olds help randomly, giving either object upon request, 24-month-olds help by giving the object the actor prefers.

Our current studies are following up on these findings to ask whether using language about desires can improve the specificity of infants' helping. In the "desire language" condition, infants hear the actor name the object she likes best, and then watch the actor choose one of two objects several times. In the test trials the actor simply requests help from the infant, and the infant can give either object to the actor. In the "general language" condition the actor doesn't talk specifically about her desires, but interacts with the infant just as much. We then score which object the child chooses to give to the actor first.



Once the experiments are complete we will compare the performance of 14- and 18-month-old infants in the two language conditions. These experiments are currently in progress so we don't know what the results are yet. If we find that language about desires has an effect on young infants' helping behaviors, we will conduct future studies to investigate just which aspects of desire language improve infants' performance. Stay tuned for the results!

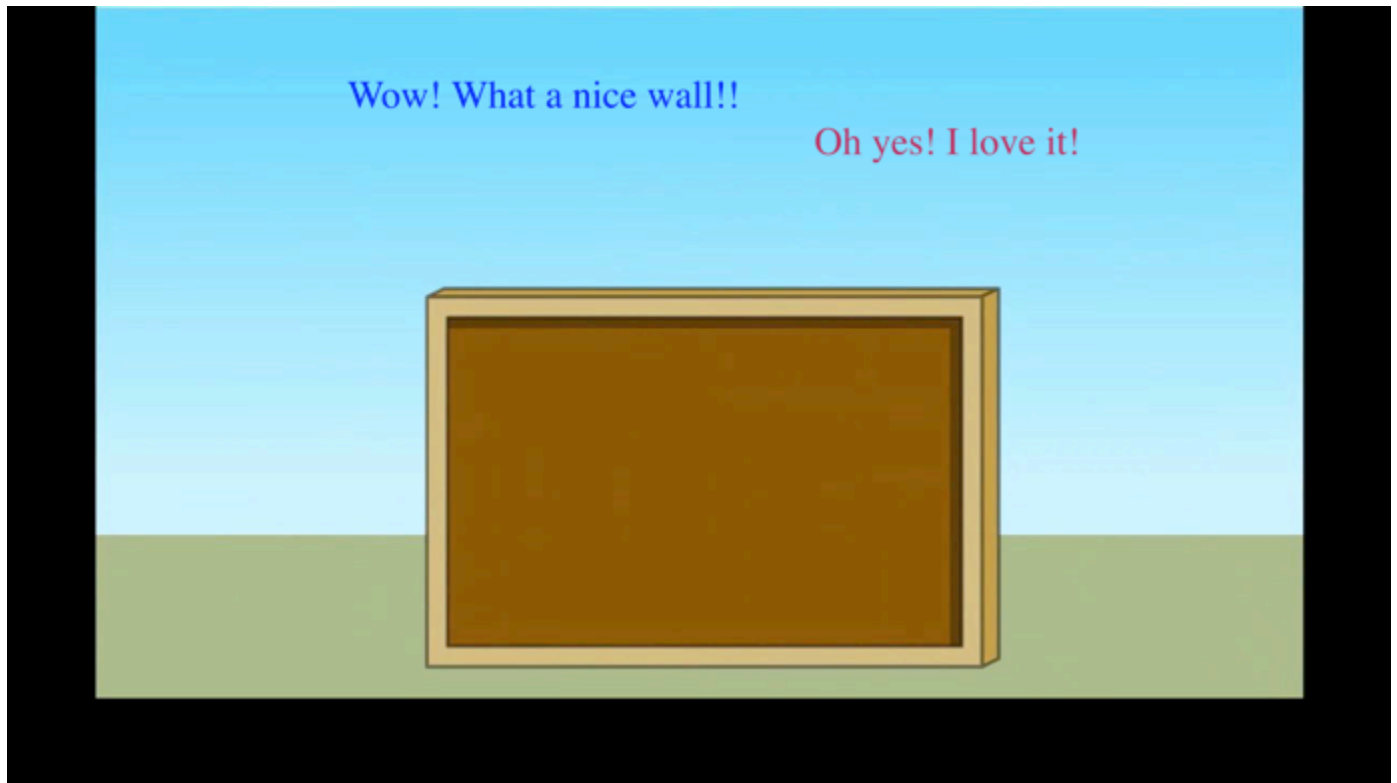


Individuation Study

Jean-Remy Hochman, Post-Doctoral Fellow

Infants very early recognize the difference between human beings and other types of objects or animals. Even newborns use the configuration of the eyes, mouth, and nose to recognize a human face. But how do infants recognize a specific person and discriminate him or her from other people? In this study, we asked whether infants preferentially use certain perceptual cues, such as skin color, clothes, voice, and spoken language, to tell people apart.

During this study children sat in their parents' lap facing a screen. The screen was equipped with an eye-tracker that automatically detects the eyes and allows us to precisely monitor where children are looking on the screen. On each trial, children saw a wall and could hear people talking. We asked whether infants would predict that there are two people behind the wall when hearing two different voices and that there is only one person behind the wall when hearing only one voice. After hearing one or two people speaking, the wall would fall, revealing one or two people. We can assess infants' expectations by measuring how long they look at what is on the screen—longer looks mean they are surprised! For example, if they are surprised when they see one person after hearing two voices, this would show that they used the differences between the two voices to tell the people apart. Our findings show that 10- to 12-month-old infants expect two people behind the wall if they hear one female and one male voice! They appear less good, however, in making that conclusion when hearing two different voices of the same gender!



Same and Different

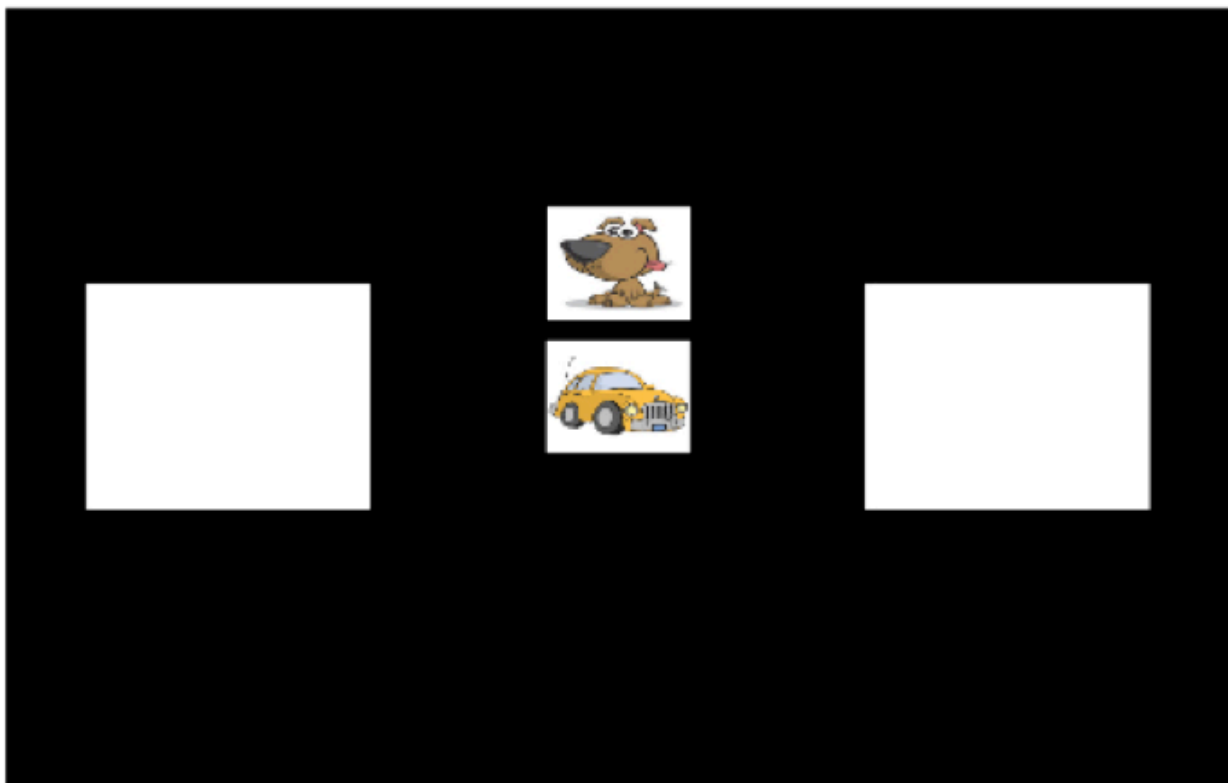
Jean-Remy Hochman, Post-Doctoral Fellow

Humans, like all animals, are born with certain concepts, such as knowledge of objects and small numbers. But only humans develop complex concepts, such as "microchip" and "freedom of speech." Humans have the unique ability to combine known concepts to build a novel concept. For example, they can combine the concepts "not" and "brown" to obtain the concept "not brown." Our study seeks to understand at what age and in what circumstances infants show this ability, called compositionality. Precisely, we ask whether infants can form the concept "different" as the negation of the concept "same" (i.e., "not same"). To look at this, we are testing 12- to 20-month-old children who have not yet learned or are beginning to learn their native language.

During this study, children sit on their parents' lap facing a screen. The screen is equipped with an eye-tracker that automatically detects the eyes and allows us to precisely monitor where children are looking on the screen. On each trial, children see two objects, after which a toy appears either on the right or left side of the screen. The toy appears in one location if the two objects are the same and in another location if they are different. There are 36 such trials. By monitoring the location of children's gaze on the screen, we ask whether they can learn to predict the location of the toy's appearance, giving evidence for their understanding of "same" and "different."

We are still in the initial phases of this project, asking whether infants can learn to make predictions about where a toy will appear after seeing examples of two things they know well at that age: cars and dogs! We have found that infants around 14 months of age are unable to learn both predictions (“same” and “different”) at the same time but learn only one. Most infants learn to make correct predictions after seeing dog pictures but not after seeing car pictures, evidencing a stronger interest for animals than man-made objects!

Unfortunately, we are unable to study infants’ understanding of “same” and “different” if they cannot learn to make two predictions. We are now testing 17- to 18-month-olds on the same experiment in order to see whether infants at that age can learn to make two predictions. If so, we can then investigate their understanding of the concepts “same” and “different.” Stay tuned!



Speech Perception

Jean-Remy Hochman, Post-Doctoral

All over the world, human communities use speech to communicate. Studying how very young infants perceive speech is therefore crucial to our understanding of language learning. In this study, we are trying to understand what the units of speech that infants recognize are. In particular, do they realize that a syllable is composed of at least two elements: a consonant and a vowel? For example, the word bay is made of two elements: a consonant b and a vowel ay. If infants know this fact, they should easily realize that the words ball, bird, bee, and bay all start with the same consonant but that the word day starts with a different consonant.

In this experiment, we exposed infants to a series of words that all start with the same consonant (e.g., ball, bird, bee, and bay). Once in a while infants would hear a word starting with a different consonant (e.g., day). We asked whether infants were surprised when they heard a word with a different initial consonant.

To measure infants' surprise, we used the diameter of the pupil, which was provided by the eye-tracker setup described in the previous study. Namely, we asked whether the diameter of the pupil increased when infants heard a word starting with a different consonant. Results show that 6- to 7-month-olds are indeed surprised when the word day is presented after words such as bay, ball, bird, and bee.

Our results therefore suggest that 6-month-old infants already know that a syllable is composed of two elements: a consonant and a vowel.



Paternalism Interview

Jana Douglas, Research Assistant

Throughout development children are constantly confronted with lessons, rules, expectations, and advice. Paternalism refers to the act of making a decision on someone else's behalf that may go against the current desires of that person. For example, children are told to eat their vegetables at every meal and to wear a hat when it is cold outside. Similarly children are taught that they should apply these rules on their own, especially in situations involving others: they should not push Susie off the swing in order to have a turn, nor should they take Bobby's paints while he is using them. Navigating this world of rules, especially when they seem to interfere with one's natural inclinations and desires, is not easy. Nor has it been simple for adults to understand what is important to children as they make decisions about pursuing desires versus conforming to norms and rules. In an attempt to examine this phenomenon, a significant amount of research has been devoted to ascertain children's perceptions of the importance of rules and norms as well as their predictions about their own feelings if they obey or break them. The study we are running, called the Paternalism Interview, is mainly concerned with children's understanding of emotional responses to situations that involve a conflict between a norm of behavior and an individual desire.



In the Paternalism Interview study we show children four short videos; each of the stories involve characters facing a “paternalistic” conflict. For example, in one story a hungry character asks for something to eat and a second character, the helper (also called the provider character), must decide what item of food to give the other character, the choices being a carrot or a cupcake. The hungry character states that she wants the cupcake even though it will make her tummy hurt and that she does not want the carrot even though she knows it will make her feel good. The provider character in the story articulates and contemplates the situation. We then ask the child to predict what the character’s decision will be, and then confront the child with the predetermined consequence. In some trials, the provider character makes a paternalistic choice (in this example, gives the carrot) and in some trials, the provider makes a libertarian choice (gives the cupcake). We subsequently ask the child a number of questions about the actions taken. But most importantly, we ask the child to postulate about what each of the characters is feeling in regards the situation and why the child thinks they feel that way.

The study was run with 7- and 9-year-olds. We aimed to examine three things: the children’s expectations about how providers will act in these situations, the children’s expectations about how each character will feel in these situations, and what types of reasoning children employ to explain those feelings. In regards to the first question, results indicate that children expected the provider to act paternalistically on 70% of first trials. To the second question, children reported different emotion ratings for the provider and receiver, which varied depending on the situation. Overall in libertarian trials, where the norm was overridden in order to satisfy the desire, children presumed that the receivers felt more positive and that the providers felt more negative. Conversely, in paternalistic trials, children presumed that the receivers felt more negative and the providers felt more positive. Many children also reported secondary or mixed emotions for both the providers and receivers. To answer our third question we assessed three types of reasoning: goal-oriented, rule-oriented, and future-oriented. We found that predominately, children explain the characters’ emotions by referencing a goal (e.g., “She’s happy because she got what she wanted.”), and rules were rarely mentioned. Furthermore, future-oriented reasoning was utilized more frequently by 9-year-olds than by 7-year-olds.



Mary “Schloves” John

Joshua Hartshorne, Graduate Student

To understand the sentence “Mary loves John,” you need to understand several things. You need to understand the emotion “love,” and how it differs from “like,” “hate,” and other emotions. You need to know who Mary and John are. You also need to know the semantic role played by the subject (“Mary”) and object (“John”) in the sentence. “Mary loves John” and “John loves Mary” are not synonymous. That is, Mary is the person who experiences the emotion, and John is the source or target of the emotion. Notice that there is nothing necessary about this. English could have a verb “shlove,” for which “Mary shloves John” means “Mary is loved by John.”

How do children learn that English has the word ‘love’ and not the word ‘shlove?’ Researchers long ago noticed patterns -- in English, and in all languages -- that would help. The subject of a sentence is typically the ‘do-er.’ So “John broke the vase” describes John doing something to the vase. “Mary threw the ball” describes Mary doing something to the ball. There are few or no verbs like “The tree pilked John,” which describe John doing something to the tree. If children are sensitive to these regularities, then that might help them learn the semantic roles for new verbs (in fact, Harvard psychologist Steven Pinker argued that this sensitivity might be crucial for learning language at all).

On the other hand, other researchers have argued that verbs are learned one at a time, and any regularities across verbs are ignored by children early in language acquisition.

Coming back to the verb ‘love,’ though, there is a problem. Who is the “do-er” in the sentence “Mary loves John?” Mary, because she is experiencing the emotion, or John, because he is causing it? Different linguists have argued for both positions. On the position that Mary is the do-er, then the verb “love” should be easy to learn. On the position that John is the do-er, then it might be very hard to learn, because the verb would be backwards relative to most verbs in English (and in all other languages). The reverse would be true for the verb “frighten,” as in “Mary frightens John,” in which the subject is the source of the emotion and the object is the experiencer. Of course, for the theorists who argue that the generalizations across verbs are not important in early verb learning, this argument is beside the point.

Verbs: A Gorp/Wixter Relationship

Joshua Hartshorne, Graduate Student

We tested whether children have intuitions about the right kind of verb to use for a given emotion. We taught them 2 new verbs: “to gorp” and “to wixter”. We defined these verbs through stories. The stories were designed so that an adult would think that the verbs mean “to disgust” and “to encourage” (verbs like “frighten”, where the experiencer of the emotion is the direct object) or “to admire” and “to pity” (verbs like “love”, where the experiencer of the emotion is the subject). We are pretty sure that the children we tested do not know these words but that they are familiar with the emotions. Will they correctly guess that if the verbs mean “to disgust” and “to encourage” that the experiencer should be the direct object, and that if the verbs mean “to admire” and “to pity” that the experiencer should be the direct object, and that if the verbs mean “to admire” and “to pity” that the experiencer should be the subject?

We tested 3 groups of children: 3-year-olds, 4-5-year-olds, and 6-7-year-olds. Both of the older groups correctly guessed the right answer. 3-year-olds were at chance for both types of verbs. This suggests that by 4 years of age, children already know some kind of generalization that helps them guess how certain kinds of emotions will be talked about – that is, what kind of verb will be used. We are currently trying to discover how children figure this out, as whatever rule children are using is one that even linguists do not completely understand.



Socially Guided Learning

Sunae Kim, Post-Doctoral Fellow

Through learning and teaching, knowledge transmission across people and generations is possible. Increasing evidence shows that children are very receptive social learners, but we know less about whether children are equally good teachers. Presumably, knowledge transmission occurs when a knowledge gap exists. If one person understands a concept that the second person does not grasp, it is natural that the first person would convey that knowledge to the second. Past research shows that young children are sensitive to different knowledge states of others and selectively learn from them. But, do children selectively inform others who lack a piece of information or others who already know the same piece of information?

In a series of studies, children ages 4-8 years old watched an animated story on a computer. Children were shown the hidden contents of a container, and were introduced to two characters who had different knowledge states regarding the hidden contents of the container. For example, one character knew what was inside, either because she looked inside the container, or because she was informed by her friend who looked. The other character did not know the contents, either because she never looked inside, or because she was never informed by her friend. Children were asked to inform one of the characters what the content of the box was. Preliminary results show that it is only around the age of 7 that children consistently inform the character who did not know the hidden contents, rather than the character who knew. Although younger children did recognize the knowledge difference between the two characters, they did not reliably select the character who did not know the hidden contents. Currently, we are trying to investigate if younger children's choice of character is partly driven by their preference for others who display competency (e.g., knowledge).

Measure Words

Peggy Li, Research Associate

In this series of studies, we are interested in how children talk and reason about quantities. Specifically, we are interested in whether there is a relationship between children's acquisition of measure-words (as in, a piece of a fork, a slice of apple, a cup of sand) and their concepts of quantification. If you have a preschooler at home, you may have noticed that while your child can count pretty well, there are times when he or she seems to have a different understanding of what makes up a unit than you do. For example, many children will describe a fork broken into three pieces as "three forks" rather than "three pieces of a fork" or "a broken fork."

In one study, we are exploring whether knowing the language that distinguishes whole objects from pieces allows children to better represent and remember the objects that they see. For example, if children are shown two forks and three fork pieces being placed into an empty box, are they representing the number of whole forks separately from the pieces of forks (e.g., two whole forks and three pieces of one fork, and not "five forks")? Could they figure out what are the remaining contents of the box after some of the forks or fork pieces are then taken out?

In another study we are looking at whether learning measure-word phrases such "a cup of sand" or "a pile of sand") is related to children's ability to make use of containers to quantify and compare amounts of substances. Some researchers have found that preschoolers cannot tell that four cups of sand has "more sand" than three. This is not because they do not know how to count cups as they can correctly determine that four cups has "more cups" than three. This is also not because they do not understand what is meant by "more sand" as they can correctly identify which side has more sand when given larger discriminable volumes of sand (e.g., 4 cups vs. 1 cup). Thus, the findings suggest that three-year-olds are failing to notice that they can use cups as units when quantifying substances.

In yet another study, we are trying to teach children measure-word language, in hopes that they start to treat units more like adults. For example, to get children to stop counting three pieces of a fork as "three forks," we introduce the term "a piece." We teach them the contrast between a piece and a whole: both that a whole fork would never be called "a piece of a fork," and that a third of a fork would never be called "a fork." Our training has moderate success in getting children to correctly label whole objects and parts of objects.

We are hopeful that studies like these, whose goal is to better understand how children come to apply measurement and counting language, and how to encourage their progress toward more adult-like use of quantificational terms, will have positive implications for early math education.

Eyes are the Windows to Sentence Comprehension

Manizeh Kahn, Graduate Student

One of the challenges of studying the language of children is that usually you can't simply ask a child whether or not they understand a sentence, or if it was difficult to understand. Reflecting on such questions and responding verbally is often too challenging and confusing for very young children. So instead we use more indirect techniques in order to measure children's language skills and comprehension. One technique we are currently exploring is pupil dilation. We know from decades of work with adults that people's pupils dilate when they are seriously contemplating something, whether it is making a difficult decision, solving a mental arithmetic problem or remembering a long list of items. So we applied this technique to children, monitoring children's pupil size while they listen to sentences. Our question in this study was whether preschool-aged children's pupils would dilate when they had to think hard about the meaning of a sentence. Using the method outlined above, we can explore what sorts of sentences are difficult for children to understand.

The study begins with a cartoon for the children to watch, and each character tells stories about Dora, D.W., Arthur and Diego. Meanwhile, the child sits in front of a computer that can remotely monitor their pupil size and eye movements. The stories they heard all include a pronoun, either "he" or "she." Sometimes it is easy to figure out to whom the pronoun referred to. For example the story about Dora and Arthur uses "he.". Other times the child must integrate information from across the sentence to figure out who the pronoun is referring to, for example hearing "he" in a story about Arthur and Diego. Preliminary results suggest that children's pupils dilate more for the latter type of story, but only if the ultimate interpretation pronoun goes against their initial biases. The study is on-going and we are continuing to work with more children to get a clearer idea about which aspects sentences affect pronoun interpretation, and how this is reflected in pupil size.



Music Enrichment Study

Sam Mehr, Researcher

This study explores the effects of music instruction on young children's cognitive development. More specifically, we are interested in exploring the effects of music enrichment activities on spatial and geometrical reasoning in young children.

Previous studies in our lab have shown a connection between instrumental music lessons and enhanced geometrical reasoning abilities in navigation tasks. However, these studies, along with many studies of "Music Makes You Smarter" effects have one major shortcoming: they are correlational, meaning they study groups of people who already study music, as opposed to randomly assigning children to receive different types of training. Inherently, correlational studies don't tell us about the direction of an effect. For example, music lessons could make children better at navigation, or navigation experience could make children better musicians, or both abilities could be enhanced by some other factor.

Our study is among the first to look at cognitive effects of music enrichment through a "true experiment." Our study's design is just like longitudinal studies from the field of medicine: it has random assignment with a pre-test, a longitudinal "treatment period" (the music enrichment classes), and a post-test. While everyone in the study gets the same type of classes, depending on your class assignment, the post-test happens either immediately after the classes have ended, or immediately before the classes start. In this way, we created two groups of children whose cognitive abilities we can compare, isolating the effects of six weeks of music classes.

Surprisingly, there are very few studies that investigate music education in this way. Even though it's common to see "Music Makes You Smarter" on bumper stickers, and to hear about connections between math and music in media reports, the vast majority of research on the subject is correlational, and thus subject to the problems described above.

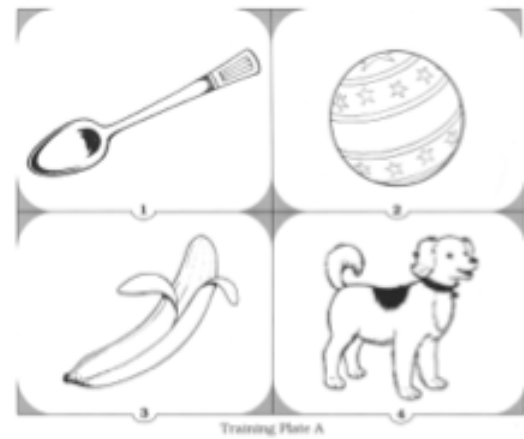
Another new part of our research is the lack of focus on instrumental music lessons, which much of the behavioral science/music research investigates. Instrumental music instruction (i.e., private violin lessons) is a controversial topic: there is considerable disagreement among music educators as to the appropriate time to begin lessons; private lessons are a strange, new experience for young children (one-on-one sessions with a stranger); instrumental music has confounding physiological issues (children aren't always physically well-matched to their instrument); and, most of all, there are many, many different methods for instrumental music instruction – there is no "right way" to teach guitar, for instance. By sticking to the basics of music learning (i.e., family music, folk songs, musical games and rhymes, and lullabies) we hope to learn more about the effects of music on cognitive development as opposed to the effects of music lessons.

One last new part of our research is that our music classes involve not only children but also their parents. Our work is guided by the evidence that preschool children do not develop their cognitive abilities in isolation; rather, they do so in rich social environments. We have aimed, therefore, to enhance musical activities not just for your child but for your family as a whole.

Pre-test: Fall 2011

In the fall, more than 50 parents responded to our flyers, emails, and phone calls to indicate their interest in the study, and many came to our lab for a lab visit. These pre-test visits included three main elements: (1) the child took a test of verbal abilities (the PPVTa), (2) the parent took the Advanced Measures of Music Audiation (AMMA) test, and (3) the parent filled out a demographic questionnaire. The PPVT score gave us a rough sense of verbal reasoning, the AMMA gave us a sense of how receptive to music teaching the parent would be, and the questionnaire gave us information about socioeconomic status (SES) and children's exposure to musicians and/or music classes. We used the data from these three tests for two reasons: first, to make sure the whole cohort was similar in a few specific ways (e.g., children had about the same vocabulary levels and were about the same age, there were no professional musicians in any families) and to give us data to work with before assigning children to classes.

We used MATLAB technical computing software to randomly assign children to either the early music session (February & March classes) or the late music session (April & May classes), while taking into account the data we collected in initial lab visits (things like age, PPVT score, income, etc.) so that the groups were randomly assigned but still balanced on the measures we had. That way, we avoided a random result where, for example, all the best PPVT scorers were in one group or all the youngest children were in one group.



An item from the PPVT-iii test. The child is asked, "Can you point to *dog*?"

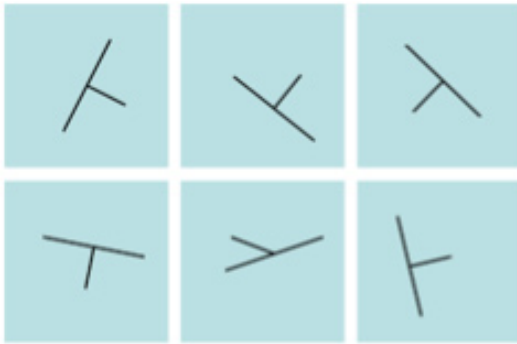
Post-test: March 24-25, 2012

Families visit our lab for a day of assessments, where we investigate possible effects that the music enrichment classes may have had on the children's geometrical, numerical, and verbal reasoning skills. We assess children in the following ways: (1) a test of geometrical reasoning, (2) a test of map use, (3) a test of numerical estimation, and (4) a second PPVT, testing vocabulary.

Descriptions of our assessments

The geometrical reasoning and map tests probe the development of two distinct kinds of spatial reasoning. In the geometrical reasoning test, children view six geometrical figures that differ in size and orientation. Five of the figures share a single property not shared by the sixth; we ask children, "Which one is different?" In the map test, children are shown a simple map depicting one of three geometrical forms (line, right triangle, or isosceles triangle) and are instructed to put a toy in a corresponding physical array of 3 containers.

Maps are rotated 90, 180, or 270 degrees for each trial. Thus, to find the correct location, children need to infer location from the geometry of the layout figure.



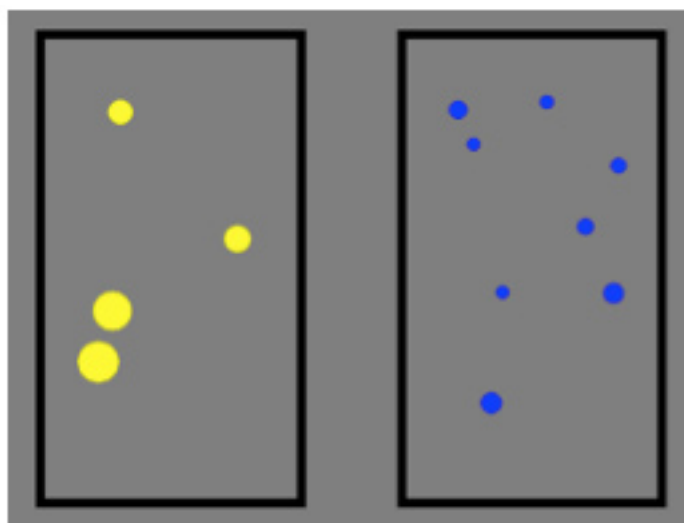
An item from the geometrical reasoning test. The child is asked, “Which one is *different*?”



A map from the map test. The experimenter feasted to a circle on the map and asked the child to place a toy on that spot. The circles corresponded to an array of buckets ten times larger, on the floor in from of the child.

The numerical estimation test probes large, approximate numerical comparison: the ability to approximate cardinal values of large sets of visual information (i.e., dots). Children are presented with “Grover’s dots” and “Big Bird’s dots” and are asked, “Who has more?” The ratio of each character’s dots varies between trials from easy (large ratio) to hard (small ratio).

The PPVTb is a measure of receptive vocabulary and includes words that children can recognize and identify, but not necessarily speak spontaneously. There are two forms of the PPVT; we used PPVTa in the fall to help with subject assignment, and PPVTb at the post-test along with the other three tests.



An item from the numerical estimation test. Big Bird’s dots are on the left; Grover’s dots are on the right. The child is asked, “Who has more dots?”

Preliminary findings

Analyses are still in progress, but early findings are showing no significant differences in performance between the groups. It's too early to tell for sure, but our results seem to be in contrast to the "Music Makes You Smarter" theory. We plan to write up our findings in conjunction with last year's music training study.

Most importantly...

THANK YOU to all of the families who participated in this study! It was a pleasure having you in our music classes. We can't thank you enough for your participation.

Music Enrichment Study researchers: Samuel Mehr, Adena Schachner, Rachel Katz, Rosemary Ziemnik, Yeshim Iqbal, Alexandros Bardis, and Prof. Elizabeth Spelke



Numerical Estimation Training Enhances Children's Math Performance

Saeeda Khanum, Visiting Graduate Student

This study investigated the development of numerical cognition in first graders. Does numerical estimation training give children an advantage when completing exact math, like addition problems? The numerical estimation training took place on a computer screen. Children watched a set of dots appear on the left side of the computer screen, and then watched the dots move out of view behind an object. They then saw another set of dots appear on the right side of the screen, which also moved behind the same object. After a short delay, children were shown a third set of dots, and were asked to guess whether this third set of dots is more or less than the sum of the previous two sets of dots. In a control group, children were shown a colorful oblong blob that changed its shape and hid behind an object. When the object was removed, children saw a circle, and were asked to guess whether the circle was lighter or darker in color than the first oblong shape.

Next, children in both the test and control groups were given addition problems to solve on paper. We compared the accuracy and reaction times between the two groups, to see if children trained with number estimation would perform better on symbolic addition than children trained with color comparison.

To find out, we did another experiment in which children were randomly assigned to either the numerical estimation condition, or to the color estimation condition, and completed the training tasks as described above. In addition, children in both groups completed a sentence completion task. The sentence completion task was intended to give us a fuller picture of general cognitive ability. Results show that children trained with numerical estimation had higher accuracy on the addition problems, compared with children who completed the color comparison training. However, no difference in performance was seen on the sentence completion task.

In the experiments mentioned above, we discovered that the color estimation task was easier than the numerical estimation task. Is it possible that the higher cognitive demands in the numerical estimation task were the reason for better performance in completing the math problems? To answer this question, we developed a non-numerical task that had a similar level of difficulty to our numerical estimation task. Two line drawings of different lengths were individually presented, then revealed as a single unit from behind an object. Children were asked whether the final line they saw was longer or shorter than what the sum length of the two individual lines should be. Children who completed this training task performed similarly to the children who completed the color comparison task. This suggests that it is not the addition aspect that increases children's performance; rather, it is the numerical estimation that primes, or warms up children's brains to have better performance on the exact addition problems in our study.

Recently we conducted another experiment, in which children compared two sets of dots. Children were presented with each set of dots in turn, and then were asked which set of dots was larger in number. These children were asked to solve addition problems, and we found that they performed similarly on the exact addition problems to the children in the numerical estimation group.

In summary, children who completed either the numerical estimation task with addition of two groups of dot or the numerical estimation task with comparison of two groups of dots, performed better on the paper-and-pencil based addition problems, compared to children who completed the color comparison or line addition training.



Perceptions of Animacy

Emily Bernier, Graduate Student

As adults, we effortlessly attribute goals and mental states to other people. Kate reaches for a cup in order to pick it up; Amy wants a cup of coffee; Emily is sad that Amy drank all of the coffee. This reasoning is so pervasive that we apply it even to non-human entities; we ascribe intentional agency (intentions/goals and mental states) to animals, robots, cartoon characters, and even simple animated shapes.

This kind of reasoning – thinking about the why of things, and assuming that people do things for a reason – appears in its simplest form in early infancy. Six-month-olds, for example, pay more attention to what a hand reaches for than to where it reaches; they look longer if the hand reaches for a new object, but not if the hand keeps reaching for the same object, regardless of where that object has moved to. Like adults, babies are not overly exclusive about who or what can have goals; infants as young as three months of age have been found to ascribe goals to all sorts of entities, as long as those entities show evidence of being animate.

So, what kind of evidence works? What features or behaviors determine whether adults and/or infants will see an entity as animate? Past research has shown that if an object has a face, or can move on its own, or is interactive (beeping in response to a baby's noises and movements), babies are likely to think that it is animate. Studies have also suggested that one-year-old babies think an object is animate after seeing it interact with someone else. This finding is especially interesting, because we don't know very much about how young babies think about interactions they see between the people around them. Before babies understand language, what do they think is happening when people interact?

The Perceptions of Animacy study is looking at whether babies at two different ages (6 months and 13 months) will treat a new object (a small, fuzzy blob) as animate after seeing the object interact with an adult experimenter. After the blob has a short "conversation" with the adult, it moves repeatedly towards one of two goal objects: a cup, or a piece of plastic fruit. The cup and fruit then switch places. We measure babies' looking patterns when the blob either 1) moves towards the same object, now in a different place, or 2) moves towards a different object, in the same place. If babies are thinking about the blob's movements in terms of goals, their looking patterns should change when the blob changes goals; we would expect longer looking times, indicating surprise, or longer processing time. This would suggest that infants are reasoning about the blob as an animate, goal-directed agent.

Preliminary data suggested that 13-month-olds attributed agency to the blob after seeing it converse with an adult, but not if the blob simply remained silent, while 6-month-olds didn't seem to care at all. Later data on the 13-month-olds was less conclusive – does it really matter if 13-month-olds see the blob interact with a confederate, or do they simply need to see the blob exhibit any kind of self-generated behavior? Are they really attributing goals under these conditions? Many questions remain – we'll keep you posted!

The Way You Do the Things You Do!

Amy Geojo, Graduate Student

We want to know how 4 to 5-year-old children learn the meanings of verbs. Verb learning is tricky since the same event can often be described from many different perspectives. For instance, if you see a dog running into a house, you could say, “the dog ran into the house”, describing the way the dog moves or “the dog entered the house,” emphasizing the path it travels. All languages have like manner verbs like run and path verbs like enter but languages differ in how many of these verbs they have and how often they are used to describe motion events. Interestingly, if you show people from different languages the same motion event and describe it using a nonsense verb, those who speak languages with many more manner verbs than path verbs, tend to think that the verb refers to the manner of motion but speakers of languages with many path verbs, think the verb describes the change in location. We want to know how children develop these expectations about verb meaning. In this study, we show children several different videos of motion events. Events are described with a nonsense-word verb, such as “the man is kradding the house.” We then show the child two new videos, and ask, “Who’s kradding?” The child’s answer tells us whether they interpret the nonsense verb as a manner or path verb. During this study, children learn many verbs. We want to know whether learning will influence how children interpret new verbs that they later encounter. We are excited to learn more about how children are able to so quickly learn verbs!



SHE has some of the bats: A battery to test pragmatics and prosody

Noemi Hahn, Researcher

Understanding utterances involves more than just understanding the meaning of the words and the grammatical structure of the sentences. Often times we also need to go beyond the literal meaning of an utterance and figure out what it implies in a particular conversation. For instance if we hear the following sentence: What a nice weather! In the middle of a thunderstorm, we need to realize that the intended meaning of the sentence is just the opposite of its literal meaning. This skill is called pragmatics. Another cue that can help us figuring out the intended meaning of this sentence is how the speaker says this sentence. If the speaker uses a negative (sad or angry) intonation then we realize that what he/she meant is how bad the weather is. The melody or intonation of a sentence is called prosody. The above-mentioned are examples, however are only small parts of these skills. Both pragmatics and prosody can serve our every day communication in many different ways, which might be relatively independent from each other. While we know little about how these different aspects develop relative to each other in typically developing (TD) children, the ultimate goal of our study is to find out which of these different aspects are impaired and which ones are spared in autism spectrum disorders (ASD), where the deficit in communion is a key characteristic. In order to find these potential differences within these two skills, we tested 6-to 9-year-old children – both TD children and age and language-skill matched children with ASD – on a battery of four studies.

1. The animal game

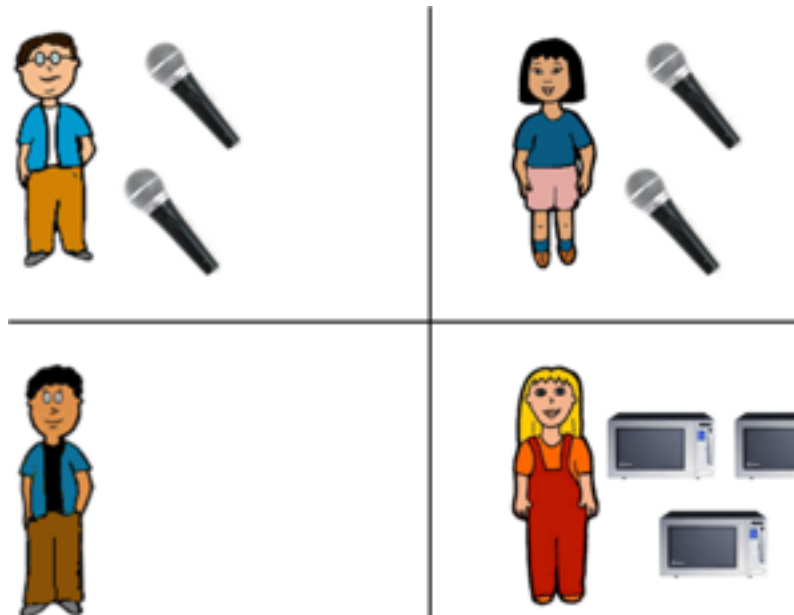
Figuring out what a pronoun refers to in a sentence is another pragmatic process that is sensitive to a wide variety of factors. Pronoun errors are frequently reported in the production of children with ASD. However, there is very little existing evidence about their ability to interpret pronouns in an experimental situation and especially when children with ASD have no language impairment. In our first study children listened to sentences with ambiguous pronouns while looking at the screen with the three characters mentioned in the sentences.

For instance: (1) Sheila (the sheep) visited Ellie (the elephant) and she called Henry (the horse). (The children learn the names of the characters before the study). If children can follow the discourse of the sentence, then they will choose Sheila as reference to “she”, since she was the first mentioned character in the sentence. There is a special case though, when she can refer to Ellie, and it is when the pronoun is stressed. (2) Sheila (the sheep) visited Ellie (the elephant) and SHE called Henry (the horse). Stress is a prosodic cue (just like the sad/angry intonation in the introduction). In this case, prosody is used to emphasize contrast: the pronoun doesn’t refer to its usual, default referent (Sheila), but to the other female character in the sentence (Ellie).

We found that TD children were able to use some of the cues to find out the correct references of the pronouns, namely 1) that the subject pronoun “she” refers to the first mentioned animal, 2) stressed subject pronoun “SHE” will less likely refer to the first mentioned animal. Children with ASD, however were not able to use any of these cues to resolve the ambiguous pronouns. This suggests, that they couldn’t follow the discourse context to figure out the references of the ambiguous pronouns.

2. The girls and boys game

Our second experiment aims at exploring how certain pragmatic interpretations are generated, by focusing on how people process words that refer to quantities like some, all, two, and three. In particular, we focus on sentences like “A girl has some of the microphones” which is logically consistent with a situation where she has all of the microphone (the total set) but is often interpreted with an inference that implies that she doesn’t have all of them (a proper subset). This is because, we as listeners assume that if the speaker wanted to refer to a girl with a total set of the microphone, he/she could have said all instead. Thus if children generate these pragmatic inferences then just like adults, when they hear the sentence “There is a girl who has some of the micro...phones.” they will look at the girl with only 2 of the 4 microphones (subset) even before they hear the word phones.



We found that at this age neither TD children nor ASD children generated this pragmatic inference during the limited time window. In order to find out whether there is a developmental delay in this pragmatic skill in ASD, we need to compare older children at an age when TD children are already capable of rapidly making the inference.

3. Last object game

It has been a long debate whether children with ASD can use contextual information. Some studies found that they have difficulties with processing global information while they are good at – sometimes even better than TD children – processing small bits, like single words. In our third study we examine how children interpret homophones; words which have two meanings, e.g. bat. Bat can refer to the animal bat or the baseball bat. In some of our sentences there is a contextual cue before children hear the homophone. E.g. John fed the bat that he found in the forest with his mom. The verb ‘fed’ helps in realizing that the homophone ‘bat’ refers to the animal in this case and not to the baseball bat. We examine whether children can use this contextual information by recording children’s eye-movements to a display where one of the 4 objects was in association with the other meaning of the homophone, baseball bat. This object was a baseball glove (the other 3 pictures were unrelated to the homophone).

We found that both TD children and children with ASD were capable of using the contextual information; both groups looked at the baseball glove, since they made the connection between the baseball bat and baseball glove.

4. The robot game

Prosody can be used to express many things, such as the speaker's emotional state or what the speaker intended to communicate. These skills are known to be impaired in ASD. Prosody, however, can be used to parse sentences in a certain way. To understand what someone says, a listener must identify individual words and then group them into meaningful units to determine the meaning of the whole utterance. Since the typical speaker produces about 2-3 words per second, we have to do this very quickly. Combining the words in different ways gives us different interpretations of the meanings of the sentences we hear; however, sometimes by the end of the sentence it becomes clear, which interpretation was correct. In our fourth study we examine if children with ASD are capable of using prosodic cues such as pause in order to find out what the structure of a sentence is, as soon as the prosodic cue is present. Since this prosodic cue doesn't require the attribution of emotional states and intentions, a skill known to be impaired in ASD, we expect this function of prosody to be spared in ASD.

Take one example:

- (1) "While the robot dressed... the nice cookies baked." or
- (2) "While the robot dressed the nice baby... the cookies baked."

This is a temporarily ambiguous sentence; until the object 'cookies' or 'baby' is presented - one can interpret it in two different ways if the words are combined differently. When children listen to this sentence, they need to figure out, which of the two interpretations is correct, using certain prosodic cues, such as intonation and pause. For example, if children can use these prosodic cues, then they will expect a new sentence when they hear the pause after 'dressed' thus they are more likely to look at 'cookies'. In other words when an animate and inanimate object are presented on the screen, a prosodic pause after the verb 'dressed' will result in expecting, and therefore looking at, an inanimate object (something that cannot be dressed). Vice versa, when there is no prosodic pause after the verb 'dressed' this will result in expecting an animate object, or something that can be dressed. As we expected, children with ASD, just like TD children, were able to use pause as a prosodic cue to combine words in the appropriate way and thus to disambiguate the sentence early on.



Turning Tones into Words

Clara Yoon, Thesis Student

Typically-developing infants grow to become masters of their native language. When we think about it, this is actually an incredibly difficult and impressive feat. How do infants even recognize which kinds of sounds count as language? There are so many sounds in the world around us and even if we narrowed it down to sounds that come out of people's mouths, there are plenty of sounds that we emit from our mouths that aren't language – coughs and sneezes, for example. Yet somehow, all typically-developing infants figure out which sounds count as language.

We sought to figure out more about how infants decide which kinds of auditory output count as language. The tool that this study focused on was a social one – specifically, contingent interaction or a back-and-forth conversational nature. In order to test this, this study built off of a previous study. This earlier study demonstrated that infants' categorization of objects is facilitated by hearing word phrases, but infants do not categorize when they hear words. That is, infants were shown a series of cartoon dinosaurs, accompanied either by a word phrase ("Look at the Toma! Do you see the Toma?") or a series of tones. Then, the infants were shown a dinosaur next to a fish. If the infants recognized that all of the previous dinosaurs were a part of the same category, then they would have a looking preference – either they would be bored with all of the dinosaurs and be interested in the novel non-dinosaur fish, or they would look at the dinosaur because it was a familiar member of the category they had been exposed to. If the infants did not categorize, then they would not have a looking preference, for both the dinosaur and fish would seem to be new to them. This previous study showed that infants had a preference (and thus categorized) when hearing word phrases but did not have a preference (and thus did not categorize) when hearing tones.

The current study used this previous study by introducing a conversational nature to tones and seeing if this additional social component would be sufficient to make the infants treat the tones like words. The infant would see a robot or an animation interact contingently with the experimenter and then with the infant before entering the categorization activity of the earlier study. If the infants have a looking preference for either the dinosaur or fish, then the infants would have categorized, like they did when they heard word phrases and thus, they would be treating the tones like words after seeing the tones used in a social contingent interaction.

Data collection has not been completed, but the data that we do have could possibly be leaning toward the infants demonstrating a preference. More data has to be collected and the procedure has to be further fine-tuned, but the potential for this experiment is very exciting!

Do Infants Understand Negative Goals as Easily as Positive Ones?

Roman Feiman, Graduate Student

We know a lot about how infants understand other people's goals. We know that when they see a hand reaching for one of two objects over and over again, they expect that hand to keep reaching for the same object even when that object changes locations, or when it is paired with a new object, previously unseen. But is it as easy for them to understand a negative goal as a positive one? Negative goals usually take the form of goals to avoid certain objects or actions -- so for example, a goal not to reach for an object. In a series of previous studies, we found that when we presented infants with information that suggested a particular object was consistently avoided (and many other objects were reached for instead), infants did not seem to notice. That is, they were no more surprised when the hand finally reached for the long-avoided object than when it reached for another new one. In the studies we conducted this past year, we were interested in the nature of infants' failure to notice the existence of avoidance goals. Was it specific to the context of goal-directed actions, or was it a general inability to notice events that are not happening? We tested this possibility by trying to replicate our previous reaching-while-avoiding-a-particular-object study as closely as possible, but taking it out of the domain of goal-directed behavior. To that end, we wanted to keep the physical contact between the hand and each object, as well as the pattern by which the hand touched all of the objects except for one. Following previous work from other labs that had found that a flopping hand making contact with an object isn't perceived as being goal-directed in the same way as a reaching-and-grabbing hand, we designed a study where the hand would flop on one of two objects every trial, and the object the hand touched would be switched every trial, while the other object that the hand didn't touch would stay the same. The objects were put on springs so that they would bobble when the hand touched them, to make the whole event more interesting for infants and ensure that they looked at all. We found the same pattern of results in this case as we had in the goal-directed reach case. When the hand finally flopped towards the one object it had never touched before, infants didn't seem to notice (ie. they didn't look longer than they had at the previous events). This tells us that non-events in general -- things not happening -- are harder for infants to notice than things happening. This might not be entirely surprising when we consider what we know about adults. We know, for example, that adults place more blame on someone who does a bad thing than on someone who fail to prevent that same thing from happening. Our research with babies might help explain the source of such moral judgments -- perhaps adults, like babies, have a harder time noticing things not happening, and therefore have difficulty placing such non-events in the context of causes for other events that do occur.

Do infants know logic?

What do infants understand about logic? Can 12-month-old infants understand a very abstract concept like "not"? Imagine what is required to understand the difference between "I am not going to the store" and "I am going to the store", or "this is not a book" and "this is a book". We tried asking whether infants can understand a concept like "not" by seeing if they could learn a rule using that concept. Infants in this study heard a whole lot of different sounds, while watching two objects on a stage. One sound predicted the right object floating up in the air and dancing, while all of the other sounds predicted the left object doing the same thing.

same thing. We predicted that if infants learned what each sound predicts separately, they should look in the correct direction (left or right) after every familiar sound played, but they should have no predictions about a new sound that they hadn't heard yet. If, on the other hand, infants formed rules like "That sound predicts something interesting happening on the right side" and "Everything that's not that sound, predicts something interesting happening on the left", they should predict that because a new sound they'd never heard isn't the same as that first right-predicting sound, it should be followed by something interesting happening on the left -- just like all the other sounds.

Unfortunately, we ended up not being able to test this prediction directly, because what we found is that infants had trouble learning any of the rules at all! We do know from other studies that, in general, 12-month-olds can learn that a sound predicts something interesting happening on either the left or the right. However, those studies were done with infants looking at a screen, not a live stage, and the "something interesting" was a flashing new shape that was changing sizes. In between them hearing different sounds, those shapes would disappear. We don't know if any of these differences between those studies and ours might have made a difference, but we're planning on finding out. We're starting a new set of studies, using a method that's more similar to the rule-learning studies that have succeeded before in other labs. Once we have an experiment where we can show that infants consistently learn at least two rules, we can resume asking whether they can learn the two rules -- "that one sound means right" and "not that one sound means left".

Does logic underlie language?

One of the most amazing things about language is that it is productive. It allows us to take concepts we know -- words we've learned -- and assemble them together in new ways to express thoughts we've never expressed before. I bet you've never thought or said, "If there was a blue bear on Neptune, he would probably be hungry". But you have no trouble understanding it and I had no trouble writing it. The project we have been working on looks at what underlies this productive ability. It turns out that one answer might be a formal logical system.

Some sentences in language are ambiguous in a systematic way. These sentences have two quantifier words (words like "some", "every", "most", and so on), or one quantifier and a negation (the word "not"). Take, for example, the sentence, "Every boy climbed a tree". This sentence could mean that every boy has a particular property -- that of climbing some tree -- meaning that each boy might have climbed a different tree than the others. Or it could mean that a particular tree has some property -- that all boys climbed it -- meaning the boys must have all climbed the same tree. It turns out that this ambiguity is well characterized by a type of formal logic (called "first order", or "predicate" logic), where logical operators (which include quantifier words like "every" and "a") can stand in different relations to each other in a way that produces exactly both meanings of this ambiguous sentence. Is this a coincidence? Or is it possible that what underlies the way we combine words like quantifiers with ideas like boys and climbing a tree is a lot like the structure of this formal logical system?

We investigate this question by presenting 4 to 7-year-olds with a sentence and giving them a choice between two pictures. For example, they would hear, "Every boy climbed a tree" and have to pick between a picture where all of the boys climbed different trees or all climbed different ladders. In this case, there was a clear correct answer, and kids almost always chose the right picture. Then we would give them a different sentence, like "Every hiker climbed a hill", and a choice between two pictures that this time, did give them a genuinely ambiguous choice between both possible readings.

One picture showed one hill and a bunch of hikers on it, and the other picture showed many hills and hikers with one hiker per hill. We wanted to see whether kids would be more likely to choose the many-hills interpretation of this sentence after they had previously had to choose the many-trees interpretation of the last sentence (we would then bring kids back for a second session where they would get all of the same items, but the opposite type of picture on the first trial -- all boys on a single tree or all boys on a single ladder). We found that indeed, much like adults, kids were more likely to pick the interpretation involving many hills after having picked the interpretation involving many trees than they were if they had previously had to pick the interpretation with one tree. This means that the structure of the previous sentence influenced their interpretation of the next, where the main similarity between the two sentences was the two-quantifier form of both. This suggests that kids, like adults, use a predicate logic structure in language to interpret sentences such as these. We are now running follow-up studies to probe the exact boundaries of this effect. In the study we ran first the only difference between the two sentences was in the nouns; we are now also changing the verbs across the two sentences (eg. from "Every boy climbed a tree" to "Every dog chased a squirrel") to see if the effect persists.



"It's not in this bucket"

Romain Feiman and Shilpa Mody, Graduate Students

When do babies and toddlers understand what the word "no" means? This question might have a lot of interest to parents worried about when their child can understand a prohibition or reprimand, but it is also interesting for its broader logical meaning. As adults, we think thoughts and say sentences about someone not doing something very frequently. When do we come to understand what that means -- that not means something like "take the opposite". In an ongoing study, we are exploring this question by setting up a hiding-and-seeking game with kids, where we hide a ball in one of two buckets behind a screen that prevents the child from seeing which bucket we hid it in. In one study, we remove the screen and then told the child that it's not in one of the buckets. We then ask the child to find the ball and see if they go to look in the other bucket spontaneously. In a complimentary study, we show the child that one bucket is empty, and then asked them to find the ball. We wanted to know if they would use the concept of "no" without language to guide them -- whether being shown that one bucket is empty would tell them that the ball is not in that one, and therefore must be in the other bucket. We are still collecting data, and so don't know how either of these studies are going to turn out, but it will be exciting to find out whether the ages at which kids can do the linguistic and non-linguistic versions of these tasks are the same, or whether one task precedes the other.

The Process of Elimination

Shilpa Mody, Graduate Student

What kinds of general-purpose reasoning skills do infants have? How do those skills change and develop as the child grows older? In this study, we asked whether infants at different ages could use one particular reasoning tool: the process of elimination.

Adults use the process of elimination effortlessly in everyday settings. For example, if you know you left your cellphone either in your bag or on the counter, and you've already searched in your bag, you can assume that it's on the counter without having to check. To reason like this, you have to be able to consider multiple alternatives, then update your beliefs with new information about where your cellphone is not, and finally combine all this to infer where your cellphone must be.

We investigated this line of reasoning in infants by playing a searching game. They watched while we hid a toy in one of two buckets, but couldn't tell which one we'd put it in. Next, we showed them that one of the buckets was empty. Then we asked them to look for the toy. Using the process of elimination, they should reason that since the toy isn't in the empty bucket, it must be in the other one. 23-month-olds and 17-month-olds picked the correct bucket about 70-75% of the time, suggesting that they're successfully using the process of elimination. However, 14-month-olds only chose the correct bucket 40% of the time, instead preferring to look inside the empty bucket!

Going forward, we're interested in understanding the reason behind the 14-month-olds behavior. Can they really not use the process of elimination at all, or were they simply not applying it in this particular case? What aspects of cognition are changing between 14 and 17 months? Is the change related to infants developing language skills? Thanks so much to all the families that participated!



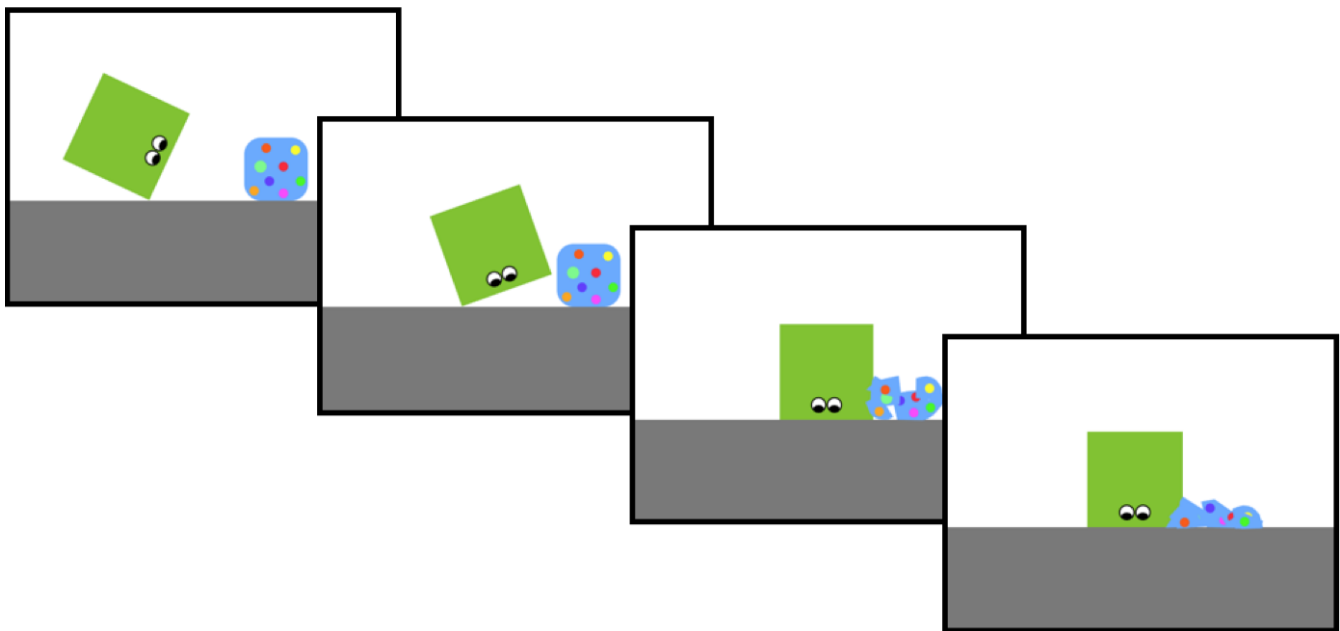
Infants' Understanding of Causal Events

Mariko Moher, Post-Doctoral Fellow; Mirta Stantic, Research Assistant

We know that a tower of blocks can fall down when we knock it over, and that one ball hitting another ball can make it roll in the same direction. Without understanding of causality, however, we would have no idea that the first event was necessary for the second to occur, and the world would be a much more chaotic place than the one we know. Events would happen for seemingly no reason, and we would be unable to predict them or react appropriately. Previous research has already demonstrated that infants have a deep understanding of simple causal events such as launching (one ball hitting another), and that this knowledge emerges in infants as young as 6 months.

However, not all causal events are as obvious or simple as launching. For example, a fragile box might be broken by a clumsy hand, or a specific button on a toy, pressed, might play music. Although these relationships maintain a similar causal structure, they don't have the overt transfer of energy like launching events. Studies in the lab over the last few years have demonstrated that 8-month-old babies see these events as causal, too, expecting the two items to touch, for example, before the event occurs.

The fact that events that vary so much in their specifics (a ball being launched, a box being broken) can all be seen as causal by infants suggests that infants' understanding of causality relies on a rich representation of components. In all of these events, there is an agent, which initiates the event, a patient, who undergoes some kind of change following contact, and an event, whether it be launching or breaking. In the current experiment, we are examining infants' rich understanding of these components.



Our overall goal is to examine whether infants can remember multiple causal interactions, and when things start to fall apart, whether they tend to preserve the agent-patient-event relationships they saw. For example, if they saw a hand break a box and a ball launch another, will they be surprised if they see a hand launch a ball? Over the last few months in the lab, we've started by exploring whether infants can represent simple events shown on a computer screen. Infants first saw movies where a cartoon character approaches a box and upon contact, the box breaks. When they became bored with the display and their looking times declined, we showed them a display that violated the causal relationship - the box broke before the character touched it. We're expecting infants to tend to look longer at this unexpected, non-causal event than they did to the causal, familiar event.

Next, we'll be testing other causal events and ultimately move on to asking whether individual babies can remember multiple causal events at the same time. Thanks to all of the babies and parents who have participated so far, and hope to see you again soon!



Language Acquisition and Theory of Mind

West Resendes, Thesis Student

As adults we constantly explain other people's behaviors in terms of mental states like goals, desires and beliefs. For instance, we reason that Sarah must have poured salt in her coffee because she thought it was sugar and she wanted her coffee sweet. This comes naturally to us, but is no small feat. Children can't explain others' actions in this mentalistic way until around age 4, though emerging findings have shown that even one-year-olds to have an implicit understanding of others' beliefs. Researchers refer to this understanding as reflecting a "Theory of Mind," and it has been an active area of research within developmental psychology for the past three decades.

Interestingly, it seems that language acquisition may play a substantial role in the development of Theory of Mind. One piece of evidence for this is the finding that deaf children who are delayed in learning language lag behind their same-age hearing peers when it comes to understanding others' false beliefs. Given this in conjunction with recent findings on infants' Theory of Mind, we wonder whether vocabulary size will be related to performance on Theory of Mind tasks in hearing children and whether deaf infants will be delayed in social understanding in the early toddler years.

This study measures 18- to 26-month-olds' Theory of Mind understanding in relationship to vocabulary size and will also compare deaf and hearing infants' performance on our battery of tasks. We use three tasks that measure understanding of others' mental states and a working memory task as well. The imitation task measures whether infants can infer an actor's goal when her actions are not quite successful and then imitate what the actor was trying to do, not what s/he actually did. The pointing task investigates infants' understanding and production of point for the purposes of both requesting and informing. The helping task asks whether infants use an adult's knowledge state in determining his/her desire and helping accordingly. Lastly, the working memory task requires infants to remember which containers they've looked in already to find a new toy. We also assess children's vocabulary size with a checklist documenting words that children understand or produce.

We've completed testing hearing children, and have found no connection between children's vocabulary size and how they perform on our social understanding tasks. We have also tested some deaf infants, and have found that they perform very similarly to their hearing peers across all tasks. These preliminary findings seem to suggest that language acquisition may not play a large role in early Theory of Mind understanding, but we will test more deaf infants this summer to assess this exciting conclusion.



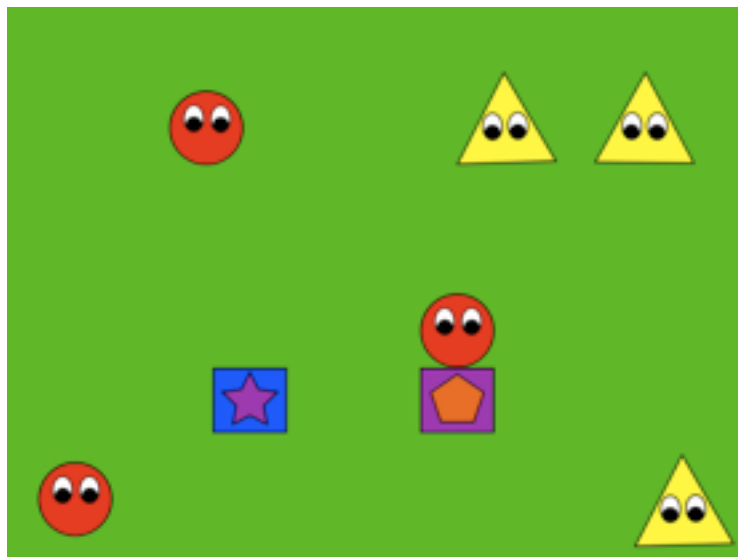
Shared Behavior and Social Groups

Lindsey Powell, Graduate Student

The social world is a confusing place, full of many strangers and consisting of relationships between people that aren't always visible to us as observers. Still, being able to predict what people will be like and who will be friendly are important skills, so we're interested in how infants may already be thinking about other people and the relationships between them. Most of this research focuses on how infants might use information about social groups to make predictions about individuals. As adults we do this all the time, using big categories like age and gender, as well as things we might know about families or groups of friends, to predict individuals' preferences and actions. This is often a helpful strategy but it can have harmful consequences as well, and understanding the development of the tendency to think of people as members of groups might help us to both capitalize on the benefits and address some of the drawbacks of this strategy.

Reasoning about Social Categories

In previous newsletters, we've described a line of studies asking whether infants already use social categories to reason about others, or whether this tendency is something that doesn't develop until later, as children are exposed to more social interaction and discussion of social groups. In these studies, we introduce babies to groups of animated shapes or characters, and then we show them that 2 out of 3 members of one group regularly do one thing while 2 out of 3 members of the other group do something different. Sometimes the contrasting actions consist of jumping on different boxes, other times they're things like sliding back and forth versus jumping up and down. We then ask whether babies use this initial information to learn about the groups or categories of individuals by asking whether they now expect the third member of each group to act the same way the first two members did. In other words, if the first two red guys both jumped instead of sliding, will babies be surprised if the third red guy slides instead? We have found that 8-month-olds are, in fact, surprised and look longer at our videos when the third member of a group does something different than when he conforms to his group's actions. So, even before their first birthdays, babies are reasoning about others not just as individuals, but as members of groups! In control conditions where we take the faces off of our shapes to help prevent babies from thinking about them in a social manner, we find that this effect goes away.



We wanted to follow up these initial results by getting a better idea of what makes infants see individuals as members of a group. In our original studies the members of each group all looked the same. They might have been, say, three identical red circle characters contrasted with three identical yellow triangle characters. In addition to this visual information, we provided social cues that the characters were affiliated with each other. At the beginning of the studies, each group of characters formed a close-knit circle and danced together, indicating they were a friendly group that did things together. In order to find out if one of these kinds of cues to group membership – visual vs. social – is more important for infants when they're figuring out who goes together, we did two new studies. In the first one there were still two sets of characters that differed in terms of their appearance – three red circles and three yellow triangles. But now, the characters did not display any cues that they were friends with one another. Instead of forming close groups and dancing together, the characters were spread out and each danced by itself. In this case, when the first two red guys jumped on one box and the first two yellow guys jumped on the other one, infants no longer cared what the third character of each type did. They looked equally long when the third red guy copied the first two red guys and when the third yellow guy failed to copy the first two yellows. This failure to generalize suggests that babies don't form social groups based on visual information alone.

The fact that infants don't simply expect characters who look the same to act the same way suggested to us that maybe the social information in our original studies – where infants expected characters that both looked alike and danced together to act the same way – was really important for getting infants to see the individuals as social groups. We wanted to test this, though, so we ran a study where we again introduced babies to two groups of characters, but now the six characters all looked different from one another. The only thing that told infants who was in what groups was which characters associated and danced with each other at the beginning of the study. We then showed babies our usual jumping actions – two of the characters from one social group jumped on one box and two characters from the other group jumped on the other one. This time, when we got to showing infants the third character from each group, they did differentiate between a character who did the same thing as his group and one who did something different. The results were a little surprising though. In the original study infants looked longer at the character who did something different than his group, a result that fits our usual interpretation of looking time as a measure of "surprise." In this case, though, infants looked longer at the character who did the same thing as his group!



So, how should we think about this change in the results? Recent work from other infant research labs suggests that the best way to think about infant looking time is not as a measure of surprise but as a measure of where infants think they can get the most information. When infants have a strong expectation about what's going to happen next – when, for example, they've repeatedly seen -- then unexpected events teach them the most by showing them that the assumption they'd built up isn't always true. But when infants are still learning something then consistent, expected information may actually be the most informative, helping babies to cement their new understanding of the situation. This might explain why infants looked longer to the character that acted just like his group in our new study. It may be harder for infants to learn which groups do which actions when the members of the groups all look different and there's no easy way to remember who is in what group. In this case, infants may be more interested in seeing a consistent action that helps them to learn that yes, in fact, members from this group really do always jump on the same box. In earlier studies, where the group members all look the same, infants seem to have already learned this rule by the time they get to the third character. However, we felt it was also possible that our unexpected results in this new study were just a fluke, so we ran both our original study and this new study, where the group members look different, again with slightly younger babies (7-month-olds) and a slightly different procedure, but we found exactly the same results. Babies in both groups can tell conforming and nonconforming actions apart, but when the group members all look the same then infants look longer at the guy that does something different than his group; in contrast, when the group members look different then infants look longer at the guy that does the same thing as his group.

What we take away from the studies described above is that infants need social information to think of individuals as members of a group. When our characters form groups that hang out and dance with one another, then infants pay attention to their actions and notice whether they are acting similarly or differently from one another. In contrast, when the characters fail to interact with one another or when we take away their faces suggesting they aren't actually animate at all, infants seem to no longer pay attention to the similarities or differences between their actions. We're following up these studies with additional question about how infants reason about groups. For example, will infants generalize any kind of action across social groups? Also, how many members of a group have to demonstrate an action before infants will expect the whole group to act that way? If just one character does the action will babies generalize it to others, or do they need to see multiple individuals doing the same thing? Initial results from this study suggest that one character is not enough – babies only seem to expect a new character to act like his group if more than one group member has demonstrated the action in question. Finally, we're looking to see if there are other properties, like weight, that infants might prefer to generalize across non-social categories, rather than social ones. We look forward to updating you on these studies in the next newsletter!

Preferences for Similar Others

As adults, we don't just expect related individuals to be more similar to one another, we also use similarity to reason about and guide our relationships. In particular, we tend to like people who are similar to ourselves more than those who are dissimilar, and we tend to try to make ourselves more similar to people when we want them to like us. We were wondering, especially in light of the results described above, whether infants might have any grasp on this relationship between similarity and liking. In studies with both 4- to 5-month-olds and 12-month-olds we have been asking whether infants use similarity as a way to figure out who will like who. In these studies we show infants two groups of two individuals – usually two red guys and two blue guys – and then one purple character sitting alone. We then use actions, sounds, or both to show that the purple character is more similar to one group than the other.

For example, the characters from the red group may jump up and down and make one sound while characters from the blue group make a different sound when they jump. Then infants would see that the purple character makes the same sound as one group but not the other. We then show babies the purple character dancing with each of the two groups and see whether they attend more to one of these actions than the other. With 12-month-olds we've expanded to ask what happens if, rather than accepting and dancing with the purple character when he approaches them, the two groups reject and avoid the purple guy when he tries to approach them.

The results of these studies show an interesting pattern across development. Based on the standard idea that infants will look longer at the event that is less expected, we predicted that infants would look longer when the purple character approached and danced with the group that was more different from him rather than with the group that was more similar. (In contrast, we predicted that babies would be more surprised and look longer when the purple character was rejected by the group that was more similar than the one that was more different.) And in the older age group, at 12 months, babies do seem to look longer when the purple character has a positive interaction with the dissimilar group compared to the similar group. At 4 months, though, we find that infants actually look longer when the purple character dances with the similar group. As in the research with 8-month-olds described above, we're tempted to interpret this in terms of how well the infants have learned to predict relationships between the characters. Older babies tend to be faster learners than younger babies, so it may be the case that the difference between the 12-month-olds and the 4-month-olds is that, having seen that the purple character is similar to the red guys and not the blue guys, 12-month-olds are sure that the purple guy is more likely to be friends with the red group whereas the 4-month-olds merely suspect that this might be the case. As a result, the 12-month-olds may be more interested in evidence that the purple and blue characters are friends, while the 4-month-olds are more interested in information that confirms their conclusion regarding the relationship between red and purple. This explanation is still speculative, though, and we'll have to do more work to follow up. As for the exclusion scenarios we've been showing to 12-month-olds, we are still collecting data, but initial results suggest that infants are looking equally when the purple character is rejected by the similar or the dissimilar group.

