Harvard Lab for Developmental Studies

Newsletter 2016

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2016 Newsletter Articles

Beyond the Words: Language in a Social Context

Ellie Kaplan, Lab Manager

Communication involves both understanding the literal meaning of what is said (semantics) as well as making inferences about what is meant (pragmatics). We study how adults, typically-developing children, and children with Autism Spectrum Disorders (ASD) comprehend and produce language with two specific aspects of pragmatics: prosody and pronouns. Our study involves several tasks in lab, as well as a training period where children practice these aspects of language at home on an iTouch device.

Prosody can be understood as emphasis put on words (e.g. how high the pitch is or how loud a word is said). In some of our games, we examined how participants produced emphasis on words, and in other games, we examined how participants understood other's use of emphasis on words. For example, adults would understand a difference in meaning for the following sentences: (1) No, I don't want the BLUE hat. Choose again! (2) No, I don't want the blue HAT. Choose again! That is, when the Picky Prince doesn't want the BLUE hat, adults guess he wants the red one. Children seem to be still developing this pragmatic understanding between ages 7 – 10 years old, and it may be that children with ASD develop this understanding differently.

In our pronoun tasks, participants heard stories about characters. The stories are sometimes ambiguous. For example: "Henry the Horse is playing in the snow with Marky the Monkey. He is wearing red mittens." Participants said whether the story was true or false. If it was false, they explained why. Adults usually think that "he" refers to first mentioned character in the first sentence. So we expect participants to look more towards Henry when they hear "he," and to say, "False, he is wearing yellow mittens!" Again, children ages 7 – 10 years old are likely still developing the bias we see in adults to interpret the pronoun as referring to the first mentioned character, and children with ASD may come to show this bias even later than typically developing children.

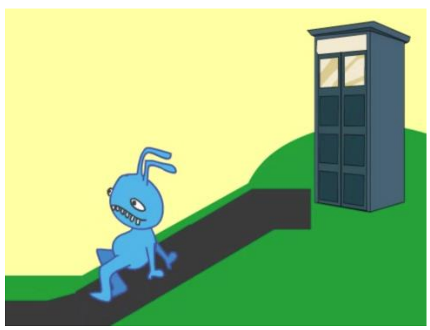
In the iTouch training, children practice some of the same tasks they did in lab. We want to know whether practicing language skills and receiving feedback on accuracy will help children to improve language skills.

Learning what Verbs might Mean: Does "Gorping" mean hopping or entering?

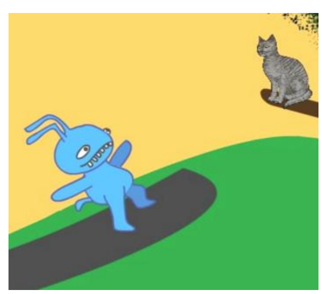
Melissa Kline, Postdoctoral Researcher and Annelot de Rechteren van Hemert, Graduate Student

Our four- and five-year-old participants have been playing a game that's designed to help us understand the guesses that children make when they learn a new word. Oftentimes, just seeing an example might not be enough: If you see a character hop around the tree and you hear "gorping", does gorping refer to the circling or to the hopping? Most adult native speaking English users guess that it's more likely to mean hopping, because there are many verbs in English that has meanings like this. But if they are asked to learn a bunch of verbs which all turn out to have meanings like ascend, descend, and enter, adults will quickly adapt and start to guesses that the next new word also refers to a path.

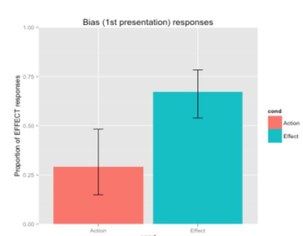
Where do these abilities come from? By age four children's guesses about manner vs. path verbs alrady matches the rates in their native language, an even very small infants are sensitive to how manners of acting and goals of acting interact with one another. Do these early systems go on to help children learn new verbs? We are using studies like the one your child participated in to help us understand this question. In this particular study, children saw silly movies like this one of a character crawling up to a phonebooth:



Then, they would see two choices: either a new scene that kept the manner (crawling) the same, or one that kept just the path (ascending/climbing the hill):



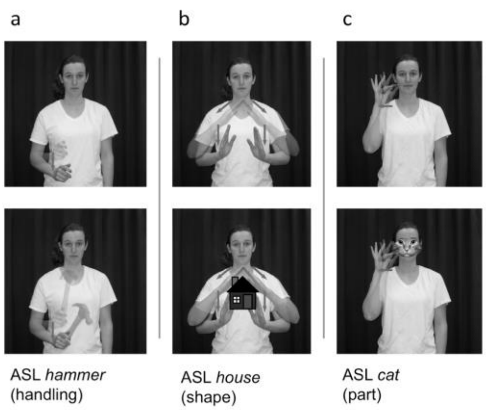
The study is still in progress, but this graph gives a sense of the pattern we are currently observing. If this trend is robust, it would suggest that these effects are based on some deep and very abstract kinds of meaning that children and adults use to put together verb meanings and sentence structures in just the right way. This line of work will help us to establish the development of language and understanding during the preschool years an, and to understand all the pieces that fit together the make this language learning possible.



What Makes a Good Symbol?

Annemarie Kocab, Graduate Student

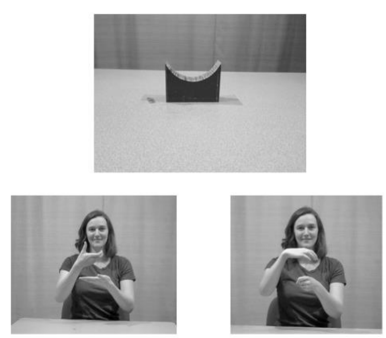
Children begin producing their first words when they are around 12 months and by age 6, know around 10,000 words. How do children learn so many words so quickly? One robust cue that children use is statistical frequency. Words that are heard more frequently in the context of an object are more likely to be thought to refer to that object than words that are heard less frequently. Less is known about other possible cues, such as iconicity, or the degree to which a symbol (like a word) resembles its real word referent (like a ball), to learn new words. Some spoken languages, like English, are thought to be low in iconicity, with the exception of onomatopoeia (words like *boom* and *bang*). Other spoken languages, like Japanese, have more iconicity, where the sounds of the vowels and consonants of some words resemble the objects they refer to (sharp consonants paired with objects with jagged shapes and smooth consonants paired with objects with round shapes).



In contrast, sign languages, as visual-manual languages, have richer potential for iconic symbols because the symbols and their referents exist in the same perceptual (visual-manual) space. For example, in American Sign Language the sign HOUSE looks like the shape of a house. The greater prevalence of iconicity in sign languages has led researchers to investigate whether iconicity confers an advantage for language processing or language acquisition. Work has shown that there is no difference in the lexical access, translation, or neural activation of iconic versus arbitrary signs in native signers of American Sign Language. The work on language acquisition is less clear, but the emerging picture is that iconicity in gesture and sign *can* be leveraged by children in some language learning contexts, but only at a relatively later age (around 3-4 years).

To address the question of whether iconicity is a robust cue for language learning, we employed a symbol preference paradigm with preschool-age children in the laboratory, pitting iconicity with another cue for language learning, statistical frequency. We showed your child different signs because the manual modality allows for greater use of iconicity. We are interested in whether children use both frequency and iconicity cues to learn new signs, and if so, which cue may be easier for children to attend to and use.

Children saw a set of toys, each of which had two different signs. One sign was presented more frequently but was not iconic, and the other sign was presented only one time but was iconic in that it resembled the shape of the object. Some children chose the more frequent signs the majority of the time while other children chose the rare but iconic sign more often. As a group, children do not seem to have a robust preference for either cue. This is in contrast to a group of adults we tested who overwhelmingly prefer the rare iconic signs. These findings suggest that as we develop from children to adults, our preference for symbols that resemble their meanings may increase.



Going Down the Garden Path!

Tanya Levari, Graduate Student

Although language comes so naturally to most of us, understanding sentences is an incredibly complicated task. For every sentence we hear, we need to identify the uttered sounds, figure out the meaning of the words, determine the grammatical structure, and fit all those things together into a conversation. We accomplish this feat by building up a prediction of what the sentence will be, as we are hearing it. As adults, we are also able to go back and revise that prediction if it turns out to be wrong. Too see this process in action, consider this sentence: "The cotton shirts are made of grows in Mississippi". I would guess that most of you first predicted the sentence would tell you about cotton shirts, and where or of what they are made. However, once you read the word "grows" you needed to go back and revise that prediction to "The cotton *that* shirts are made of, grows in Mississippi".

In my study, we are interested in exploring the developmental changes that allow kids between the ages of 5 – 8 to become much better at understanding sentences as they get longer and more complicated. Specifically, we are interested in seeing what types of information they are able to use in order to make predictions and how they learn to revise those predictions. Does the improvement reflect simply an increase in linguistic experience? Or, does it reflect a more general development, specifically of executive functions? Executive functions describe cognitive skills such as mental flexibility, attentional control, and working memory.

In order to study this, we asked both monolingual and bilingual children to play different games aimed at testing executive functioning. For example, one game asked children to press a left button when they see a particular image (which appears on the left side of the screen) and the right button when they see a particular image (which appears on the right side of the screen). Sometimes, the images switch sides. When this happens, the child must control how they react – they must stop themselves from pressing the button on the same side as the image in order to correctly press the button associated with that specific picture. In other games, we tested skills such as working memory by seeing how many numbers the child can hold in his or her mind.

The children that participated also got to play three different computer games designed to see how they understand different sentences. These games were performed with an eye-tracking computer, which allows us to see moment by moment how the child is interpreting what they hear. In these games, kids were shown pictures while they listened to different sentences, some of which contained an ambiguity, or a moment where two interpretations were possible. We were interested in seeing if kids are able to use context in order to select the more likely interpretation.

By comparing monolingual and bilingual participants' performance on this task, we hope to see whether children's executive functioning, their experience with a specific language (English), or their experience with language overall is related to the types of information they are able to use in order to make commitments and build up predictions and to their ability to revise those commitments once they are made. So far, our data suggest that bilingual children are better able to use context in order to help them understand ambiguous sentences. It is possible that growing up with two languages requires bilingual children to rely more on the contextual information, resulting in a better understanding of how context and language can inform each other.

What is in a name? The origin and development of cross-cultural differences in the semantics of proper names

Jincai Li, Graduate Student

At birth, we are all given a name, which often, but not always, follows us through life. When people use your name, they refer to you. But what is the mental link that ties a name to a person and gives it reference? This question is critical for philosophers studying language, linguists investigating meaning, and psycholinguists interested in how children acquire names.

There are two well-known proposals. The first, labeled the descriptive theory, contends that a name gets its referent through a definite description. When a speaker uses a name, they refer to whoever uniquely satisfies the descriptive content associated with that name. The second is called the causal-historical view, which proposes that a name refers to a person because it was linked to him/her in the initial act of naming. This link is then passed down through a community of speakers.

Previous studies consistently suggest that people from China and Japan tend to agree with the first theory, while Americans generally endorse the second one. In our study, we want to see whether the observed cross-cultural difference hold up in a more natural task (that is different from those used in the previous studies) and if so, how early the cultural patterns emerge. We created five stories involving several characters, each of which has a unique name. There are also two statements about the characters at the end of each story. Participants in our study are asked to judge whether the statements are true or false. Crucially, in two of the stories, the judgment depends on which theory of reference people adhere to.

We tested 37 English-speaking kids in the U.S. and 37 Chinese-speaking kids in China, who were invited into lab and told the five stories verbally while pictures were shown on a computer screen. These kids are all around age 7. To see whether people of different age judge the statements differently, we also collected data from 47 English-speaking college undergraduates in the U.S. and 47 Chinese-speaking college undergraduates in China who finished the study online.

We found that, similar to previous results, our U.S. adult participants' responses are more in line with the causal-historical view while the Chinese adults' answers are more consistent with the descriptive theory. Interestingly, the same pattern is also found kids and Chinese kids in our study. Namely, children in both groups respond similarly to adults in their own culture. That means children already have a culturally specific theory of reference by age 7. Therefore, we think that whatever leads to the cross-cultural difference must be happening earlier. The formal education and socialization that happen late in development seem to be irrelevant. In future studies, we plan to test younger children (e.g. 4-year-olds) in both cultures in order to trace the origin and the developmental pathway of the observed cross-cultural difference in people's judgements about how the reference of a name is fixed.

Judging and Describing Events

Jayden Ziegler, Graduate Student

This is part of a larger study that looks at what children and adults know about verbs. Words that are verbs share certain similarities. For example, in English, only verbs can come before the suffix "–ing." Do children understand this fact? Alternatively, do they treat each verb-like word as its own special case?

We are interested in a specific class of verbs called *datives.* Dative verbs are used in situations where there is transfer of possession. For example, *giving* involves a person who gives, the thing being given, and a recipient. Other dative verbs include *show, bring, pass, throw*, etc.

In this study, children heard and produced dative sentences. Elicited sentences were similar either to (1) or (2) below:

1. The boy brought the camel the keys.
2. The boy brought the keys to the camel.

We evaluated children's real-time production of these sentence. Which were they more likely to say?

Elicited sentences were preceded by two prime sentences. Our main hypothesis was that children's responses would be influenced by the type of prime sentences they heard. For example, if the children first heard two sentences with the same structure as that in (1), they would be more likely to use (1) to describe the scene. Alternatively, if the children first heard sentences like that in (2), they would be more likely to use (2) instead.

What does this tell us about children's and adults' knowledge of verbs? In this study, we used prime verbs that were either the same as or different from the elicited verbs. On the one hand, if the prime verbs influence children's production of a sentence with a different verb, this in effect shows that children understand at least some of the similarities *between* verbs. On the other hand, whether the type of prime verb influences the strength of priming in different ways over the course of development has possible implications for existing theories of language acquisition.We are finding evidence for an increase in performance with age, suggesting that children's knowledge of the differences and similiarities among verbs strengthens over development.

Role of prior mention in children's language understanding

Pooja Paul and Jayden Ziegler, Graduate Students

Previous work from our lab and elsewhere have found that under some conditions, adults show a preference for previously mentioned items in a conversation when guessing what items might be referred to later on in a sentence. For instance, when people hear sentences like (1) '*Bill picked an apple and a banana*', followed by (2) '*Jane only picked an ap…*', they tend to expect the continuation to be *apple* rather than *apricot* (as measured by greater proportion of looks to *apple* over *apricot* on a screen). The goal of our study was to understand whether this preference seen with adults extends to younger children under similar conditions. We also wanted to know how the presence and relative position of abstract words such as 'only' within a sentence influenced these looking preferences. More specifically, does the bias towards previously mentioned objects persist if the sentence does not contain 'only' ('*Jane picked an ap…*'), or if the 'only' appears at the beginning of the sentence ('*Only Jane picked an ap…*') rather than before the verb *('Jane only picked an ap…'*)? We expected that it would not.

In our study, 6-to-8 year-old children listened to descriptions of groups of friends going on adventures together, and the item(s) these characters picked as their "favorite" from each trip. We measured children's eye-movements to different items on a computer screen during the task. Data collection is ongoing, but our preliminary results indicate that unlike adults, 6-to-8 year old children fail to show a preference for previously mentioned items when listening to sentences containing 'only', such as in (2).

Can toddlers use negative information to learn a person's name?

Roman Feiman, Postdoctoral Researcher

In a study looking at toddlers' understanding of the word and the concept "not", we use a video study to test whether younger and older two-year-olds can use information about who a person (say, John) is not, to figure out who he is. The video shows two characters who both start out dancing. Then one of them stops, and a voice-over tells the child that "John is not dancing". Then both characters stop. Can the child find John? This requires some complicated reasoning! To identify John, they have to understand what "not dancing" means, identify the character who isn't dancing, and then remember that that person's name is John for later. We are still running this study, but so far, it seems that older two-year-olds are pretty good at looking at the not-dancing person when we say "John is not dancing", but not as good at identifying John later on. The fact that they do process the negative word "not" at this age provides some converging evidence from another method that age two is around the time when children begin understanding verbal negations like "not" and "no" in their logical sense.

Can toddlers use negative information to learn what an object is called?

Roman Feiman, Postdoctoral Researcher

In another, similar study, we show two-year-olds videos of people playing with toys. First, a girl plays with one of two toys on the a table, and then a boy plays with the other one. When the boy plays with the second toy, a voice-over says, "Look, now it's different! He's not playing with the dax!" Does the child know that the dax is the other toy -- the one that the girl played with but the boy didn't? Once the boy leaves, both toys are on the table, and the child is asked, "Where's the dax? Can you find the dax?" This study is still ongoing, but much as with the other studies looking at the word "not", we are finding that older two year-olds seem to understand the word, but younger two year-olds do not consistently get it yet. We are hoping that converging evidence from a few types of studies will give us a good idea of the age at which children learn the logical meaning of this word, and allow us to start figuring out how it is kids learn such abstract logical concepts at all.

"It's not *this* many!"

Roman Feiman, Postdoctoral Researcher

When kids start to combine words together, they can do it in new and productive ways to express longer thoughts. In this study we look at how the meanings of words are combined by asking whether children can combine meanings that they have not yet learned the words for. In particular, we know that children know that a picture with 3 toy ducks has a different number than a picture with 4 toy ducks, before they've learned that the words "three" and "four" are used to express these different quantities. If we show children a picture of 3 toy frogs and then ask them to "Show me the one that has *this many*" by choosing between a picture of 3 and 4 ducks, will they be able to choose the picture with three ducks correctly? More interestingly, the word "not" combines with the meanings of other words in a systematic way that adults understand well. Can this word combine with meanings that don't yet have words attached to them? If we ask a child in the task above to "Show me the one that does *not* have *this many*", will they then be able to choose the picture with 4 ducks rather than the one with 3? If so, it would show they understood the meaning of "not" and were able to combine it with a knowledge of the number of entities in the picture, without needing to use or know the meanings of the words "three" or "four". We've just started this study and do not yet have an answer to these questions and do not yet know whether and when children succeed. We're excited to find out!

"It's not in this bucket. Where is it?"

Roman Feiman, Postdoctoral Researcher

When do babies and toddlers understand what the word "no" means? This question might have a lot of interest for 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 frequently think thoughts and say sentences like, "I'm *not* going to the store today" or "that's *not* a very good book". When do we come to understand what the "not" part of those sentences means? 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 either a bucket or a truck behind a screen that prevents the child from seeing where we hid it in. In one study, we remove the screen and then told the child that it's *not* in either the bucket or the truck. We then ask the child to find the ball and see if they go to look in the right place spontaneously. In a complimentary study, we show the child that one container is empty, and then asked them to find the ball. We wanted to know if they would use the concept of "not" 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 location. So far it looks like the ability to understand logical "not" emerges around 26-28 months of age, and that learning the word isn't easy. Slightly younger children won't use linguistic information about where the ball is "not" to infer where it is, but they will successfully avoid looking in the bucket they saw was empty. It also looks like getting affirmative information first (like, "It's in the bucket" or "It's in the truck" helps younger two-year-olds -- around 24 months -- to successfully find the ball in another search later on, when they do get negative information like "It's not in the bucket".

We are still conducting these studies, so the results might change. But if there is a gap between when kids can reason about the empty bucket, and when they can use the word "not" in that reasoning, it would mean that learning the word in this context isn't as easy as a lot of other word-learning is, like the names of objects, which kids often learn after they've heard them once.

Understanding And & Or (2- and 3-year-olds)

Shilpa Mody, Graduate Student

Although the words *and* and *or* are very common in our everyday speech, they have surprisingly complex meanings. These words don't refer to individual, specific things in the world, but rather to the relationship that connects two things. Furthermore, they can be used to describe the relationship between many different kinds of words and phrases, from objects (*the cat or the dog*) to actions (*kicking and screaming*) to longer phrases (*Jack fell down and broke his crown and Jill came tumbling after*).

How and when do children learn what these words mean? On the one hand, they have complex meanings that might be hard for children to pick out, which should make them hard to learn. But on the other hand, we use these words all the time, so children have a lot of input to learn from. We know that children generally begin to say *and* when they're 2 years old, and *or* when they're 3 years old, but children often understand words well before they say them. Surprisingly, very little is known about how and when children come to understand these words.

In this study, we're asking when children begin to understand simple sentences that include the logical words *and* and *or*. We introduce kids to a stuffed bear and a bunch of different small toys, then ask them to hand specific toys to the bear. Some of these requests use the word *and* (*Can you give Mr. Bear the bunny and the cup?*), while others will use the word *or* (*Can you give Mr. Bear the truck or the ball?*). Based on children's actions, we can infer what they think these phrases mean.

Our results suggest that 3-year-olds really understand what both words mean: they give both objects over 90% of the time when asked *and* questions, and one of the objects over 80% of the time when asked *or* questions. Similarly, 2.5-year-olds' most common response to *and* questions is to give both objects, and their most common response to *or* questions is to give one of the objects, although they don't do quite as well as the older children.

However, the results from the 2-year-olds are less clear. On average, they do different things when asked *and* questions vs. *or* questions, indicating that they know that these words mean different things. However, their actions are generally a lot less predictable – for example, they often hand Mr. Bear a toy we never mentioned, or all of the toys on the table! In fact, giving Mr. Bear all the toys on the table is their most common response to *and* questions (even more common than giving him both the toys we asked for). Maybe 2-year-olds are just less likely to listen to our instructions than older children – after all, it's easy to get distracted by all the fun toys we put in front of them, or to give Mr. Bear whichever toys they enjoy playing with, regardless of the instructions. However, it's also possible that they are making these kinds of unpredictable responses because they really aren't sure what the instructions mean. Our best guess is that it's a combination of these factors!

Thanks so much to all the families that participated!

Reasoning and Causality 1 (14- to 18-month-olds)

Shilpa Mody, Graduate Student

Young children are fascinated by discovering and recreating cause and effect relationships – just consider how much they love pushing elevator buttons that light up! In fact, studies have shown that even infants as young as 6 months old have some understanding about how simple causal scenes will unfold, like a ball hitting another ball and launching it into motion. An important aspect of causality is *what causes what* – if you see an event, can you figure out what might have caused it to occur?

In this study, we're asking whether 14- to 18-month-olds can use the process of elimination to determine the cause of an event. We do this by introducing children to a toy that lights up when some – but not all – blocks are placed on it. On each trial, we demonstrate the effect of two blocks on the toy, then encourage children to "make it go" themselves. Based on their choices, we can infer what kinds of reasoning patterns they use to understand cause and effect.

On the first few trials, we show kids both positive and negative information: one of the blocks causes the toy to light up, and the other block doesn't. In this case, children across the whole age range pick the block that works more often than not. This shows that they understand the demonstrations, and are motivated to make the toy go.

On the next trials, we show kids only negative information, to see whether they can use the process of elimination to *infer* which block might activate the toy. First, they see an ambiguous event: when you put both of the blocks on the toy together, it lights up. Then, we show them that one of the blocks alone doesn't cause the toy to light up, and we don't give them any direct information about the other block. On these more difficult trials, 17- and 18-month-olds still pick the block that works! This shows that they can use the process of elimination to eliminate one block, and infer that the other block is the best choice. In contrast, when we show these trials to 14- and 15-month-olds, they don't seem to distinguish between the two blocks, picking each one about half the time. It seems that these younger children can use positive information about which block works to choose it, but they can't use negative information about which block *doesn't* work to guide their choice to the other one instead.

A really interesting thing about these findings is that they look surprisingly similar to a previous study that we did about kids' ability to use the process of elimination to find a hidden object. In this study, we hid a toy inside one of two buckets, then showed children that one bucket was empty – would they eliminate that option and look for the toy in the other bucket instead? We found that 17- and 18-month-olds searched in the correct bucket about 80% of the time, while 14- and 15-month-olds picked each bucket about half the time – the exact same ages as in our causality study!

This seems to indicate that children are developing a general, multipurpose ability to use the process of elimination between 14 and 18 months of age. We are really excited about these results, and super thankful to all the kids and families that helped us with this research!

Reasoning and Causality 2 (2- and 3-year-olds)

Shilpa Mody, Graduate Student

Deciphering cause and effect relationships is an important skill for understanding the world around us. In some situations, there are multiple possible causes of an event; for example, a headache could be due to stress, a lack of sleep, a lack of coffee, or any number of other things. However, if you always get a headache when you haven't had your morning coffee, regardless of your sleepiness or stress levels, the coffee is the most likely cause of the headache. In this study, we're looking at kids' ability to use different patterns of evidence to determine the most likely cause of an event.

First, we introduce children to a toy that lights up when some – but not all – blocks are placed on it. To help them remember which blocks are which, we tell them that the ones that activate the toy are "blickets", and ones that don't activate the toy are "not blickets". Then on each trial, we demonstrate the effect of three or four blocks on the toy, including some combinations of the blocks. These are situations in which several of the blocks *might* cause the toy to light up, but (adults would say) one block is more probable than the others. We then encourage children to "use a blicket to make it go". Based on their choices, we can infer what kinds of reasoning patterns they use to decide between several possible causes of an effect.

On the trials with 3 blocks, we show kids that one block activates the toy by itself, saying "this one's a blicket", and then place the other two blocks on the toy together, telling them that "one of these is a blicket". So far, it looks like children across the whole age range preferentially try to activate the toy with the block that they can be *sure* is a blicket, rather than taking a chance and picking one of the blocks that *might* be a blicket. There don't appear to be any differences between the older and younger children. This shows that by the time children are about 2.5 years old, they're sensitive to probability information when trying to recreate an effect.

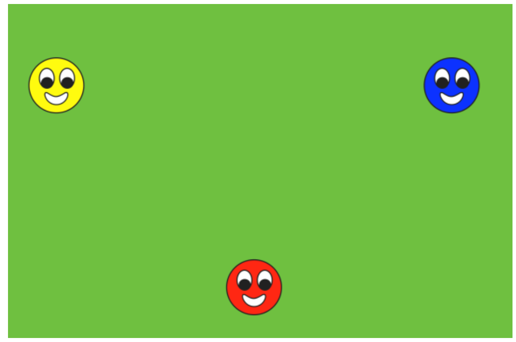
The trials with 4 blocks are trickier: here, children have to infer which block is surely a blicket instead of being shown directly. We show kids that one pair of blocks activates the toy, then that the other pair of blocks activates the toy. Finally, we show kids that one of the four blocks by itself does not activate it. Our question is whether children will infer that the block that was paired with it will definitely activate the toy. In other words, since one of that pair was a blicket, and we've showed them which one is *not* a blicket, do they infer that the other one *must be* a blicket?

Our results so far suggest that 3- and 3.5-year-old children do make this inference; in fact, they are just as good at these trials as the 3-block trials, where we directly showed them which block was surely a blicket. However, 2.5-year-olds don't do as well – their choices on these trials seem to be random, or based on things like their favorite color. Based on these results, it looks like the ability to make inferences to pick between several potential causes continues to develop between children's 2^{nd} and 3^{rd} birthdays.

We're still working on this studies, and we hope to have some more interesting results to share with you in the next newsletter! A huge thank you to all the children and families who have helped us out with this research!

Noticing imitation

Narges Afshordi, Graduate Student



Imitation is ubiquitous in human life. By copying those around us, we learn, we bond and we fit in. We also notice when other people imitate each other. Can infants do this too? In this study, we show infants between 14 and 18 months of age simple cartoon animation with three characters: Yellow, Blue, and Red (see figure below). Each little scene starts with Yellow and Blue jumping up and babbling different sounds. For instance, Yellow says "roo roo" and is followed by Blue saying "shay shay". After both have spoken, Red also jumps and babbles. Importantly though, Red copies one of the other two, say Yellow, saying "roo roo" as well. We show infants a number of scenes like this with the characters saying new things each time. This repetition will help babies catch on to what is going on. If they realize that Red is copying Yellow, they should expect this to happen every time and become a little bit more bored at each new instance of the same pattern. But then when they least expect it, the tables turn! Now, Red starts to say the same thing as Blue every once in a while. If the baby has been paying attention, this is the opposite of what they were expecting and they will be surprised. This surprise would be reflected in intently staring into the screen for a long time trying to figure out what happened and what they missed.

From the preliminary data we have so far, it seems that 18-month-old infants can notice imitation and are surprised when the pattern is broken. If infants are able to notice imitation in scenes like this, they may be able to do it in real life too, which would be a useful skill. It can allow them to learn useful actions that others are performing and copying. It may also allow them to figure out who likes who by observing their actions.

In a related study, we are asking the same question with young children. We want to know when they are able to notice imitation between people they are observing. You may be surprised that we are asking this question with older participants if we think that infants could do this. Don't kids just get better at stuff? Well, yes and no. Our looking-time study with infants may show that they can recognize imitation, but being able to directly respond to a question about it takes a deeper understanding than what infants are capable of.

In this second study, we show two-, three-, and four-year-old children different stories in which there are three characters, one of whom copies the actions of another. For instance, the woman in the center in the figure below, Jenny, moves her leg like the woman on the right, instead of moving her head like the one on the left. After children watch a few of these animations, we show them one that is incomplete. Here, Jenny watches the other two do different things but doesn't do anything herself. The child's job is to predict whom she will copy. We also ask another question: Which of the other two women does Jenny like best? We ask this question because we are interested in seeing whether children are able to use imitation as a clue to people's feelings towards each other, in this case, thinking that Jenny likes the person she copies more.

Our current findings, which should be taken with a grain of salt since they are not complete, suggest that two- and three-year-olds may have trouble with this task, while four-year-olds do much better. Stay tuned for final results from these two projects and thank you for your participation!

The Growth of New Kind Concepts

Paul Haward, Graduate Student

Human beings are alone in the animal kingdom in developing an extraordinary repertoire of intricate kind representations during the earliest stages of development—for things like *dogs*, *watches*, *cities*, and *mountains*. A normally developing young child takes as input experience with the particular things she encounters, sometimes only one or two particular things, and outputs a representation of an entire category that can then, in principle, apply to indefinitely many novel instances. Young human beings create new kinds in this way thousands of times during early development, with very limited training or formal instruction—something unparalleled in any other species. In addition, kind representations play a promiscuous role in human thought—we generate kinds across all conceptual domains (including abstract kinds, like *triangles* and *quarks*), and they provide the conceptual input for some of our most distinctive computations (e.g., natural language and logic).

One fundamental question we can ask of kind representations is: what are they like? What information is included in each kind representation, and how is it stored? Previous research has shown that each kind representation contains a deeper formal structure, in which some pieces of information — called *properties*, like being square or having a particular function — have a more privileged status (we call these *principled properties)*. Principled properties are the properties of kinds that are understood as making a thing what it is (e.g., *telling time* for the kind *watch*, or having *three sides* for the kind *triangle*), and they can be distinguished from properties that are simply highly associated with the kind (e.g., having a *round face* for the kind *watch*). Work in our lab has shown that both adults and children are willing to explain *principled properties* of kinds by simply referring to the kind of thing it is. For example, when asked why a watch tells time, people might reply "because it is a watch." But they will not do this for simply highly correlated properties which are not part of the deeper formal structure. For example, when asked why a watch is round, the answer "because it is a watch" does not seem as natural.

In our most recent study, we were interested in how children generate completely *new* kind representations. Do they assign certain properties as being principled as soon as the new kind is learned? To test this, we developed a task with novel objects that the child hadn't seen before, in which each object had a particular shape, color, texture, and function. Each child was shown the novel object, and they were told a short story which described its existence and some of its properties, and they were able to hold and feel it. We then had two tests. First, we tested if children would immediately treat some properties of these completely new concepts as principled—do new kind concepts contain a deeper formal structure? Second, we were interesting in whether the type of property understood as principled differed depending on whether the new object was an animate thing (e.g., a creature), or an artifact (e.g., some kind of tool).

We recently finished data collection for this project. Our results suggest that children do privilege some properties as soon as they have formed a new kind — they treat some properties as *principled*. Furthermore, in these particular studies there was no effect of whether the new kind was an animate thing or an artifact. These findings suggest that though our understanding of a kind may involve many associations and relations to a variety of properties, a subset of the properties of those kinds are understood as privileged, and that this is true as soon as a new kind concept is formed.

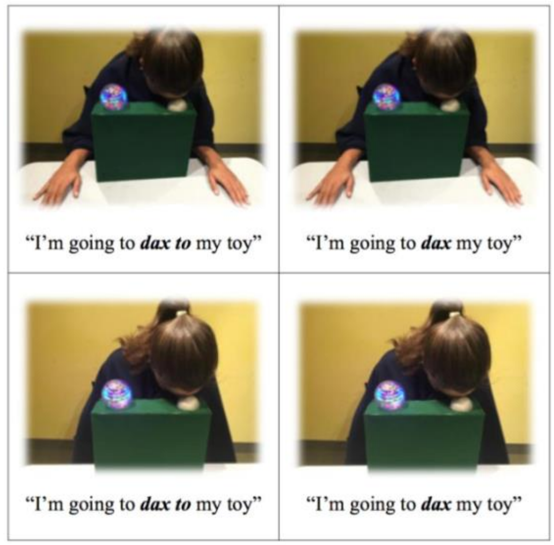
I’m going to *dax my toy*! Can you *dax the toy*?

Understanding new verbs and other people’s goals at 18 months

Melissa Kline, Postdoctoral Researcher and Chelsea Lide, Thesis Student

Thank you to all of the families who participated in this study! This experiment was designed to help us understand how children begin to use sentences as a clue to verb meaning…but it has also taught us some new things about how toddlers understand the intentions of people around them.

Our study began with an existing finding from another lab group (Gergely et al 2002) that *fourteen*-month-olds can understand the difference between a real goal and a ‘side effect’. In the demonstration, all babies saw the experimenter do a funny new action – touching the toy with her head and making it light up. Half of the kids saw something like the top left, where her hands are visible – and where she could have chosen to use her hands instead. The others saw something like the bottom left, where her hands were wrapped in a blanket as she turned on the toy. In the second case, but not the first, they seemed to reason that she really just wanted to turn the toy on, not specifically with her head: these toddlers tended to reach out and try to turn the toy on with their hands, rather than imitate the funny head-touch action.


“I’m going to ***dax to*** my toy” “I’m going to ***dax*** my toy”
“I’m going to ***dax to*** my toy” “I’m going to ***dax*** my toy”

In our study, we were curious to see how children might use this ability in the context of language learning. The same distinction – between *what happens* and *how we do it* – runs through our verb vocabularies, and interacts with the kinds of sentences the verbs appear in. For instance, we say “I broke the lamp”, but “I ran **to** the store.” We wondered if eighteen-month-olds, who are saying verbs of both types, would use sentences just like the hands free/hands occupied distinction – as a cue to decide whether to focus on what happens (lighting up the toy) or how it happens (with your head.)

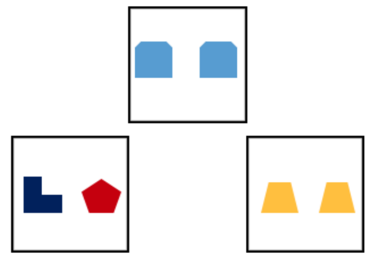
Surprisingly, the eighteen-month-olds in this study didn’t do what we expected. Instead, *all* the toddlers – no matter which versions they heard/saw – did the same thing: about 1/3 of participants touched the toy with their head, and about 2/3 with their hands. Deciding to touch the toy with your head can be a big decision – it’s a little bit silly, and you have to lean farther away from Mom or Dad then you do to use your hands. But when they did do the head touch, why did they do it? Were these older kids “not paying attention” to the details of what the experimenter did? We think the opposite may be true: eighteen-month-olds, but not fourteen-month-olds, may understand that people are more likely to teach something unusual or new than something familiar. That is, the older kids realize that even though there is a ‘cover story’ about being cold and hiding your hands in a blanket, the demonstrator is probably trying to show them something special with the unusual head-touch action.

We are planning follow-up studies to understand these social abilities more fully, and to puzzle out how children make the leap from understanding what someone is teaching to learning verbs – of many different kinds – to describe those same actions.

Exploring relational thinking through matching games

Ivan Kroupin, Graduate Student

A lot of the time when we think about things being the 'same' or 'different', we tend to think of their surface qualities. For example, an apple is different from an orange because it is red, a car the same as a wagon because both have wheels etc. This kind of reasoning is pretty easy and has been shown across all ages and species.

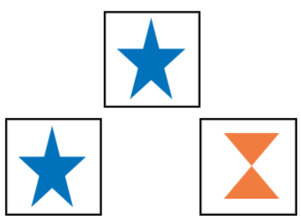


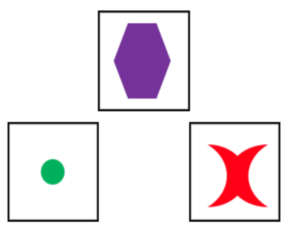
A harder version is thinking about 'sameness' and 'difference' in terms not of the relations holding between objects. For example, in the pictures to the right, the card on top goes with the one on the right and not on the one on the left because the objects in the top one share a relation with the objects in the one on the right (i.e. both have objects that are the same).

This kind of thinking is surprisingly tricky and kids don't usually match cards in this game correctly until after their fifth birthday. What's particularly puzzling about this is that kids know the words 'same' and 'different' by the time they're three and a half. Why is it that kids who know the words can't match 'same' to 'same' and 'different' to 'different'?

If kids really can't figure out the game before five years old, despite knowing 'same' and 'different', there should be no way to get them to succeed before that age. However, one possibility is that the kids *can* do the task, but are just confused as to how they should be playing the game. If this is the case, giving them some practice may help them succeed.

To test this hypothesis, we gave kids a few simpler practice games (the specific games varied over the course of the study) to help them understand how to play the harder one, for example the two illustrated below:





The one on the left is solved by matching the two cards with the same object, the one on the right by matching the two objects that are relatively big.

Though we haven't finished testing kids, results so far suggest that at least some kinds of practice games significantly improve performance on the final game. This is preliminary evidence that relational reasoning of the kind needed to play the hard game is difficult not only because you need the right ideas in your head, but because you need to have the right expectations of when and how to apply them.

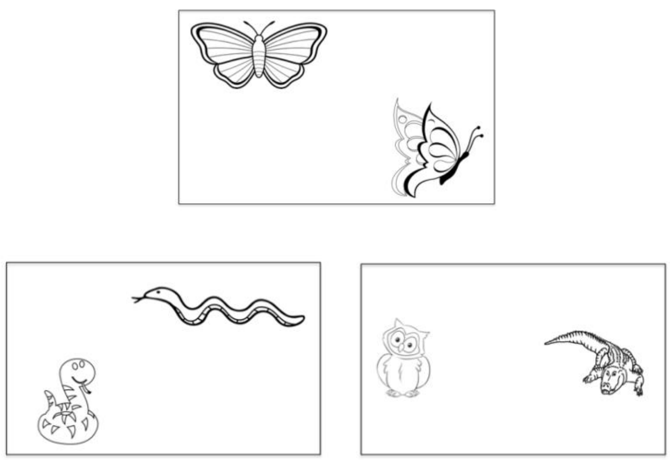
Labels help four-year-olds succeed on a relational reasoning task

Rebecca Zhu, Lab Manager

Despite the fact that many three- and four-year-olds can comprehend and produce the words *same* and *different*, kids often struggle to use these abstract relational concepts in simple tasks, such as a card-sorting game. In this classic paradigm, called a relational match-to-sample task, kids must match a *same* card (AA) or *different* card (BC) to a target card that is either *same* (XX) or *different* (YZ). Four-year-olds fail to realize that AA goes with XX and BC goes with YZ long after they grasp the basic concepts for same and different.

Why is sorting cards by abstract relations so hard? One possibility that researchers have suggested is "object focus", namely that kids are paying too much attention to the individual objects to notice relations between objects. Indeed, when kids who fail the task are asked to explain why two cards match, they will often say, "Because these two things look alike!", whereas kids who succeed will say, "Because these cards both contain things that are the same/different".

In a series of studies, we tried to make the relations between individual objects more salient and interesting. Instead of using Wingdings symbols or basic shapes (objects of a same or different *identity*), our cards contained non-identical animals (objects of a same or different *kind*).



Which one of the cards below goes with the card above?

In Study 1, the experimenter presented children with a training phase in which the experimenter labeled the animals on each card (i.e. "See this card? This card has a snake and a snake! And see this card? This card has an owl and an aligator!") while teaching them how to play the game. During the crucial test phase, the experimenter stopped labeling the animals and just asked children to match cards. Four-year-olds were significantly above chance at matching *same* cards to *same* cards and *different* cards to *different* cards by themselves after the experimenter had named the animals during the training phase. However, three-year-olds did not succeed at this task.

In Study 2, we modified the training phase, such that the experimenter taught the child how to play the game without labeling the animals on each card. In this version, four-year-olds failed to match *same* to *same* and *different* to *different*, even though they should have been able to name the animals by themselves.

In Study 3, we changed the cards so that they contained unknown animals (unfamiliar Pokemon). In the training phase, the experimenter labeled the animals with novel names (i.e. "See this card? This card has a dax and a dax! And see this card? This card has a blick and a cheem!"). In the test phase, children still successfully matched cards on the basis of the abstract relations same and different, despite being unable to name the unknown animals themselves.

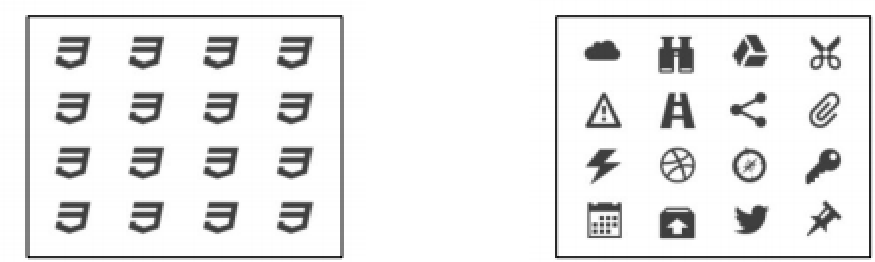
In Study 4, we asked if children needed to hear specifically nouns in order to succeed, or if any kind of linguistic repetition helps. The experimenter showed children the unknown animals from Study 3, but labeled the animals with novel adjectives (i.e. "See this card? This card has a daxy one and a daxy one! And see this card? This card has a blickish one and a cheemful one!"). We are still collecting data for this study but results could go in two directions. If children succeed, the result would indicate that kids just need both auditory and visual input to make the abstract relational concepts very obvious; however, if children fail, the result would indicate that there is something special about labels for nouns, possibly pointing to more abstract kind representations, that also highlight the abstract relations required in this card-sorting task.

Understanding all same and all different

Rebecca Zhu, Lab Manager

When do children acquire the vocabulary to express basic relational concepts such as *same* and *different*? Moreover, when can children successfully combine these abstract relations with other logical concepts, such as *all* and *not*?

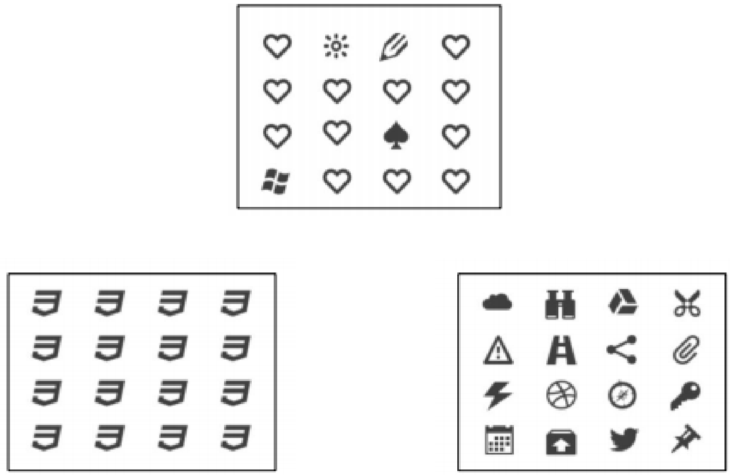
To answer the first question, we presented two- and three-year-olds with pairs of cards that had arrays of same or different icons and asked children, "Can you show me the card where the pictures are the *same*?" or "Can you show me the card where the pictures are *different*?".



Can you show me the card where the pictures are the same?

Previous work in the Carey lab shows that, when presented with 2-icon cards, four-year-olds reliably understood the words *same* and *different*. Half of three-year-olds understood the words, and all two-year-olds failed at the task. Although we hypothesized that 16-icon cards might be trickier because *same* and *different* generally refer to a relation between two icons rather than an entire set of icons, we obtained the exact same finding as with 2-icon cards: specifically, half of three-year-olds succeeded at the task, whereas two-year-olds all failed. Notably, kids who understood the word *same* also understood the word *different*, suggesting that the acquisition of these relational words occurs simultaneously in an all-or-nothing manner.

Moreover, we wanted to explore how and when kids could linguistically combine these abstract relations with other logical operators such as *all* and *not*. Therefore, we devised a slightly trickier task, in which we asked three-, four-, and five-year-olds to match cards based on whether or not the icons were *all same* or *not all same*. An experimenter presented kids with two choice cards, a card with 16 identical icons and a card with 16 unique icons, and asked kids to match one of the two choice cards with a target card. The target card contained 16 icons that were all same, four same, eight same, twelve same, or all different.



Which of the cards below goes with the card above?

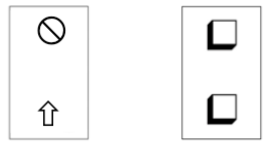
The card above is both 'not all same' and 'not all different', so kids can match either of the two below cards depending on what rule they are following. If kids are matching by 'all same'/'not all same', then they will place card on the right with the card above, since both of them are 'not all same'. However, if they matching by 'all different'/'not all different', then the card on the left goes with the card above, since both of them are 'not all different'.

When asked to match cards on the basis of *all same* or *not all same*, all three age groups successfully did so. We also gave four-year-olds the harder version of the task by asking them to match cards on the basis of *all different* or *not all different.* Surprisingly, when asked to sort based on *all different*, four-year-olds (and adults!) sort incorrectly; specifically, they follow the rule *all same* and *not all same*. This finding suggests an imbalance between *same* and *different*: namely, that *different* may be logically composed as *not same*. Thus, sorting by *not all different* is especially hard because in the logic-of-thought this phrase contains a double negative (*not all not same*).

Representations of entropy and the relations *same* and *different*

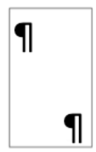
Rebecca Zhu, Lab Manager and Robert Long, Graduate Student

Here is a task that is very easy for human adults to perform. Consider the following two cards:



Card 1 *Card 2*

Which of those cards goes with this card?

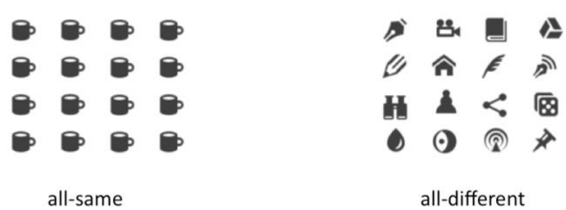


Card 3

Card 2 goes with Card 3 because they have something in common: both have two items that are the same (more verbosely: both cards' items instantiate the *same-as* relation). In contrast, the items of Card 1 instantiates the *different-from* relation.

For adults, this is a highly natural way to think of these cards: we easily recognize the abstract similarity of Cards 1 and 2, even though they look rather different and in fact have nothing in common in terms of of their individual items. But when we gave kids this task here at CareyLab we found that children below the age of 5 fail. Why do children fail at this task before 5, and what does it take to succeed?

The animal literature offers some clues. Non-human animals also find this task extremely difficult (or even impossible, some argue), even after extensive training. However, baboons and pigeons can succeed at a similar matching task when the number of items is increased:



With (still quite a lot of) training, some animals can correctly match the all-same arrays with each other.

Why are animals able to succeed with 16-item arrays and not 2-item arrays? One suggestion is that animals don't understand the abstract relation of sameness at all; instead, they succeed by using a general visual feature of the arrays known as entropy, which measures the total variability of the array. According to this story, using 16-item arrays increases the entropy contrast between same and different cards, allowing them to succeed. (In contrast, 2-item cards will have an entropy contrast that is too low for the animals to discriminate.)

Another suggestion is that the animals do in fact use the same or different relation, and using 16-item arrays helps them do this by making the relation easier to notice.

In a series of studies, we are hoping to disentangle the use of entropy and the deployment of the concepts of *same* and *different*, as well as understand what happens when kids learn to succeed on this task.

First we ask: can 3- and 4-year-olds, like pigeons and baboons, succeed at the task when we increase the number of items to 16? Our results indicate that they can, with only a bit of training. What accounts for this success?

We are curious how children react to cards with intermediate amounts of entropy. Consider this card:

4-different

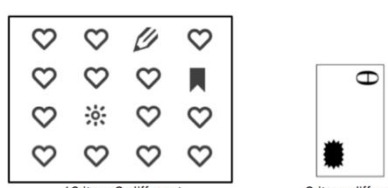
Some, but not all, of the items are the same; this array has less entropy than an all-different array but more entropy than an all-same array.

Will children place this with an all-different card, since it is *not* all same? Or will they place it with an all-same card, since it is closer in entropy to that card? Given this task, we found that children, like baboons and pigeons, show a graded response to entropy--they sometimes place intermediate ones with "same", sometimes with "different". This could indicate that they are reacting to entropy and not an abstract, all-or-nothing relation of "same" and "different"; but it could also just mean that they formulating their own cutoff points for the tasks (we do not tell them any "right" answers for how to respond to intermediate trials).

So another important question is: can kids who successfully train on 16-item cards transfer their success to a 2-item task? In another study, we trained kids with 16-item cards. If they learned to match 16-item cards successfully, will that help them notice the relations and match 2-item cards correctly? Our results suggest that performance on 2-item arrays was *not* improved by training with 16-item arrays. This seems to be more solid evidence that they are succeeding on 16-item matching on the basis of entropy.

Our results with the intermediate cards also indicated that children might have a more fine-grained ability to distinguish different entropy amounts than baboons and pigeons.

Another study tries to probe children's visual acuity at distinguishing entropy. According to the way that entropy is calculated, the following two cards, although they have different numbers of items, have the same measure of entropy:



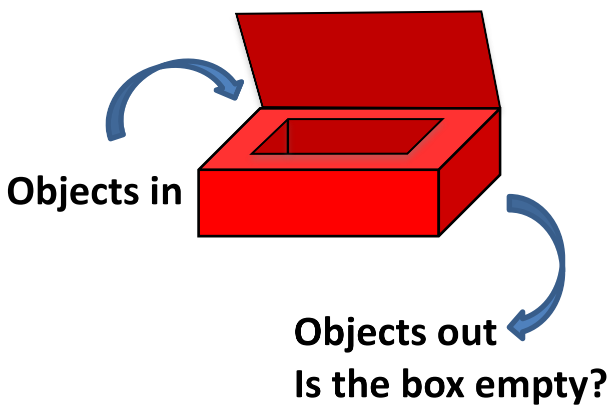
16 item 3-different 2-item different

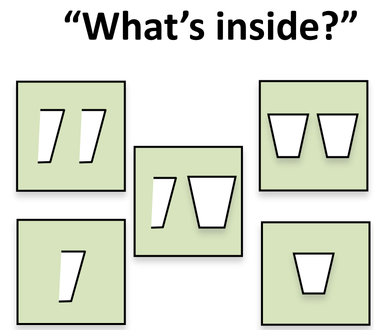
In this study, we train kids to put the card on the left with different, and an all-same 16-item card with same. Then we test them on that task, and test them on a 2-item task. By giving them two tasks with the same entropy contrasts but different numbers of items, we hope to further investigate whether entropy discrimination is what drives success or failure on this task.

What's in the Box? Language and Object Identity
Peggy Li, Research Fellow

As children become more and more familiar with the physical world, they begin to learn how to track and identify objects through time and space. Four month olds who see a toy passing in and out of sight can identify it as the same toy. 12-month-olds who see two physically distinct toys at separate times can identify them as two different toys. However, children still have trouble identifying some objects even as older toddlers.

In this study, children played a box game in which they watched as an experimenter placed a number of objects in a box (e.g. two half cups and two whole cups) and took a number of objects out (e.g. one half cup and two whole cups). Children were asked if the box was empty, and if not, what was inside. Children then had to choose what was inside from a set of panels.





Real objects mounted on cardboard as choices. Children asked to choose the panel that looks like what's inside.

Children also completed a language assessment task in which they were tested on partitive vocabulary including "whole," "half," and "pieces." Results demonstrated that children who knew the vocabulary for partitives performed better at the box game, as they were better able to identify and attend to what was in the box. This suggests that language may play an important role in object identification.

Currently, another similar study is being performed examining simple adjectives including "big," "small," "large," and "little." Children play the same box game with big cups and small cups. We are investigating the relationship between adjective comprehension and ability to identify what is in the box. We are curious whether we will find the same relationship—do children who know the terms for "big" and "small" better able to identify the big and small cups in the box? We hope that these studies, exploring the relationship between language and ability to identify objects, will provide insight into how children use language to attend to objects around them.

“Angle” as a Scale-Invariant Geometric Feature

Moira (Molly) Dillon, Graduate Student

In elementary school and middle school, we teach children that shapes have certain properties, e.g., that triangles have three sides and three corners. We also teach them that these properties, in turn, have properties of their own, e.g., a side can be long or short and a corner can be big or small. In this study, we examined whether 5-6-year-old children could make simple “fit” judgments about angle sizes when angles were formed by sides of different lengths.

Previous studies have shown that children, even up until 12 years of age, confound the size of a shape’s angles with its overall size. For example, if the bottom two corners of a fragmented triangle are moved farther apart, but their angle sizes do not change, children judge that the third angle of the triangle will get bigger, not stay the same size. Indeed, children even judge that an angle formed by longer lines, covering more surface area, or with a greater distance between its endpoints is bigger.

All of these prior studies, however, were linguistically and conceptually demanding: Maybe children could not judge what a “bigger angle” was because they didn’t know which shape property was being referred to. In this study, we removed all such linguistic and conceptual demands, simply asking children if “V” shapes of certain angles size would fit into cutouts of the same or different angle size. Critically, we varied the lengths of the sides forming the angles to see if this absolute length information interfered with children’s angle judgments.

We found that the absolute lengths of the sides forming the angles did, in fact, interfere with children’s judgments about angle fit: Children judged angles to be larger than their actual size if the angles were formed by very long sides and smaller than their actual size if the angles were formed by very short sides. These tendencies applied to both acute and obtuse angles. Our results indicate that there is a real interference between angle size and absolute size in children’s attention to shapes and their properties. Such an interference could make learning a scale-invariant concept of angle, which is required for formal geometry, much harder. We also observed that with feedback, children became more accurate at judging angle over and above absolute size. In future work, we plan to examine if such size interference persists in older children and if there are certain teaching strategies that might attenuate it.

“V” shapes and cut-outs testing the relation between angle size and overall size in children’s judgments of angle “fit”

The Beautiful and the Accurate

Igor Bascandziev, Postdoctoral Researcher

More often than not, we learn about the world around us by accepting information given to us by other people. However, we do not believe everything we hear and we do not consider all people to be equally trustworthy. We categorize people into knowledgeable and ignorant, experts and novices, smart and dumb and we use that to decide who is right and who is wrong and whom to trust.

Children appear to be similar in this regard. They too track and remember who was accurate in the past and they use that information to make a decision about whom to trust in the future. But they also trust familiar over unfamiliar informants, informants who speak with a native accent versus a foreign accent, and attractive over less attractive informants. This suggests that in addition to considerations about the knowledge state of the informant, other considerations (most likely driven by emotions) also influence children's selective trust decisions.

In a series of experiments, we asked how these different factors interact. For example, would children's bias to trust more attractive individuals go away once they learn that both individuals are equally knowledgeable? Would children's bias to trust more attractive individuals reverse if they receive evidence that the more attractive individual is ignorant and the less attractive individual is knowledgeable?

The data collection is still ongoing, but we can already see a pattern of results that seems pretty stable. The first question is about the attractiveness bias: does this bias go away once children have information about the informants' previous accuracy? The answer to this question is no. Children continue to seek and endorse information from the more attractive informant even when both informants are equally accurate. Moreover, children's bias to trust the more attractive informant is not completely reversed even when they learn that the more attractive informant is always inaccurate. Even though there is no complete reversal, there is a small decline in seeking and endorsing information from a more attractive informant who is always inaccurate compared to an informant who is more attractive and accurate. Thus, children seem to track the accuracy of the informants, but it also seems that the effect of attractiveness is not neutralized even when information about the informants' accuracy is available.

Can thought experiments advance young children's understanding of matter?

Igor Bascandziev, Postdoctoral Researcher

Thought experiments are experiments conducted in the mind. The history of science tells us that this important aspect of the human imagination has been central to many scientific revolutions. But the efficacy of thought experiments raises a fundamental paradox: How can a process involving no new data about the world contribute to advances in knowledge about the world? Several resolutions have been offered, including: a) thought experiments involve imagistic simulations (i.e., imagining events in the head) that produce "new data;" b) thought experiments s are arguments and that is how they lead to new knowledge about the world; c) thought experiments highlight contradictions among beliefs, which can motivate efforts to resolve those contradictions.

We asked if a thought experiment can help young children to advance their understanding of matter, and if yes, then how. Like Aristotle, young children believe weight to be a property that some physical entities lack. Thus, many children believe that a single grain of rice or Styrofoam weigh nothing at all. Of all tested children, those who maintained that a single grain of rice weighs nothing at all were assigned to a real experiment and a thought experiment condition. In the real experiment, children received evidence that a single grain of rice can topple a card placed on a fulcrum. The thought experiment was structurally equivalent, but it was simulated in the head. We are still collecting data in these experiments, but some interesting results are already emerging. For example, both the real and the thought experiment had large and positive effects on posttest judgments about the weight of a grain of rice. Details of the data confirm imagistic simulation (i.e., imagining a grain of rice toppling the card on a fulcrum) can drive belief change, and at least in this case, there is no evidence for the other two resolutions of the fundamental paradox.

Children automatically activate real-world size when they see pictures of objects

Bria Long, Graduate Student

The real-world size of objects dictates how we interact with them: we tend to manipulate small objects with our hands (e.g., cups, pencils) and navigate with or around big-objects (e.g., couches, cars). However, we have to learn which objects are big and small in the real world. By the time we're adults, when we recognize a picture of an object, we automatically know how big it usually is, regardless of how large it appears on our retina at that moment (Konkle & Oliva, 2012).

In this study, we asked whether 4-year-olds know how big or small an object is in the world as soon as they see a picture of it. To do so, we asked 4-year-olds to judge the visual size of an object, while ignoring it's size in the real-world. On all trials, children had to judge which of two objects was smaller on the screen. On congruent trials, the two objects relative sizes in the world matched their sizes on the screen (e.g., a visually big car and a visually small apple). On incongruent displays, the visual sizes of the objects were mismatched with their relative size in the real world (e.g., a visually big apple and a visually small truck). Overall, children were slower at visual size judgments on incongruent trials, suggesting that they automatically activated real-world size information, and that this information interfered with their ability to make visual size judgments. These results suggest that 4-year-olds activate real-world size information, just like adults do! This finding has led to us to ask whether infants might already also know how big or small objects are in the world when they see pictures of them.

How big is a car? Infants represent the real-world sizes of common objects

Bria Long, Graduate Student

The real-world size of objects dictates how we interact with them: we tend to manipulate small objects with our hands (e.g., cups, pencils) and navigate with or around big-objects (e.g., couches, cars). However, we have to learn which objects are big and small in the real-world. By the time we're adults, when we recognize a picture of an object, we automatically know how big it usually is, regardless of how large it appears on our retina at that moment (Konkle & Oliva, 2012).

In this study, we asked whether 13-month-olds know how big or small an object is in the world as soon as they see a picture of it. For example, when babies see a picture of a truck, do they know this is something that is typically big in the real-world? To ask this question, we monitored infant's eye gaze while they looked at two different kinds of displays. On congruent displays, the objects relative sizes in the world matched their sizes on the screen (e.g., a visually big truck and a visually small shoe). On incongruent displays, the visual sizes of the objects were mismatched with their relative size in the real world (e.g., a visually big apple and a visually small shoe). We hypothesized that, if 13-month-olds automatically activated the real-world sizes of objects when they saw them, their patterns of looking should differ between these two kinds of displays. In general, infants tend to look towards objects that are visually bigger on a screen. We found that infants tended to look mostly at the visually big object on congruent displays, but at both objects equally on the incongruent displays. In other words, infants' looking behaviors suggested that they knew how big these objects were in the real-world, and that they activated this information automatically.

Last year, we ran our first study on this topic, and this year, we are working on confirming this finding with other follow-up studies. Stay tuned!

Object Recognition in Early Childhood

Bria Long, Graduate Student

As adults, we recognize objects so quickly and efficiently that we rarely even think about it. For instance, when we recognize a picture of an object, we automatically know how big it usually is in the real-world, regardless of how visually big it is at the moment (Konkle & Oliva, 2012). In addition, we rapidly process whether this picture is of an animal or an inanimate object.

In a previous study, we found that children also rapidly process the animacy and real-world size of objects. In this study, we asked children to find a specific picture of an object while ignoring other pictures of other distractor objects. Here, children found pictures of animals faster when the distractor pictures were of inanimate objects (e.g., couches) than when they were pictures of other animals. Similarly, children found pictures of small objects (e.g., pens, cups) faster when the distractor pictures were of big objects (e.g., cars, couches) than when they were pictures of other small objects. However, children did *not* find pictures of food (e.g., cupcakes, carrots) faster when the distractor images were pictures of non-food (e.g., cups, pens) than when the distractors were other pictures of food. Why might this be the case?

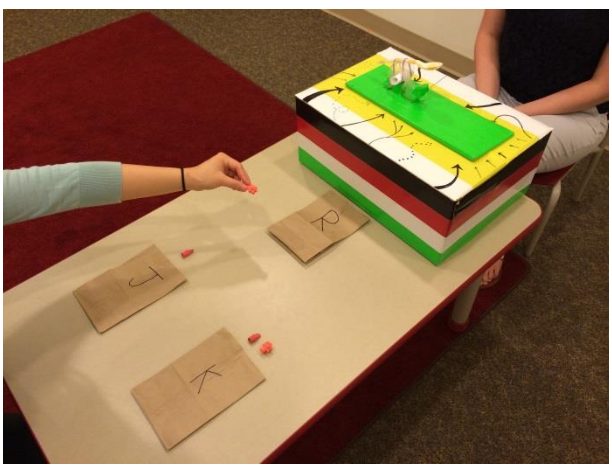
One idea is that children may not explicitly know which of the pictures we used were edible vs. non-edible. Thus, in this follow-up study, we asked what children could tell us about of the animacy, real-world size, and edibility of the images from the first study. To ask this question, we showed children pictures of the same images used in the previous study on a screen, one at a time. Children were asked to teach Mr. Frog about the answer to three different questions during three different parts of the experiment. In one part of the experiment, children taught Mr. Frog about whether the thing on the screen was a picture of an animal. In another part of the experiment, children told Mr. Frog about whether the thing on the screen was a picture of something they could pick up. In another part of the experiment, children told Mr. Frog about whether the thing on the screen was a picture of something that was okay to eat.

Overall, we found that children could easily tell us about the animacy, real-world size, and edibility of many different pictured objects. These results help us better understand our previous findings, and suggest the visual system in both adults and children processes the animacy and real-world size of objects differently than it processes edibility.

Bribery

Natalie Benjamin, Lab Manager; Cassandra Favart, Lab Manager; and Randi Vogt, Lab Manager

Although the word “bribery” sometimes has negative implications, triggering thoughts of corruption and other undesirable behaviors, from a formal point of view bribery does not necessarily have a moral connotation. Instead, it involves a person giving a resource to someone in order to influence his or her behavior. Because of this, bribery is highly related to reciprocity, in that the briber must be confident that the recipient will reciprocate his or her behavior in a way that is beneficial to the briber. This study explores this phenomenon.



In this study, children played four rounds with two adults (game owner & competitor). First, the child and the competitor each received two toys, a high-value toy and a low-value toy. For example, in one round they received a low-value circle sticker and a high-value fish sticker. Next, the child and the competitor were told to choose which one they wanted to keep for themselves and which one they wanted to give to the game owner. Finally, the game owner chose a partner to play a game with: she could choose either the child or the competitor. These steps were repeated for the other three rounds, with different toys and different games. The crucial point of this task was that children knew in advance that the game owner was going to choose a partner for the game. If children understand that they can influence the owner’s decision by being nice to her, they will give the best toy to the owner.

Initially, we ran this study with both 5- and 7-year-olds. We found that both of these groups of children are able to discern which toy is the more valuable one, and are more likely to give away the high-value toy to the game owner in order to be chosen to play the game. 7-year-olds give away the high-value resource spontaneously, while 5-year-olds learn this behavior throughout the study. Since both 5- and 7-year-olds understand this concept and behave accordingly, we decided to run this study with 3-year-olds to see if they, too, understand the concept. We found that 3-year-olds do not notice the connection between giving away the high-value toy and being chosen to play the game. This may suggest that the cognitive capacities needed to understand this type of bribing strategy develop between 3 and 5 years of age.

Thank you to all the families who participated in this study!

Reciprocal sharing in toddlers

Natalie Benjamin, Lab Manager; Cassandra Favart, Lab Manager; and Randi Vogt, Lab Manager

Most social relationships that we build throughout our lives are based upon reciprocal exchanges of resources, support, and help. We expect people we benefit to return the favor, and often we feel obligated to give back kindness to those who have been generous with us. In this study we are interested in this second type of reciprocal behavior, whether children are selective in their reciprocity based on past interactions.

We know from past studies that children as young as 21 months old are able to distinguish between adults who helped (or did not help) them in the past, and that those children prefer to later help the adult who had good intentions toward helping them in the past. We also know that in a past study, 3-year-old children (but not 2-year-olds) have shared more when an adult has shared with them in the past than when the adult has not shared with them in the past. In this study we present children with two partners, one who shares and one who does not, and we explore whether children will distinguish between these two partners in sharing differently with them.

We originally ran this study with 2.5-, 3.5-, and 4.5-year-olds. In the study, we presented children with a game apparatus (either a jingle box or a zigzag ramp), which required golf balls in order to play with it. The child was introduced to two other players (puppets), and the three of them each got a chance to divide up eight golf balls between themselves and another one of the players. Each of the puppets played with the child, and then the child played with one of the puppets at a time. One of the puppets always shared the balls equally, keeping four for herself and giving four to the child. The other puppet never shared with the child, keeping all eight balls for herself. The child then got to play with both puppets, one at a time. We were interested in seeing if children would share differently with the puppet who consistently shared with them than with the puppet who never shared with them at all.

After testing 2.5-, 3.5-, and and 4.5-year-olds, we found that no age group differentiated their sharing behavior between the two puppets. These children did successfully distinguish between the puppets, accurately pointing out who shared with them and who did not, but they do not seem to be using this information to dictate their own sharing behaviors. It is important to note that in that version, the puppets did not verbalize their decisions. One reason for children not differentiating their own sharing behavior could be that they did not view the puppets' decisions as intentional. To address that, we are now running this study again with 3.5-year-olds, but this time the puppets verbalize their decisions by saying, "I want to share with you" or "I don't want to share with you." Data collection is under way and we look forward to sharing our results with you!

Why do older children share more than younger children?

Monica Burns, Graduate Student

Children often engage in prosocial behaviors, including sharing. Previous work investigates children's sharing by giving children prizes and asking them if they would like to give some amount with another child. Across many different versions of this task, sharing increases with age: three-year-olds rarely share prizes with another child but nine-year-olds often share about half of their prizes. We might be tempted to conclude that older children are more generous than younger children. However, we also know that children undergo a lot of psychological changes between three and nine years of age, and older children might share more than younger children for any number of reasons. For example, older children might care more about winning prizes for others than younger children, or they might care less about winning prizes for themselves. We aimed to design a study about sharing that would be able to tease apart how much kids cared about winning prizes for themselves and how much kids cared about winning prizes for others.

In this study, children watched a computer animation of tokens falling into two buckets, and told an experimenter (who could not see the screen) where the tokens landed. Children played 3 rounds of this game. In one round, one bucket was for them and one was for another kid; in another round, one bucket was for them and one was for no one; in another round, one bucket was for the other kid and one was for no one. Children knew tokens that went into their own bucket would be traded for prizes to keep, tokens in the other kid's bucket would be for the other kid to trade in, and nothing would happen to the tokens for no one. After making sure kids understood how to play, we put a blocker on the computer screen so children could see the tokens start to fall, but would not see where they landed. This made it difficult to tell where the token actually landed, so children had to make guesses.

What the child sees   What is actually behind the blocker

If children just guessed randomly, they would guess about half fell into each bucket, regardless of which bucket was theirs and which was for another kid or for no one. In fact, we found when one bucket was for themselves and one was for no one, children guessed more than half fell into their own bucket. This suggests that children have a self-serving bias and report winning more tokens when no one else is affected. Surprisingly, children from 4 years old to 12 years old showed the same patterns of findings, suggesting these motivations may not change with age. This suggests older children do not share more simply because they care less about the prizes.

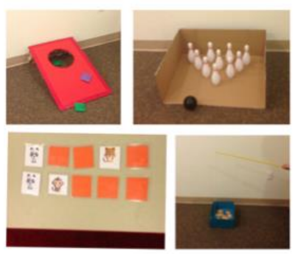
When the buckets were for themselves and for another kid, children guessed about half fell in each bucket. This suggests children did not show this self-serving bias when it would affect another child's winnings. However, this time, there was an effect of age: younger children did show a self-serving bias. This suggests older children may share more because they really do care about equity more than younger children.

Do young children care about being a sharer?

Monica Burns, Graduate Student

From the study above, we know that older kids really do seem to be motivated to create equity, while younger children do not. Why are older children increasingly concerned with equity? Previous work on perspective-taking and impulse control, for example, have not yielded satisfying explanations. An interesting possibility is that older children may actually be motivated by the desire to be a good person. We know from previous studies that young children help more after getting instructions about “being a helper,” and that adults are more likely to vote after getting instructions about “being a voter.” This is thought to be because talking about “helpers” and “voters” suggest a *kind of person*. If kids are motivated by the desire to be a particular kind of person, talking about being a “sharer” should increase kids’ sharing.

In this study, we tested 4- and 5-year-olds. They did four fun activities with an adult and earned four sets of different prizes.

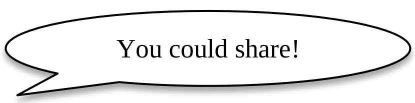


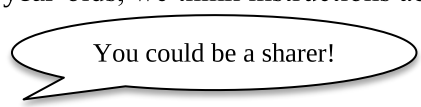
Activities

Prizes

Then, we told them they could give any amount they wanted to another child who would come to the lab later. Half of the children were told they “could share” by putting some prizes in a bag for the other child, and half of the children were told they “could be a sharer.” Then, children were left alone in the room to make their decision in private.

Data collection is ongoing, but based on previous work with 4- and 5-year-olds, we think instructions about “being a





sharer” will increase children’s sharing. Next, we are interested in seeing whether these instructions affect older children even more than younger children.

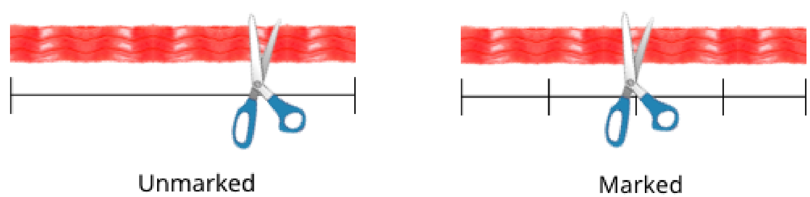
How do children share continuous materials?

Monica Burns, Graduate Student

Many experiments investigate children's sharing behavior by giving children prizes, usually stickers or candy, and ask whether they would like to share them with another person. Younger children rarely share prizes, and older children (around 8 or 9 years of age) often share about half of them. However, stickers and candy are items that are easy to count. In the real world, adults often make decisions about how to fairly divide things that aren't so easily countable, for example, the portion of salad being passed around a table at a dinner party or the amount of time spent doing chores at home.

But what would children do if it were more difficult to determine how much is half? We predicted when it is easy to tell how much is half, sharing would increase with age (as usual). However, when it is difficult to tell how much is half, we predicted older children would be less generous than usual, because they could be sneaky.

To do this, we asked children to divide a long piece of candy (a strip of Fruit by the Foot) between themselves and another child, twice. One time, the candy was on an unmarked tray. The second time, the candy was on a tray with marks at ¼, ½, and ¾. We did not point out these markings or explain what these markings meant.



On average, kids shared the same amount, whether the tray was unmarked or marked. They didn't completely ignore the markings, though: kids in the marked condition were more likely to share almost exactly half, while kids in the unmarked condition more often shared a little more or a little less than half. In stark contrast with previous work on sharing, we found kids overall shared fairly, including kids as young as four years of age! This is very surprising, and we're still not sure why this is the case. It might be simply that children did not understand how to do the task (however, kids were good at answering questions about who each piece was for and which was bigger). Or maybe children didn't think they would like this unfamiliar candy, and this led them to be strikingly generous. Another (more interesting) possibility is that when young children can't count out the number of candies, they are more likely to divide it equally. In future work, we will try to understand what is driving this surprising result.

Children’s Evaluation of Third-party Punishment and Compensation

Young-eun Lee, Graduate Student

It has been suggested that adults often intervene in a third-party’s unjust situation and try to restore justice by punishing a person who are not fair. They pay their own costs to punish the perpetrator even though they don’t know victims and they will never meet the victims again in future. This tendency to punish perpetrators has been observed across different human societies. And it was shown that children as young as 6-year-old can punish an individual who was not fair in resource allocations.

However, punishment is not the only way to restore justice in the real world. There is another way to restore justice: third-party compensation. In third-party compensation, people can restore justice by compensating victims instead of punishing wrongdoers. Recent findings suggest that third-party punishers are not only loved but also feared, and there are mixed feelings for third-party punishers in adults. Additionally, third-party compensators who compensated a victim of unfair resource allocations were rewarded more than third-party punishers who punished an unfair resource divider. Thus, it is important to explore how children evaluate third-party punishment and compensation.

In the present study, we investigated how 6- and 7-year-old children evaluate third-party punishment and compensation, and how this is related to their own intervention decision. Children were told a vignette of 4 characters playing a candy game at a Summer camp. In the vignette, there were 3 roles: a decider, a recipient and two watchers. The decider has 6 candies and s/he always keeps all 6 candies for him/herself and gives 0 candies to the recipient. Then, one watcher (i.e., third-party punisher) takes 3 candies away from the unfair divider by giving up his/her chocolate, while the other watcher (i.e., third-party compensator) gives 3 candies to the victim of the unfair division by giving up his/her chocolate. Finally, at the end of the story, children were asked how much they like each watcher using smiley face likert scale and who they like better between the two watchers. They were also given a chance to intervene in the unfair resource allocation.

The results revealed that children tended to like both compensator and punisher, but they liked compensator more than the punisher. When they were directly asked who they prefer between the two, they preferred compensator over punisher. Also, they preferred to compensate the victim rather than to punish the unfair divider when they were given an opportunity to intervene in the situation. Interestingly, those who showed preference for punisher also wanted to compensate when they were given a chance to intervene. The results suggest that around 6 years of age, children evaluate third-party compensation more positively than third-party punishment. The current findings have implications for moral development.

Future planning and reciprocity

Kristin Leimgruber, Postdoctoral Fellow and Randi Vogt, Lab Manager

As adults, we engage in a wide range of cooperative interactions on a daily basis – from waiting our turn at an intersection, to holding the door for a stranger, to picking up coffee for a coworker who doesn't have time to take a lunch break. While we engage in many of these behaviors without a second thought, costlier actions – such as buying a coffee for a coworker – are more likely to give us pause, and thoughts like "What would I want if I were in her situation?" and, "How likely is she to return the favor in the future?" strongly inform our decisions. In this set of studies, we are interested in how 3- to 5 year-old children approach problems just like this. Specifically, we are interested in how young children's abilities to take the perspectives of others and plan for the future influence their willingness to give to others in a reciprocal sharing game.

The first of these studies took place over two separate visits, spaced 7 to 10 days apart. In the first visit, children played a series of short games designed to measure their ability to think about the minds of others and plan for the future. These activities included a delay of gratification game in which children chose between one sticker to use right away and two stickers to take home, vignettes asking them to consider the thoughts and feelings of various characters, an object-choice task that simulated packing for a hypothetical outing, a reverse planning game in which children delivered mail to a pretend neighborhood as efficiently as possible, and three problem-solving tasks in which children were presented problems and given the opportunity to solve them creatively after a short delay.

In the second visit, children played two rounds of a sharing game with two different puppets and two different sets of toys. Both rounds of the game started at Table 1, where the child had the opportunity to share balls needed to play with a somewhat attractive toy with a puppet. After the child and the puppet used their balls to play with the toy at Table 1, they moved to Table 2, which held a more attractive toy. In the Control round of this game, the number of balls that the puppet and the child got to play with at Table 2 were predetermined by a deck of cards; in the Test round of this game, the puppet got to decide how to share the balls with the child at Table 2. In the Test round, the puppet always shared the same number of balls the child shared with her at Table 1.

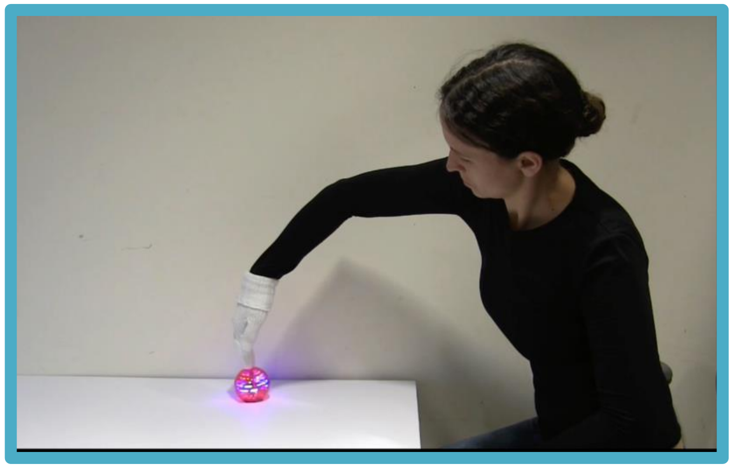
We were interested in seeing if children were more likely to share at Table 1 when their sharing behavior could influence the puppet's behavior at Table 2 than when their sharing behavior had no bearing on the outcome at Table 2. Additionally, we were interested how each child's performance on the perspective taking and future planning tasks related to his/her behavior in the reciprocity game. We found that children's performance on all of the future-oriented tasks as well as the reciprocity task improved with age. Furthermore, we found promising evidence that the ability to think about, and plan for, the future was related to children's performance on the reciprocity task.

Given the findings from this first study, we began piloting on a second study designed to improve children's performance on two of our future-oriented tasks with the hopes of also improving their performance on the reciprocity task. After trying out these tasks with a small set of children, we came to the realization that we may need to revise our training methods before running a full set of subjects. As a result, this portion of the project is on hold at the moment, but we are very thankful for the families who helped us to pilot this training paradigm and look forward to introducing a new and improved version of this project in the lab in Fall 2016!

Finally, we are just beginning a third study in this line of work that pairs the games involved in the first visit of study one with a new reciprocal sharing task in the second visit. Thank you to all the families who helped us in various stages of data collection for our studies! We look forward to updating you with our results in next year's newsletter!

What do prereaching babies know about reaching?

Shari Liu, Graduate Student



The human motor repertoire includes a wide range of intentional action: cooking, dancing, acting, reading, buying, throwing, pulling, climbing, and so on. Mechanisms that help us understand the structure of these actions is essential for interpreting the behaviors of others, and for learning novel actions from others. Previous research from our and other labs suggests that giving babies action experience supports their action understanding, but the exact benefit of action experience is still unclear. This set of studies aims to ask (1) what babies need to learn about intentional action and (2) whether action experience is the only way for them to learn it.

In particular, we were interested in whether babies who are still mastering reaching interpret reaching as a goal-directed action. We tested this by asking whether young babies expect a reach to be efficient, a key signature of intentional action. In two experiments, we presented 3-month-old babies with an actress who reached over an obstacle and caused an object to light up on contact (Exp. 1) or picked up the object with her hand (Exp. 2). Then, we removed the barrier. Given that the actress is going to reach again for the object, how will she direct her reach: in a familiar and curved but newly inefficient path of motion, or in a novel but newly efficient path of motion? If 3-month-old babies interpret reaching as a goal-directed action, then they, like older infants, will look longer at an inefficient than an efficient reach. But if they do not interpret reaching as goal-directed, they will either show no looking preference, or will look longer at the efficient action, since the path is novel. We found that 3-month-old babies expect reaching to be efficient over a change in the obstacles in the actress's way, both when the actress caused the object to light up (Exp. 1) and when she picked up the object (Exp. 2). Results from an additional condition in Exp. 1, where the actress's actions are not constrained by an obstacle, shows that babies did not merely find curved motion more interesting to look at.

These findings are important for several reasons. First, they show that infants do not need any motor experience reaching around a barrier (which babies do not master on their own until 8-10 months) in order to understand that agents must direct their reaches around obstacles. Second, they show that infants do not need any motor experience with reaching at all in order to interpret reaching as a goal-directed action. This finding actually makes a lot of sense, given the wide range of human actions—we need to be able to understand what others are doing in order to learn new actions from them!

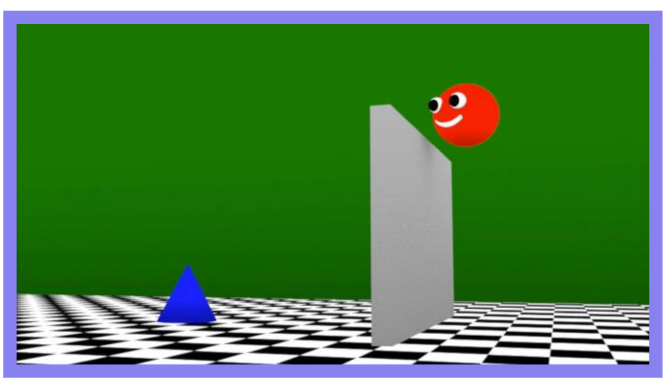
Babies think about physical effort as a continuous variable

Shari Liu, Graduate Student

Many experiments report that babies expect agents to pursue goals rationally. More specifically, after first watching a character leap over a tall barrier toward a goal, babies expect the character to follow a straight path when the barrier is gone rather than follow the same (but now inefficient) arced trajectory of motion. We were curious about how exactly infants analyze efficiency in action—do they simply expect agents to follow curved paths around obstacles and straight paths in the absence of obstacles? Or do they expect agents to minimize the cost of their goal-directed actions?

To ask this question, we ran a series of 5 experiments very similar to the one described above: We showed 6-month-old babies movies of an agent leaping over tall obstacles in order to get to a goal. But instead of taking the obstacle away, we made the obstacle very short. Given that the agent is going to navigate over the new, tiny obstacle, how tall do babies expect the agent to jump? We showed babies two alternatives—the agent either took a big, inefficient leap over the tiny barrier, or a small, efficient hop over it. We reasoned that if babies expect agents to minimize the cost of their actions, they will look longer to the less probable, inefficient leap. We found that babies expected the agent to minimize the cost of its actions and looked longer when it didn't (Exp. 1). We then followed up on this finding and established that babies were not merely responding to the height or velocity of the two actions, but rather differences in their efficiency (Exp. 2). Two additional studies found that infants expected the agent to minimize the cost of its actions even when they previously saw it act inefficiently (Exp. 3), and the very first time they saw the agent move towards its goal (Exp. 4). To follow up, we are currently running a replication of Experiment 4 (Exp. 5).

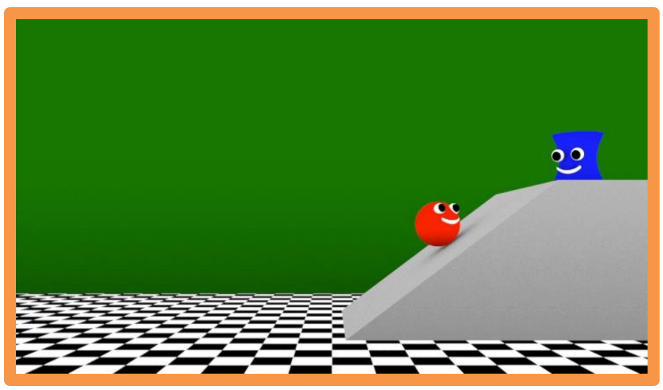
These findings tell us that by the time babies are 6 months old, long before they're in the business of launching themselves over obstacles or even reaching around them, they understand that physical effort is a continuous thing. Furthermore, they expect agents to minimize physical effort the very first time the agent navigated over any obstacle (Exp. 4) and the very first time the agent moved towards the goal at all (Exp. 5). These findings tell us that infants either come into the world with or rapidly construct rich, abstract knowledge about the costs associated with actions, which guides their interpretations of and expectations about others' behaviors.



What's worth your while: Early understanding of effort and value

Shari Liu, Graduate Student

As adults, we understand that one reliable way of inferring someone's subjective valuation of a goal (e.g. apples) is how much of a cost she's willing to pay for them ($1? $12? a trip to the store? climbing a tree?). While previous experiments have shown that babies know something about the goals of agents and the effort associated with actions, it's an open question whether they, like adults, understand that effort is informative about value. To ask this question, we ran 2 experiments where we showed 10-month-old infants that an agent is willing to jump a higher barrier (Exp. 1) or climb a steeper ramp (Exp. 2) to reach one of his friends over the other. During the critical part of the experiment, the agent then chose either the higher-value friend (for whom he expended more effort) over the lower-value friend (for whom he expended less effort), or vice versa. We reasoned that if can infer value from effort, then they will look longer when the agent chose the lower-value friend. Consistent with these predictions, we found across both experiments that infants expected the agent to choose the higher-value friend.



We are currently running a third experiment to ask whether this effect holds when the agent is willing to move a heavier object for one friend over another. We are also piloting an additional study asking whether infants understand that if an agent pays a given cost for a reward (e.g. jumps an obstacle of height 5 for an apple), he would also be willing to pay any cost less than this for the reward (e.g. jump any obstacle of height 0-4), but would not necessarily be willing to pay a greater cost.

These findings are important for several reasons. First, they tell us that infants, like adults, think about effort and value together. Second, they tell us that infants use this joint understanding of effort and value productively in order to infer unknown information in the world (e.g. how much the agent likes friend A or friend B) and to make predictions about an agent's actions (e.g. whether the agent will choose A or B). Third, they suggest that our species' knowledge about the physical world—objects and their movements—and the social world—agents and their motivations—is integrated early in life!

Judgments and decisions in 5-year-old kids

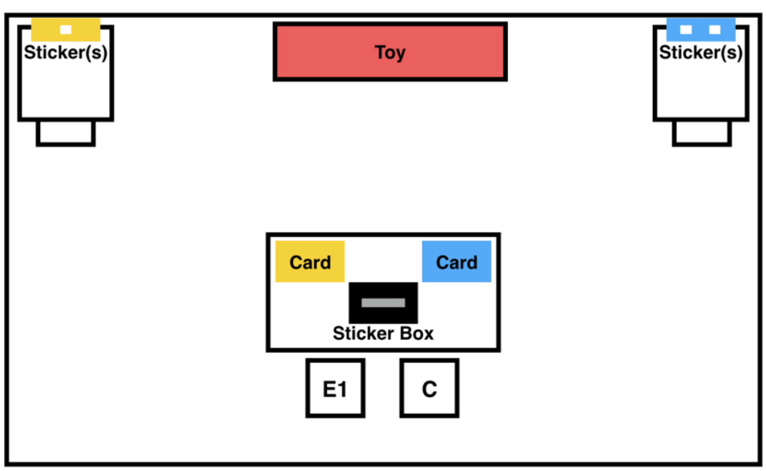
Shari Liu, Graduate Student

Everyday action planning requires us to make accurate judgments about and decisions between the things we want in the world and the costs we need to incur in order to reach them. Time is one example of a cost that each of us faces every day, and one that has been extensively studied in adult human and non-human populations: Given that the future is uncertain, how do we know when to pursue immediate rewards and when to forgo these rewards in hopes for something better? We were interested in exploring how children make decisions, because insights from developmental work advance theories of mature decision-making. They help us answer questions like “Do we have to learn how to be rational? If so, what is learned (e.g. what costs and rewards are, what kinds of things in the world are rewarding and costly, how to integrate over them)?”

Our initial study aimed to ask several questions. First, we were curious about how 5-year-olds make decisions on the basis of costs and rewards alone. We found that when given the choice between a smaller and bigger reward (both with no waiting), kids chose the bigger reward. We also found that when given the choice between waiting a long or a short time for a fixed reward, kids chose to wait less time. Second, we asked whether kids trade off between costs and rewards by presenting them with a series of decisions where they could either earn a small reward immediately or a larger reward after a delay. We found that as the cost of the bigger reward increased (from 0 to 90 seconds), children became less and less likely to choose it. Both of these initial 2 findings are consistent with evidence from adult deciders.

We also asked one last question: are kids more or less rational and patient when earning rewards for themselves versus another child? Overall, we found that children were just as rational (reward-maximizing and cost-minimizing) when earning rewards for themselves versus others. When trading off between the two, kids were more patient (willing to tolerate a higher delay) when earning rewards for themselves.

These findings are important because they tell us that rational decision-making emerges early in life, before formal schooling, and that this decision-making process integrates over many sources of information: costs, rewards, and whom the rewards benefit. We are currently following up to investigate 5-year-old children’s fine-grained judgments about temporal cost, and so far, we’re finding that kids are surprisingly good at detecting and judging varying lengths of delay. This ability may support the rich decision-making that we observed in the first experiment**.**



Quick Updates: Babies, Kids, and Understanding Social Relationships

Annie Spokes, Graduate Student

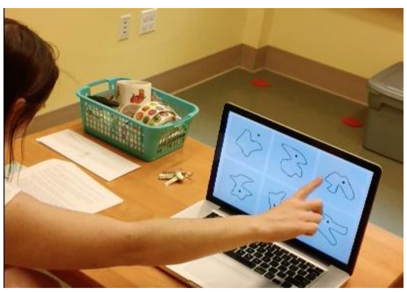
Quick Update #1: Children's expectations and understanding of kinship as a social category

We ran several studies with 3- to 5-year-old children that asked what they understand about different social relationships: siblings, friends, and strangers. We also asked children questions about who of those people they would expect someone to share with or who they would share with themselves. This set of experiments has been published in a scientific journal! The citation and a link to the paper can be found below (and also on our LDS website). A *HUGE* thanks to all of the families who participated in these studies!

Spokes, A. C. & Spelke, E. S. (2016). Children's expectations and understanding of kinship as a social category. *Frontiers in Psychology*, *7*(440).

Read it online: http://journal.frontiersin.org/article/10.3389/fpsyg.2016.00440/full?

Quick Update #2: Working to Benefit the Self & Others



We ran a study with 4- and 5-year-old children looking at how much effort they are willing to put in to win prizes for themselves and other people (friends, siblings, parents, and kids they have never met before). In this study, children played a geometric intruder game on the computer. We showed them a group of six pictures that all have something in common except for one picture that does not belong. We asked them to point out which one is not the same as the rest. We had a big set of these for them to play, but they got to choose when to stop. The more they played and got right, the more stickers they won. Preliminary analyses suggests that 4-year-olds, but not 5-year-olds, played longer for family members (siblings or parents) than non-family members (friends and strangers). We are finishing up the analyses and planning a follow-up experiment.

Examples from the Geometric Intruder Task

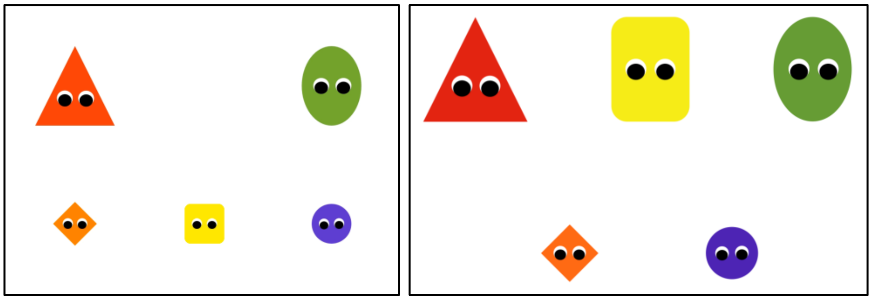
Quick Update #3: How do babies think gender plays a role in social interactions?

We are starting a new line of work asking how infants think gender plays a role in social interactions. Do babies expect characters of the same gender to be friends or characters of different genders? Do babies expect one gender to be more responsive to a baby's cry than another gender? We are just starting these studies with babies around 7- to 9-months-old and around 13-months-old, and we look forward to sharing more about them next year!

Early Understanding of Social Interactions & Relationships

Annie Spokes, Graduate Student

We have been continuing a line of research asking how babies think about and understand the people around them and how people are connected to each other in social interactions and relationships. We show babies animated shapes instead of people in these studies (pictures below). This year, we have had studies for babies around 11-months and 15- to 18-months-old and have been finishing up a group of studies in order to publish the results.



Animation Examples (from left): 1- Picture of the study with two adults (big shapes) and three babies (small shapes); 2- Picture of the study with three adults and two babies.

With 15- to 18-month-olds, we have now completed six experiments, and we have found that babies at this age expect characters with a mutual social connection to get along and look longer when they see characters without a social connection hanging out. All of these studies had five shapes, “characters.” In the first experiment, there were three little shapes (“babies”) and two big shapes (“adults”). In the first videos, babies saw that each baby cried, and one of the adults went to the baby, made a soothing noise, and rocked with the baby. One adult soothed two babies, and a second adult soothed the other baby. Next, the little shapes played together—either two soothed by the same adult or two soothed by different adults. We watched to see how long babies looked at these two types of videos to see if they might look longer and be more surprised by one social interaction. Excitingly, babies at this age looked much longer to interactions between babies soothed by different adults, suggesting that they do not expect this interaction as much as interactions between babies soothed by the same adult. We then ran five more experiments to follow up on this finding. One study had characters of all the same size that were laughing and playing together rather than being soothed, and infants no longer expected those who played with the same friend to hang out with each other. We also ran a study with three big shapes and two little shapes: two adults soothed the same baby, and one adult soothed the other baby. In this study, infants looked longer when adults with different babies interact as compared to the two adults with the same baby. The three experiments we have run with 11-month-old babies suggest that they can also keep track of the social relationships.

We are continuing studies with 11- and 15- to 18-month-olds to further explore how babies think about social relationships and networks. One study has five same-sized shapes laughing and playing, where the shapes have a back and forth interaction rather than just having one character laugh—to mirror more what real friend interactions are like. Along a similar line, we have a study with baby and adult shapes where the baby giggles instead of crying. These studies are still ongoing, so we look forward to sharing more about results in the next newsletter.

Thank you to all babies and parents who helped to make these studies possible!

Understanding Emotions: Cries vs. Giggles

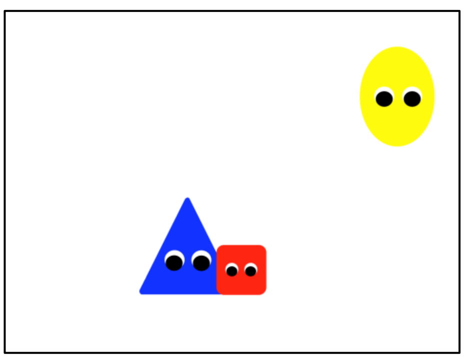
Annie Spokes, Graduate Student

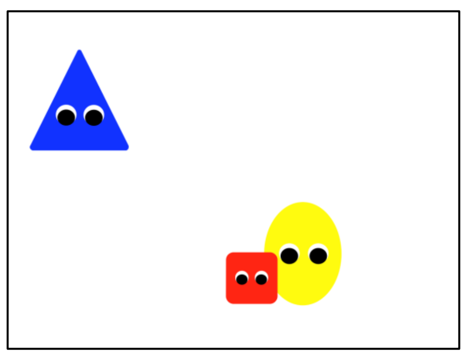
In previous studies, we found that babies think about social networks differently in situations with crying versus giggling. We ran two experiments to follow up on these studies asking how babies think about another baby's cry versus giggle. In addition to telling the difference between these two emotions, we wanted to see how babies interpret social interactions involving these emotions. We do this with our usual animated characters (pictured below). In both experiments, the videos have three shapes, "characters": two bigger shapes that are like adults and one small shape that is like a baby. In alternating scenes, the baby is either crying or laughing. In each scene, one of the adults responds to the baby's noise by moving toward the baby, and then the baby stops making its noise. The adult and baby then rock together in unison.

In the first experiment, after showing these two scenes over and over, we then presented the two adult characters and asked babies, "Who do you like?" We wanted to see if babies liked to look more at the soothing adult or the adult who responded the baby's giggle. We found that all babies looked to *both* shapes, and they looked roughly *equally* to both.

In the second study, the first scenes were the same—a baby cried, one shape responded, and then the baby giggled, and the other shape responded. The second part of the show was different: now, both of the big shapes jumped up and down, and then the little shape went up to one of them, choosing to play and rock back and forth with one but not the other. In alternating videos, the baby went to the shape who responded to its cry or its giggle, and we measured how long babies watched these videos. We wanted to see if babies though the little shape would choose one or the other, but we found that they looked roughly *equally* to the videos.

After these two experiments, we conclude that babies might see a response to a baby's cry and a response to a baby's giggle both as caregiving events and do not have a strong preference for someone who responds to one more than the other.





Animation Examples: Each adult character joining the baby character after the baby either cries or laughs.

Infants’ Detection of Parallelism and Perpendicularity

Moira (Molly) Dillon, Graduate Student

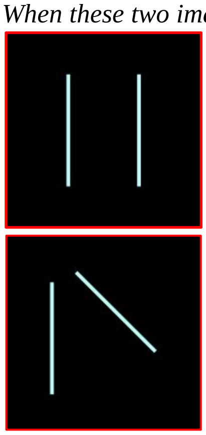
Infants are equipped with certain spatial abilities very early in development. How might these abilities relate to the later learning of formal geometry in school? In this study, we aimed to investigate whether parallelism and perpendicularity, which are two important geometric concepts to Euclidean geometry, are perceptually salient for infants. If they are, then mapping these percepts to concepts later on in a school might be easier.

We presented 6.5-7.5-month-old infants with two streams of images presented on either side of our big screen. On one side there were pairs of parallel lines or perpendicular lines flipping back and forth with a pair of skew lines. On the other side, there was one of these types of line pairs flipping back and forth with a smaller or larger version of itself. We measured how long infants looked at the side that presented the change from parallelism or perpendicularity versus the side that did not. Since infants tend to look longer at things they find interesting, we used this design to see whether infants find parallelism or perpendicularity salient by noticing the change.

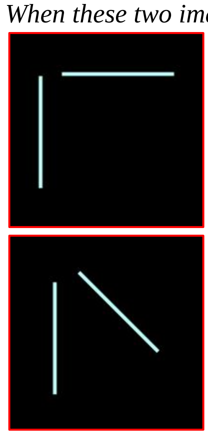
We found that infants looked longer at streams presenting changes away from parallelism but not changes away from perpendicularity. We think this is particularly interesting because even 4-year-old children are able to pick out a pair of parallel lines as being the “most different” from five other pairs of lines that vary by the same magnitude in their relative orientations (e.g., lines at 10°, 20°, 30°, 40°, 50° relative to one another). However, not until around age 8 years do children pick out perpendicular lines as being the most different from other pairs of lines that vary by the same magnitude in their relative orientations (e.g., lines at 100°, 110°, 120°, 130°, 140°, relative to one another).

These findings support a link between the perceptual sensitivities that infants have to apprehend the spatial world and the kinds of spatial concepts we ask them to learn later in formal schooling. Continued research may help inform teaching by making clear the foundational spatial knowledge that young children bring with them into the classroom.

Infants detect a change in parallelism
When these two images flip back and forth



But infants do not detect a change in perpendicularity
When these two images flip back and forth



Connecting Numerical and Geometric Intuitions to School Learning in Mathematics

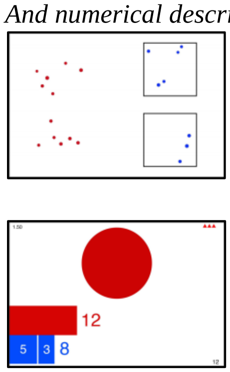
Moira (Molly) Dillon, Graduate Student; Chrissie Carvalho, Visiting Graduate Student; Natasha Kalra, Lab Manager

In school, children are taught important mathematical skills such as counting, arithmetic, and the geometric properties of shapes. Basic research in our lab and others has shown that at the core of these later-developing mathematical abilities might be early emerging, unlearned cognitive abilities with dedicated sensitivities to numerical and geometric information. These abilities allow adults, infants, and non-human animals to guess the approximate number of individuals in a group and to differentiate between objects and visual forms based on their angles, lengths, and topologies. In this study, we aim to test directly whether short-term training of these early emerging numerical and geometric skills using simple card games might improve school-relevant mathematics outcomes for children, like performance of symbolic arithmetic and judgments of shape properties.

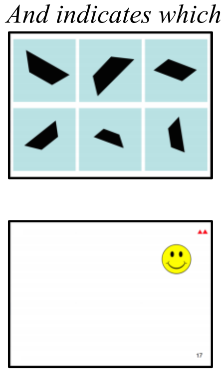
Over the past year, we have invited 4-7-year-old children into the lab to play card games of our own design exercising their core numerical and geometric skills. Our number game challenged children to sort cards based on the color of the more numerous of two dot arrays. Our geometry game challenged children to find which one of six shapes didn’t belong with the rest based on one particular geometric property. We have also evaluated how we might measure short-term gains in mathematics achievement by creating and testing short mathematics assessments. Throughout the year we have refined the design and play of our games, and in the summer of 2016, we begin our first full-fledged training study in the lab: children learn to play one of the games, take the game home for a week, and track their individual progress. With a battery of assessments before and after the training, we will measure if our games promote school-relevant mathematics achievement on the short term.

Although this study has just begun, we have tested similar games on a large scale in preschool and elementary school classrooms in New Delhi, India and Montevideo, Uruguay. Our results are promising! Children show long-term gains in core numerical and geometric intuitions and short term gains in symbolic arithmetic and shape knowledge. Our continued work aims to make these improvements last longer. Our eventual goal is to harness what we’ve learned in the lab about the origins of mathematical knowledge to help children around the world learn mathematics better!

Our number game presents dots on the front
And numerical descriptions on the back



Our geometry game presents shapes on the front
And indicates which shape doesn’t belong on the back



Infants' understanding of communication

Alia Martin, Postdoctoral Researcher

How do babies learn to communicate? Recent evidence suggests that quite young babies know how communication works even before they are speaking much themselves! In these previous studies, 6- and 12-month-old infants watched a actor reaching for one object over an other, displaying a strong preference for the chosen object. Then, infants saw a new scene were the actor was present but could no longer reach the objects, and a new actor who could reach them was also present. The first actor turned to the second and produced a speech sound (the nonsense word "koba!") or a nonspeech sound (coughing). Do infants expect speech to transmit information about the first actor's preference to the second actor? It turns out that they do! If the first actor used speech, infants looked much longer at the scene if the second actor have the first actor the nonpreferred object than if the second actor gave the preferred object. This suggests that infants expected the second actor to understand the first actor's speech as indicating her preference, and provide that object. On the other hand, if the first actor coughed instead of speaking, infants looked for about the same amount of time no matter what object the second actor gave.

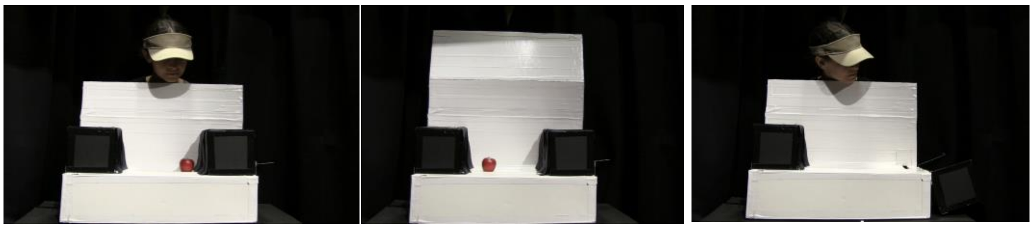
This past year, we've been running a study to ask whether infants understand that successful communication requires the people involved in the communicative interaction to have proper access to information. Twelve-month-olds watched a video version of the communication study described above. All babies saw the first actor speak to the second actor to communicate about her object preference, but some of these babies saw a modified video where the second actor was wearing a blindfold! Do babies understand that even though speech can be used to communicate, it can't be effective if the person responding to it cannot see what it might be referring to? If so, they should not expect the blindfolded actor to choose the right object. Data analysis is ongoing.

The first actor shows a preference for the red object by picking it up and playing with it. Later, this actor cannot reach the objects and uses speech to communicate with a blindfolded or unblindfolded second actor, who then offers one of the objects.

Do infants pay attention to what other people think and know?

Alia Martin, Postdoctoral Researcger

As adults, we're often thinking about other people's thoughts in order to understand why they act the way they do, or figure out what we might be able to learn from them. We were interested in asking whether babies are also thinking about what others think and know from an early age. We conducted a study with 7- and 11-month-old babies where we presented a live show with a human actor. We showed babies that a bright red plastic apple could move around on a stage while the actor watched, and sometimes the apple moved into the black boxes on the stage where the baby and the actor couldn't see it.



In Picture 1, babies watch as the actor sees the apple move into the box on the right. In Picture 2, babies watch the apple move into the box on the left, but the actor can't see this happen! In Picture 3, the box on the right flips open, and there is no apple underneath. This should be very expected from babies' point of view, because they just watched the apple move into the box on the left. But from the actor's point of view, this should be surprising, because the apple last saw the apple move into the box on the right.

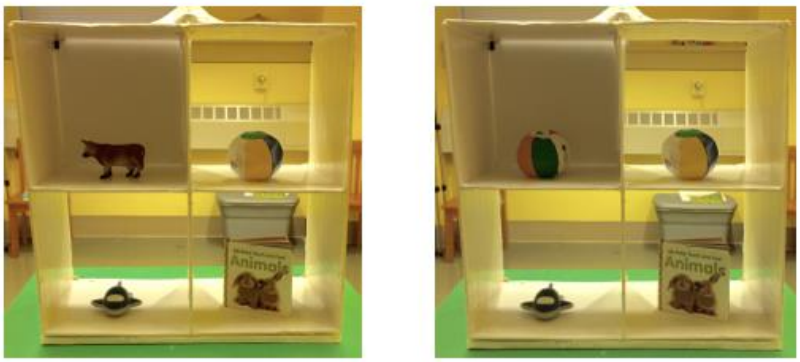
We were interested in whether babies are thinking about what they see only from their own perspective, or whether they are influenced by the actor's perspective about where the apple might be (studies have suggested that adults are often unintentionally influenced by others' perspectives and beliefs). Half the babies who participated in this study saw a "Perspective-consistent" version of the show, where babies and the actor both watched the apple move into the box on the left, and then the box on the right flipped open and was empty. Babies should not be too surprised by this and should stare at the scene for a very short time after seeing that the box is empty, because an empty box was expected both from their point of view and from the actors. The other half of the babies, however, saw a "Perspective-inconsistent" version of the show, where babies saw the apple move from the box on the right into the box on the left but the actor was hiding behind an opaque barrier and did not see the apple's location change! If babies who saw this version were influenced by the actor's perspective, they should show increased attention to the scene, looking for a longer time after seeing that the box on the right is empty. We recently finished data collection in this study and are now coding the videos to see how long babies looked.

Does similarity influence children's perspective-taking?

Alia Martin, Postdoctoral Researcher

We often need to take others' perspectives to know what they are trying to communicate to us, or in order to communicate effectively with them. We have been conducting a study investigating whether 3- and 4-year-olds are more or less likely to take the perspective of someone who is similar to them than someone who is different from them.

In this study, children played a communication game with two research assistants, one who they learned at the beginning of the study was knowledgeable about some of the same things they knew about, and the other who they learned was knowledgeable about other things they did not know about. During the game, the research assistants took turns asking the child for specific objects. Importantly, sometimes children could see two replicas of the object they were being asked for (for example, they were asked for an apple but there were actually two apples the child could see), and the asker could only see one (one apple was hidden from the asker's view). Children thus had to consider the requester's point of view to determine what they were asking for.



The bookshelf seen from the child's side. In the first picture there is only one ball, so when the asker on the other side of the shelf asks for "the ball", children tend to respond quickly and select the correct object. In the second picture, there are two balls, but the child can see both and the asker can only see the one on the right. Here we are interested in whether children's likelihood of taking the asker's perspective and choosing the ball the asker can see is different depending on whether the asker is similar to them or different from them.

We are currently coding the videos to analyze the results of this study, but are excited to find out whether and how similarity influences children's perspective-taking.

Do babies think about others' preferences when helping them?

Alia Martin, Postdoctoral Researcher

Humans are a relatively cooperative species, but helping other people requires some complicated cognitive capacities. For instance, we might think it's a good idea to help people by giving them things that they like, but this requires us to figure out that other people may like different things that we do! Some previous research from our lab suggests that even though 14-month-olds are very good at identifying another person's preference for a particular toy by watching what the person tends to reach for, infants at the very same age do not seem to use this preference understanding when they are asked to help the other person by giving her a toy. They tend to choose randomly when the person asks for help!

We began a new study to try and find out why infants weren't using the preference information to help the other person, thinking that maybe it would help babies to understand that the person wants a specific object if she used language to express a preference. Fourteen-month-olds watched live events where an actor showed a preference for one of two objects by repeatedly reaching for it, and then asked infants for help to get a specific object, “the koba”. Infants were then allowed to reach for one of the objects to hand to the actor. However, infants continued to choose randomly, so we began a new version of the study where the actor labeled the object every time she reached for it, saying “I like the koba!” with a happy smile. Results again showed that infants did not consistently choose either object, despite many other studies in the literature showing that infants at this age are certainly able to tell and remember which object the person likes. We hope to do some more research into this interesting puzzle – one possibility is that infants’ own preferences for one of the two objects makes it difficult to choose the object the other person prefers.

Music and Infant Soothability

Samuel Mehr, Graduate Student and Marina Ebert, Research Assistant

How does exposure to melody and spoken rhymes impact infants’ behavior? Are songs more preferrable as a soothing technique as compared to infant-directed speech? To start getting at these questions, we designed the following study.

In this study, 64 infants aged 3.5 to 7.5 months listened to several lullaby and play songs, both familiar and remote, half of which were sung to a melody and the other half spoken as a rhyme. We are interested in differences in infants’ behavioral and physiological reactions to these types of songs.

During the study, babies stayed in the crib in front of two speakers equipped with led lights, which lit up when the song was playing. Overall, across all songs and rhymes, we looked at babies’ looking time at the audiovisual stimuli, body movement, skin conductance and heart rate response, and their emotional state. We measured infants’ reactions to the songs and rhymes using the physiological band placed on infant’s foot. The band allowed us to track infants’ heart rate and skin conductance (EDA) response as measures of how excited or soothed the babies are during each audiovisual stimuli. We also asked parents to indicate whether each song played to their baby was familiar and whether the baby liked it or not.

We are still in the process of analyzing data from this study. While some of the measures are exploratory, based on previous research, we hypothesize that infants would enjoy more and look longer in the direction of the speaker while it’s playing familiar lullaby songs, which would indicate that they are more interested in melodic versions of the songs as opposed to infant-directed speech. Our expectations regarding physiological response are driven by the pilot data indicating that both familiar songs and spoken rhymes gradually raised the EDA (skin conductance response) more than unfamiliar songs and rhymes. At the beginning of the song, in both cases, we expect to see a drop in EDA during sung stimuli, but not in spoken versions of the songs.

We are looking forward to fully analyzing and presenting the results from looking time, motion, and physiological reactions to songs and spoken rhymes in the next lab newsletter. Thanks to all the families who participated in this research!