NEWSLETTER 2015

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2015 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 others' 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 a character called 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 than typically-developing children do.

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.

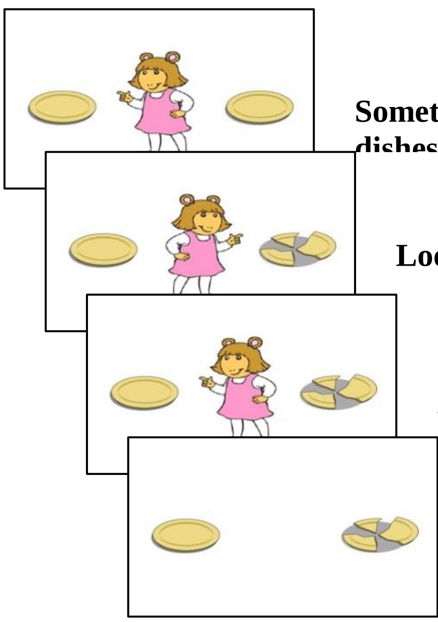
What's your toddler's favorite word?

Tracy Reuter, Lab Manager

Many toddlers have a favorite word: *NO!* Although they frequently produce negative sentences, young children have difficulty understanding negative sentences in a variety of tasks. Distinguishing affirmative from negative is important. How do we do it, and why might young children have difficulty understanding?

Some researchers think that we understand the meaning of a negated sentence via the affirmative. That is, to understand, *I didn't read the book*, your thought process would be something like: *I read the book…not*. This means that processing negatives would inherently take longer. However, our recent studies show that children as young as 2 years old process negative sentences incrementally. That is, under some circumstances, they're just as fast to understand negatives as affirmatives.

In Study 1, children saw pictures on a screen, and heard a male narrator tell stories about the pictures (see below). After each story, a female narrator chimed in with a conclusion to the story: *Oh, I know what happened! D.W. broke/didn't break one of the plates. Which one was it?* We recorded children's responses, as well as which picture they looked at on the screen.



Sometimes, DW accidentally breaks dishes

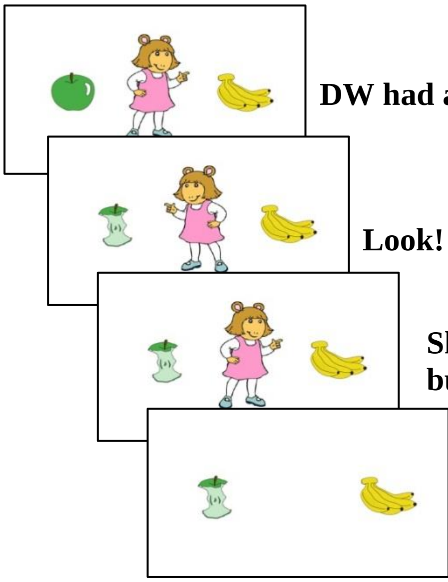
Look! She broke the plate.

She was going to break the other plate too, but her mom helped her instead.

Oh, I know what happened!
DW broke/didn't break one of the plates.
Which one was it? Can you show me?

We found that 3-year-olds understand both affirmatives and negatives. They look quickly to the correct picture and select the correct picture in both cases. However, 2-year-olds had some difficulties in this task. For both affirmative and negative sentences, 2-year-olds initially looked to the correct picture, but upon hearing, *Which one was it?* they looked equally to the two pictures, and then selected the correct picture only 50% of the time! So it seemed like the 2-year-olds were just guessing.

Next we made some changes to see if 2-year-olds could succeed in Study 2 (see below). We included more practice trials, used different pictures during each trial, and used a “blocked design” (4 affirmatives followed by 4 negatives, or vice-versa). We again recorded children’s responses, as well as which picture they looked at on the screen.



We again found that 3-year-old children understand both affirmatives and negatives. In contrast, 2-year-olds succeed in a specific way. 2-year-olds who heard 4 affirmative sentences followed by 4 negative sentences understood both types of sentences, whereas those who heard 4 negative sentences followed by 4 affirmative sentences did not.

It’s possible that encountering the affirmative form first helps “scaffold” the process. This could help the 2-year-olds understand the subsequent negative sentences. We’re currently writing this paper for publication and are excited to report our final results soon.

Thank you for all your help in these studies!

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

Roman Feiman, Graduate Student

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 one study, we remove the screen and then tell 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.

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

Roman Feiman, Graduate Student

In another 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, Graduate Student

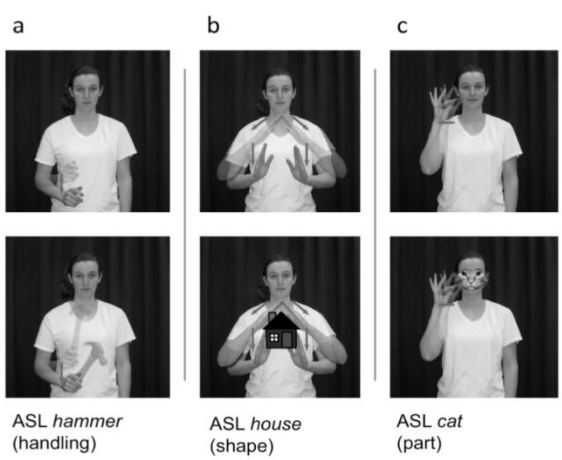
In another, similar study, we show two-year-olds videos of people playing with toys. First, a girl plays with one of two toys on the table, and then a boy plays with the other one. When the boy plays with the second toy, a voice-over says, *Look, now it's different! He's not playing with the dax!* Does 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.

Biases for symbols

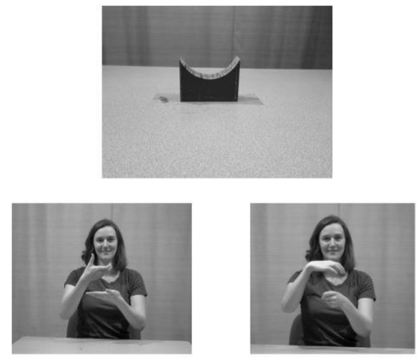
Annemarie Kocab, Graduate Student

Children begin producing their first words when they are around 12 months and by age 6 they know around 10,000 words. How do children learn so many words so quickly? Past research shows that 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 (e.g., Baus, Carreiras, & Emmorey, 2013). 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 language creation 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. In one version, one sign was presented more frequently than the other (*frequency* condition). In another version, one sign looked more like the toy than the other sign (*iconicity* condition).

We look forward to sharing our results in the next newsletter. Thank you!

Are previously mentioned items easier to understand?

Pooja Paul, Graduate Student

We use language in our everyday lives to describe the objects and individuals in our environment. Understanding how we integrate information from our external environment with language, and vice versa, gives us important insight into the relationship between language and other domains of cognition. We were specifically interested in studying how we use visual and other sensory information to unconsciously formulate expectations about upcoming words as we listen to spoken language, and to identify whether there are systematic (and therefore predictable) patterns in which we form such expectations.

Previous studies have found that under some conditions, people 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) *Jane is only holding an ap…* directly after a sentence like (2) *Bill is holding an apple and a banana*, they tend to expect *apple* rather than *apricot* as a continuation in (1). We suspect that the preference for *apple* is because it takes less effort to think about an item that is already familiar from the conversation, than to come up with an object that is not already familiar. In this case *apple* was mentioned before but *apricot* was not.

The goal of our study was to better understand why this happens, by investigating whether this preference diminishes or disappears under certain conditions. For instance, does the bias towards previously mentioned objects persist if the sentence does not contain an *only* (*Jane is holding an ap…*'), or if the *only* appears at the beginning of the sentence (*Only Jane is holding an apple*). We expected that it would not.

In our study, adult participants were asked to view objects and characters on a computer screen while listening to a description of two characters and the item(s) they had in their possession. While they carried out the task, we measured their eye-movements to different items on the screen.

Our preliminary results indicate that adults do indeed look to the previously mentioned item more quickly when listening to sentences containing *only*, such as in (1), compared to sentences that do not contain *only*. We also found, in line with our predictions, that the position of *only* matters: having the *only* appear at the beginning of the sentence leads the so-called Previous Mention bias to disappear. A third finding was that mentioning multiple items (for instance, both *apples* as well as *apricot*) in the preceding discourse leads to the disappearance of the Previous Mention effect. We would next like to extend these studies to 6-9 year old children, to investigate how early in development this bias begins to emerge.

Sentence processing in children

Tanya Levari, Graduate Student

One of the incredible things about human use of language is how efficient it is. After each sentence, people do not stop and take time to slowly piece together everything that was uttered – people have conversations. We do this by building up the meanings of sentences right as we are hearing them. One of the key questions that we investigate in our lab is how people are able to do this – what kinds of information do we use when understanding a sentence? What might be the mechanisms involved? And, critically, how does this ability develop?

A key challenge for studying how we build up meanings to sentences we hear is studying this process without interrupting it. One tool that we have at our disposal is looking at eye movements. When we speak, we tend to look at the things around us that we're talking about. We can certainly talk about things that don't exist or aren't in the room, but eye movements to objects within our environment are generally a good measure of what we are attending to during language comprehension. This year, we've applied this method in order to study what kinds of sentence structures children have available to them at 4 years old. When hearing a sentence, do 4-year olds attend only to the specific words that are being used? Or do they attend to a more abstract grammatical structure?

The study we conducted this year investigates this question by looking at how children hearing one type of sentence will affect how they understand a second, subsequent sentence. We know that adults, when they hear a sentence with a particular sentence structure (e.g. *The girl gave a ball to the boy)*, then expect the same sentence structure to repeat in a subsequent sentence (e.g. *The child gave a treat to the dog*) and are surprised, or slower to build up a sentence meaning, when a different grammatical structure is used (e.g. *The child gave the dog a treat*). We call this effect, "priming" – adults are primed, or ready and expecting, to hear that same sentence structure again. This pattern of behavior in adults suggests that proficient language users attend to grammatical structures and use previously heard sentences to help them build up meaning of new ones!

We want to know if children are able to do the same thing. Children that came into the lab listened to a story and were then given instructions which they acted out with various toys laid out in front of them. Sometimes, the sentences they heard in the story had the same structure as the sentences they heard in the instructions, and sometimes they were different. We wanted to see if children would make predictions during the instructions based on the sentences they heard in the story. For instance, when children were presented with sentences that had an animate subject after the verb (i.e. *She sang the boy a story. Then she read the girl a song.)*, they looked more at the animate toys on the stage than the inanimate ones. Some of the objects on the stage started with the same sound (i.e. *money* and *monkey*, right). In these cases, children looked more at the animate monkey than the inanimate money even before they heard the whole word, even though it wasn't clear which toy was being talked about!

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.

Judging events

Jayden Ziegler, Graduate Student

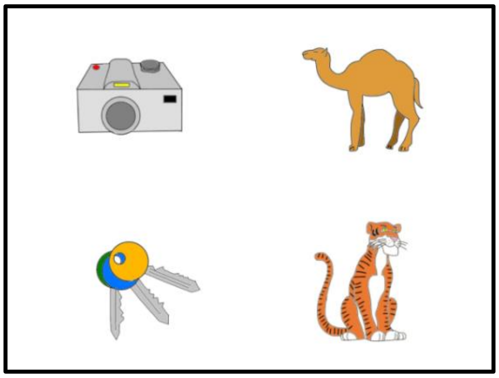
This is part of a larger study that looks at what children and adults know about verbs. Words that are verbs share certain similarities. For example, in English, only verbs can come before the suffix "–ing." Do children understand this fact? Alternatively, do they treat each verb-like word as its own 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 dative sentences. Test sentences were similar either to (1) or (2) below:

1. John's gonna bring the camel the keys.
2. John's gonna bring the camera to the tiger.

As the children heard *bring the cam…*, it was temporarily ambiguous as to whether the entity being referred to was the *camel* or the *camera*. We evaluated children's real-time interpretation of the sentence by tracking their eye movements to a set of objects on a screen. Eye movements have been shown to be closely time-locked with language processing. When the children heard *cam…*, were they looking more at the camel or the camera?



Test sentences were preceded by two prime sentences. Our first hypothesis was that where the children looked would be influenced by the type of prime sentences they heard. For example, if the children first heard two sentences like that in (1), they would expect the first noun in the test sentence to be the animal and therefore look more at the camel. Alternatively, if the children first heard sentences like that in (2), they would expect the first noun in the sentence to be the object and look more at the camera.

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 test verbs. On the one hand, if the prime verbs influence children's interpretation 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. Data collection is ongoing, but we will hopefully have news to share in the next newsletter!

Exploring how infants represent the real-world sizes of objects

Bria Long, Graduate Student

When we recognize an object, we automatically know how big it usually is in the world, regardless of how large it appears on our retina at that moment (Konkle & Oliva, 2012). 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). In addition, the parts of our brains that respond when we look at objects are sensitive to whether an object is big or small in the real world.

In this study, we asked whether 13-month-olds already automatically activate real-world size when they see an object. To do this, 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 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). In general, infants will tend to look towards to the visually big object on the screen. 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.

We found that infants tended to look mostly at the visually big object on congruent displays, but at both objects on the incongruent displays. In other words, their looking behaviors suggested that they did automatically activate real-world object size.

Since this is the first study we have conducted that has asked whether infants automatically activate real-world object size, we will be running more studies to better understand this effect.

Thank you for your participation!

The growth and structure of kind concepts

Paul Haward, Graduate Student

Some of our most basic concepts are for *kinds* of things, such as the concepts *table*, *ship* and *cow*. These concepts allow you to look out at the scene in front of you and quickly group the things you see. They also allow you to form expectations about these objects — for example, expectations about the functions, form, and material characteristics of the object, as well as how it relates to other objects.

Many of these *kind concepts* are universal across human languages, and children learn them at a remarkable rate — often learning up to ten words a day during the peak periods of language growth. A foundational problem in cognitive science, then, is to determine how each kind concept is understood and how children acquire these concepts at such a rapid rate.

One way to access the structure of a kind concept like *cow* is to look at the different ways that children naturally explain the *properties* that compose the concept *cow* (e.g. having four legs, having a tail, eating grass). Previous research has shown that adults explain some properties of concepts by simply referring to the kind of thing it is. For example, when asked why a car has four wheels, adults might reply "because it is a car", but when asked why a car has a radio, the answer "because it is a car" does not seem as natural. These observations allow us to better understand the structure of our linguistic concepts by helping identify some kind-property relations as being more principled than others: they help us learn about the implicit structure in the child's understanding of words such as *car* and *cow*.

In our study, we are interested in how children understand the relation between the kind of thing something is (e.g. a car) and its properties (e.g. having four wheels, or having a radio). To test this, we have developed a task with a puppet and a picture book. Each child is shown pictures of basic concepts — for example, pictures of cows and ships. They are then told a story about the items, followed by a game where they are asked to explain to the puppet why some of the properties exist as part of the object (e.g. "why do these things have four legs?" while pointing at cows). We have two tests. First, we have been looking to see if children, like adults, treat some properties of these concepts as special, in that they license an explanation in terms of the abstract category (e.g. Researcher: "why do these things have four legs?", Child: "*because they are cows*"). Second, we have been looking to see whether, when you take away a special property, children, like adults, judge that there is something wrong with the object in question (e.g. a cow without four legs, or a car without a radio).

We recently finished data collection for this project. Our results suggest that children, like adults, do privilege some properties — they explain these properties by referring to the abstract category, and they think there is something wrong if you take them away. Furthermore, children treat some properties as special even at the youngest ages we have tested (four years of age). These findings suggests 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. In future work, we will look to build a theory of how kind concepts are generated in development around these privileged properties.

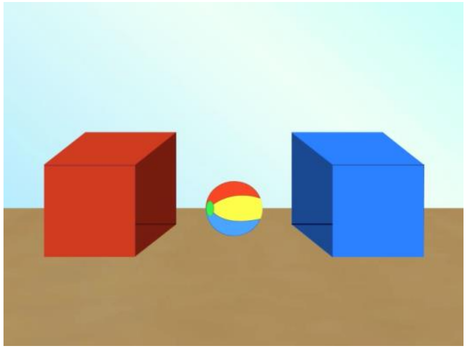
Understanding *no*

Sophia Sanborn, Lab Manager
Nicolò Cesana Arlotti, Graduate Student,
Universitat Pompeu Fabra

No is a word with a highly abstract meaning. The word *no* does not refer to any one thing in the world. In fact, when *no* is used, it usually refers to what *isn't* present and what *wasn't* said. It can be used to express many subtly different meanings that center on a general concept of "negation"; for instance, *no* can be used to reject something unwanted, to assert that something is not present, or to assert that a statement is not true. These last two uses are particularly important for reasoning and communicating about our world.

Despite the fact that *no* has such an abstract meaning, it is one of the earliest words that children learn. Several researchers in our lab are interested in determining what children mean by *no* when they first learn it and how this concept develops into a more complex form that can be used to draw inferences about the world.

This study of *no* investigates the age at which children understand that *no* can be used to assert that something is not present. We are currently running this study with two-year-olds. In this study, children watch a video on a screen that tracks where they are looking. We can infer how children interpret the sentences they hear based on what they pay attention to during the video. Children see an object (an apple, ball, boy, or cup) hide in one of two empty boxes.
They are then asked either question (1) or (2):



(1) *Where is the box with **the ball**?*
(2) *Where is the box with **no ball**?*

If children understand that *no* can be used to describe the location where the ball is *not* present, they should pay more attention to the empty box when they hear question (2).

We are still in the process of collecting and analyzing data, but preliminary results suggest that children begin to comprehend these negative sentences at around 27 months.

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 do not 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, 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.

So far, our results suggest that 3-year-olds understand what both words mean: they generally give both objects when asked *and* questions, and one of the objects when asked *or* questions. However, the results from the 2-year-olds are a little less clear. On average, they do different things when asked *and* questions vs. *or* questions, suggesting 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! Maybe 2-year-olds are just less likely to listen to our instructions than 3-year-olds, but it's also possible that they really aren't sure what the instructions mean.

We're still working on gathering and analyzing the data for this study, and look forward to sharing the final results with you in the next newsletter! Thanks so much to all the families that participated!

Reasoning and causality (17-month-olds, and 2- & 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.

We introduce 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 several blocks on the toy, including some combinations of the blocks. We then encourage children to choose one of the blocks to try out. Based on their choices, we can infer what kinds of reasoning patterns they use to understand cause and effect.

For the 17-month-olds, we're interested in seeing if they can use positive and negative information to decide between two blocks. In some trials, they see both positive and negative information: one of the blocks causes the toy to light up, and the other block doesn't. In this case, 17-month-olds generally pick the block that works. For the other trials, we make things a little harder – they see *only* negative information: one of the blocks 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, it looks like 17-month-olds still pick the block that works! This shows that they can use negative information about which block *doesn't* cause the effect to guide their choice to the other one instead.

For the older children, we want to know if they can use probability information in situations where there are several possible causes of an event. We show children trials with three or four blocks, in which several of the blocks *might* cause the toy to light up, but one block is more probable than the others. So far, it looks like 3-year-olds usually choose a block that has a 100% chance to light up the toy, rather than one that has only a 50% chance. In contrast, 2-year-olds don't seem to differentiate between the 100% blocks and the 50% blocks, although they do choose both of them more often than blocks that have a 0% chance of lighting up the toy. Based on these results, it looks like the ability to use probability information to pick between several potential causes develops sometime between children's 2nd and 3rd birthdays.

We're still working on both these 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!

Analogy, relational reasoning, and the concepts *same* and *different*

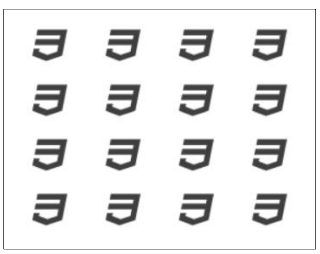
Sophia Sanborn, Lab Manager
Jean-Remy Hochmann, Researcher,
Laboratoire sur le Langage, le Cerveau et la Cognition

The ability to detect similarities in the abstract *relational structure* of perceptually dissimilar things is often considered a distinctive feature of human cognition. This is part of what underlies the human capacity for analogical reasoning. For example, we readily recognize that "a mason is to stone as a carpenter is to wood" because we recognize that the same relationship holds between the two items in each pair (namely, that the first item is a builder who uses the second item as their material) – despite the fact that each pair is perceptually quite dissimilar.

The simplest version of this type of analogy is one that involves the concepts *same* and *different*. For example, the cards on the left below are alike because the items on each card stand in the *same-as* relation to one another. The cards on the right are alike because the items on each card stand in the *different-from* relation.

As adults, this is a highly natural and automatic way to think of these cards. We recognize the abstract similarity of these cards despite the fact that they share very few perceptual features. Studies investigating this ability with children have suggested that children are not able to recognize these abstract similarities until age 5.

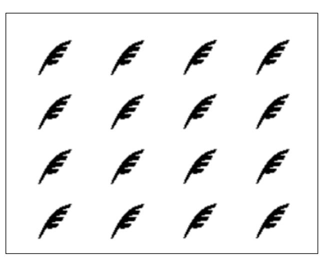
Similarly, non-human animals are unable to succeed at this type of task, even with extensive training. However, recent studies have shown that baboons and pigeons can succeed at a similar task. In this task, the animal is shown two arrays, like the ones below.



Array 1

Array 2

On one array, all of the icons are the same and on the other, all of the icons are different. The animal is then shown a third array, like the one below (either an *all-same* or *all-different* array, and must select which one (of array 1 or 2) it goes with.

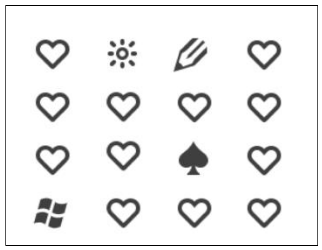


Array 3

Followup studies found that animals were not using an understanding of the relations between the items in the card to succeed at the task; rather, they were matching on the basis of a common perceptual feature in the two arrays: the degree of entropy. *Entropy* in this instance can be described as visual variability. According to this story, animals are matching the cards correctly because the *all-same* cards exhibit low entropy and the *all-different* cards exhibit high entropy.

We ran this study with children to see if children would be able to succeed now that the task does not require representing abstract relations. We found that without any instruction, 3-year-olds match *all-same* cards to the *all-same* card and *all-different* cards to the *all-different* card at rates that are significantly higher (but marginally different) from chance.

Currently, we are running a follow-up study that begins with a short instructional session. We are interested in seeing how children will generalize the rule they've learned to novel cards with intermediate degrees of entropy, like the one below.

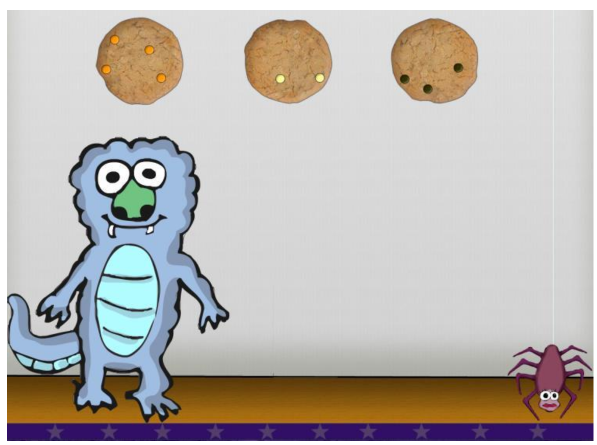


So far both 3- and 4-year-old children are highly successful at this task. We are still analyzing the data from the intermediate entropy cards to determine whether children are using entropy to succeed.

Teaching two and three

Rebecca Distefano, Lab Manager

Research has shown that children learn the meanings of number words long after they have learned to count to ten. For example, a two-year-old may be able to count a number of fish in a line, but if you then asked that child for one fish, he would likely give you a handful. While the timing of this development varies across children, by about two and a half years old many children understand the meaning of the numeral *one* and will correctly give you one fish when asked (one-knowers). About six months later, children understand *two* (two-knowers), and a few months after that, they have an understanding of *three* (three-knowers). Once children acquire the meaning of the numeral *four*, most understand all other numbers in the count list (i.e. they understand that the number they count to *is* the number of items in the set). In this study, we were interested in understanding why these meanings are acquired so slowly and what information children use to learn the meanings of the numerals.



To begin to answer this question, we attempted to train children on the next number in their count list and varied the types of feedback we provided to them during the training. We used a series of computerized take home training games to train one-knowers on the number two and two-knowers on the number three. In order to gain insight into what types of input facilitate this development, we had three different feedback condition: a language condition, a counting condition, and a visual feedback condition. In the language condition, we asked if the numerical markers in our language support this development (e.g. the distinction between singular "book" and plural "books"). In the count condition, we asked if counting in a training context helped children learn. Finally, in the visual feedback condition, we asked if being shown how the numeral maps onto objects in the real world (e.g. fingers) would facilitate number development.

Overall, the results show that children in the training condition improve more than children in the control condition (children who were trained on a numeral they already knew). This suggests that the training game might help improve number knowledge. However, there does not seem to be differences in learning among the three experimental conditions (e.g. lanugage, counting, and visual feedback), so at least from this study, we are not yet able to determine what types of information support this learning. Thank you to all the families who participated!

From copying actions to copying people

Narges Afshordi, Graduate Student

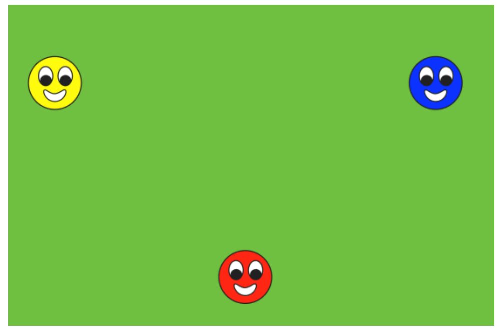
What do we see when we see a person imitate another? Do we see the copier as copying the specific actions of his or her target? Or do we see the copier as copying the other person, striving to resemble them as much as possible? As mature social observers, we see both. We understand that imitation happens when the specific actions of another are copied, but we also appreciate that the goal of the copier can be to copy the person in the abstract, regardless of the actions.

We know that babies like to imitate others pretty much as soon as they are born. Going back to the two levels mentioned above, do babies see imitation on the abstract level too, just like us? We asked babies this question by showing them cartoons featuring simple characters (which we know they like watching from previous studies in the lab). Babies saw Red copy the sound made by one of the top characters (say, Blue), but not the other one (in this case, Yellow). Afterwards, they got to see Red copy *both* Blue and Yellow after they demonstrated different ways of moving around. If babies understand that Red's goal is to copy Blue, they should not be surprised to see Red copy Blue again, even though the type of action has changed (from sounds to movements). However, they should be surprised to now see Red begin to copy Yellow as well. We measured babies' surprise or lack thereof by comparing the amount of time they look at the expected and surprising scenes.

We tested 10-month-old babies in this study and they do not seem to distinguish between the two scene types at test. This may suggest that these babies are too young to understand imitation in the abstract sense. It may also be that the events were pretty complicated for them. We are in the process of revamping this study and trying a simpler version on older babies, so stay tuned!

Approach as a goal-directed social action

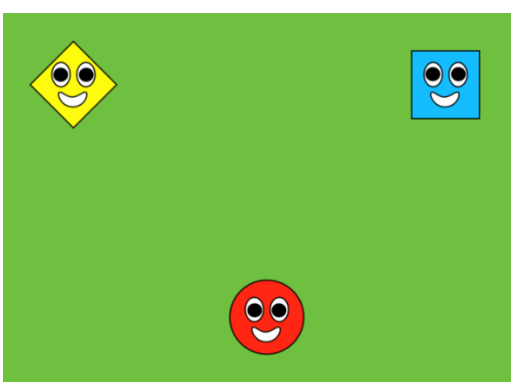
Shari Liu, Graduate Student



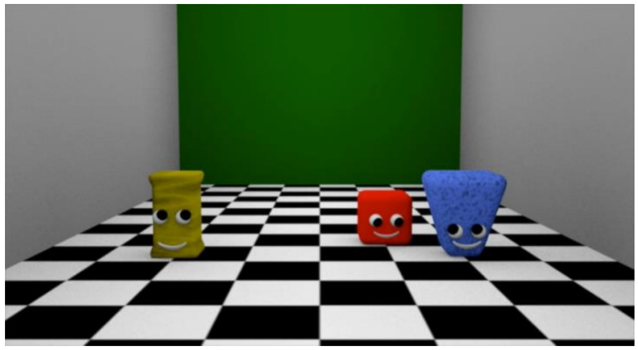
Even though infants are limited in their ability to carry out their own goals, they seem to be very attentive to the goal-directed motion of others. For instance, after seeing a hand selectively reach for a bear over a ball over and over again, infants expect the hand to reach for the bear after the objects switch locations. That is, they seem to understand something about reaching actions as directed towards specific goals (the bear, no matter where it is) rather than arbitrary locations in space.

We were curious about whether this sensitivity to goal-directed action extends to approach actions, and social approach specifically. The logic of this study is similar to the bear vs. ball scenario described above: After seeing a character (Red in the two images below) move towards one social partner over another (say, Blue), do babies expect the character to approach the Blue again when the social partners switch positions? To get at this question, we compared infants' looking time when the Red approached Yellow at the familiar location to when the Red approached Blue at the new location.

We tested this study with babies at two different ages: 3 months, and 7-9 months. We were interested in whether babies at these two different ages would interpret approach in a meaningful way, and whether this ability changes over time. In order to make the study as accessible as possible to each age group, we used different displays. For the young, 3-month-old babies, we used simple geometric shapes with eyes and a mouth that moved in a 2D plane (first figure below). To keep the older babies interested, we showed them more complex and interesting scenes with 3D looking characters that moved in a 3D space (second figure below).



Data collection is still ongoing with the younger babies, and we hope to have findings to share soon! With the older babies, we found that infants looked equally to these two events. Specifically, they did not recover their attention when the character chose to approach a novel social partner. There are several ways to interpret this finding. It could be that infants did not interpret our events in the way that we intended—perhaps it was difficult for them to track who was where. Another possibility is that infants do not have robust expectations about approach behaviors in the same way that they do for reaching behaviors. A third is that they do not think about social goals in the same way that they think about object-directed goals. We are currently trying to distinguish between these possibilities by modifying our movies and seeing what new groups of babies think about the changes!



Social interactions: Infants' preference for imitators

Heather L. Kosakowski, Undergraduate

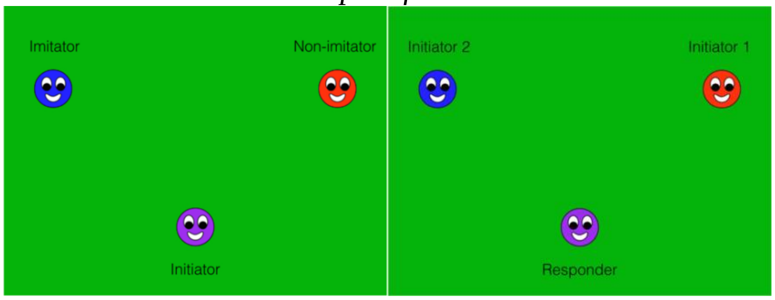
The social world is a complex environment for babies, children, and, sometimes, even adults. Yet, every human is able to navigate a variety of social interactions in a variety of environments. There are several factors that facilitate social interactions such as a shared language, interests, and even body language. One well-studied phenomena that facilitates social interactions is known as non-conscious behavioral mimicry, or imitation. While we know infants like to be imitated and even engage in imitation, little research to date has directly asked what infants think about imitation when they are not part of the imitation (third-party imitation). That is, what preferences do infants have when they observe, rather than engage in, social interactions that involve imitation? In our last newsletter, Lindsey Powell, PhD, reported findings in which infants expect characters to like the character that imitated him better than a character that didn't. She additionally showed that infants' have a preference for imitators compared to non-imitators when they are observing the social interaction. As a follow-up to her work, the studies presented here are to further probe infants' third-party imitator preferences in three ways: by reversing the order of imitation in the animation, by manipulating visual access, and by using actors rather than animations. By reversing the order of imitation in the animation study Dr. Powell reported last year, we are able to probe infants' to determine if they have a preference for imitation in general or if there is something special about imitators. To determine if infants like imitators rather than characters that accidentally copy behavior, we conducted studies manipulating what the imitator and non-imitator are able to see. Finally, to see if these data are generalizable to humans and not just animated characters, we are conducting a series of studies investigating infants' third-party imitator preferences using actors.

<u>Infants' third-party imitation preferences</u>:
Study 1: Last year, Dr. Powell conducted a series of studies to determine if four-month-old-infants have a preference for imitators or non-imitators when they are observing the social interaction. When infants came in for this study, they sat in a car seat in front of a screen. Once settled in, a green screen appeared featuring three characters – the initiator, the imitator, and the non-imitator. Infants watched a sequence of events in which the initiator would produce a sound (e.g. *ping*) and jump up and down. Then the imitator would respond by producing the same

sound (e.g. *ping*). The initiator then repeated his sound and the non-imitator responded by producing a different sound (e.g. *boing*). Infants saw this sequence of events four times. At the end, the experimenter came out and presented the infant with physical versions of the blue character and the red character and conducted a preferential looking test. As reported last year, Dr. Powell found infants spend longer looking at the imitator than the non-imitator.

Study 2: While these data are consistent with findings other findings from this lab, it is possible that the longer looking time to the imitator is a preference for similarity of behavior or repetitive actions and isn't about intentional imitation. To test this, we ran a second condition in which we reversed the order of imitation. In this condition, initiator 1 jumps up and down and produces a sound (e.g. *ping*) followed by the responder jumping up and down and producing the same sound. Then, initiator 2 jumps and down and produces a different sound (e.g. *boing*) followed by the responder jumping up and down and producing the same action he did the first time (e.g. *ping*). In this way, the responder is imitating initiator 1 but not initiator 2. Again, we showed infants this sequence of events four times followed by a preferential looking test using physical versions of the blue and red characters. For this condition, our overall results indicated no difference in the amount of time infants spent looking at both of the initiators. These data indicate infants do not have a preference for a character that is imitated. Combined, these two studies provide interesting evidence indicating infants as young as four-months-old have a preference for characters that imitate but not for characters that are imitated.

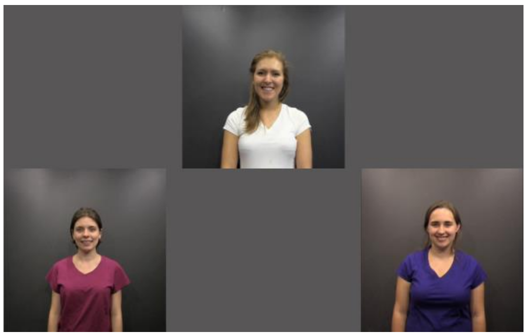
Example of stimuli



Study 1 *Study 2*

Imitator preferences and visual access:
Last year, Dr. Powell also reported findings in which 12- to 13-month-old-infants had a preference for the imitator when the imitator could see the initiator. However, the preference disappeared when the imitator was unable to see the initiator. To manipulate the visibility of the action produced by the initiator, gray animated screens came down to cover the imitator and non-imitator. Then, in the visual access condition the screens went back up before the initiator performed his action. In the condition without visual access, the screens went back up after the initiator completed his action so that the imitator and non-imitator would be unable to see the action the initiator produced. These findings indicate infants' imitator preference requires an intentional act of imitation and not merely an accidental act of copying behavior. To further probe these findings, we conducted this study in 6- to 8-month-old infants. We did not reach significance for the imitator preference in either the condition with visual access or the condition without visual access. While these results may seem surprising initially, it is possible that the movement of the screens complicated the animation and made it difficult for the infants to track which character was doing which action.

Infants' imitator preferences with people:
Our findings regarding imitator preferences this far are exciting! But, our primary hypothesis is that imitation is an important feature of social human interaction that infants as young as four-months are able to recognize and display a robust preference for. Therefore, our understanding of infants' imitation preferences will be strengthened if we replicate this study using actors instead of animations. For our last set of studies we want to know if infants' imitator preferences emerge if we used videos of people rather than animations. We recorded videos of three different people performing actions that were modified from American Sign Language. Just as in the animated version, the initiator (in this case, the actor with the white shirt) performs an action then the actor with red shirt responds by performing the same action (imitator). Then the actor with the white shirt performs the same action she did the first time followed by a response from the actor with the purple shirt doing a different action (non-imitator). Infants saw this sequence four times and then we conducted a preferential looking test and gave infants 20 seconds to look at both the actor with the red shirt (imitator) and the actor with the purple shirt (non-imitator). We then measured how long infants spend looking at each person. Preliminary data suggest infants spend longer looking at the imitator than the non-imitator!



Example of stimuli with actors

An interesting question we got from many parents was if infants have a preference for one actor over the other because they might like that actor better or they might like a specific action better. Data suggest infants do not have a baseline preference for either actor or action. However, to control for that possibility, we showed different infants different scenarios. Some infants came in and saw a video in which the actor with the red shirt was the imitator while other infants saw a video in which the actor with the purple shirt was the imitator. In this way, if infants do have a preference for a specific actor or action, it would not be likely to bias the results.

To further probe if infants demonstrate a preference for imitators and not imitation in general, we conducted a second condition in which we reversed the order of imitation. In this study, the actor with the red shirt performs an action followed by the actor with the white shirt performing the same action. Then, the actor with the purple shirt would perform a different action followed by the actor with the white shirt performing the same action she did the first time. In this example, the actor with the white shirt is imitating the actor with the red shirt but not the actor with the purple shirt. We have just started collecting these data so hopefully we will have something to report in our next newsletter!

For our final study using videos featuring people, we asked older infants (9- to 10-months-old) if they would also have an imitator preference using a toy choice measure. In this study, after the actors performed their actions, the imitator and the non-imitator demonstrate their interest in a toy and then point to the same toy sitting on a table in front of the baby. Previous studies using this method have shown infants will choose a toy from the person they like better! In this way, we will be able to further probe the social aspect of infants' third-party imitation preferences. We just started collected data for this study and we to have exciting data to tell you about next year!

Causes of behavior

Larisa Heiphetz

Earlier studies in our lab showed that religious background has different effects on how children and adults judge religiously and secularly motivated behaviors. In this prior work, 5- and 6-year-olds reported slight preferences for characters whose behaviors were motivated by religious reasons (e.g., wanting to make God happy) rather than secular reasons (e.g., wanting to make their parents happy). This pattern emerged for children from religious as well as secular homes. However, by adulthood, we saw sharp differences based on religious background. Religious adults, similarly to children from religious backgrounds, showed slight preferences for religiously motivated characters. Meanwhile, secular adults showed very strong preferences for secularly motivated characters.

The purpose of the current study was two-fold. First, we wanted to see whether we would find similar results in a new sample of children and adults. Second, we wondered whether people's evaluations of religiously versus secularly motivated characters were driven by the fact that most people in the United States are religious. To answer this question, we told half of the participants that many people are religious, and we told the other half of the participants that many people are not religious. Both stories were true (for example, although *most* people in the United States are religious, it is still true that *many* people don't believe in God), but they emphasized different aspects of our diverse culture. Then we asked participants how much they liked people who performed behaviors for religious reasons and people who performed exactly the same behaviors for secular reasons, in just the same way as we did in our earlier study.

Again, we found that children from religious and secular backgrounds expressed slight preferences for religiously motivated characters, that religious adults also expressed slight preferences for religiously motivated characters, and that secular adults expressed strong preferences for secularly motivated characters. These patterns were not influenced by the information participants heard in the first part of the study, suggesting that our results are not due to the perceived prevalence of religious versus secular individuals.

Children and adults' ability to understand hierarchical relationships

Marine Buon

Social beings consistently have to deal with the social group they are part of. Despite the clear advantage of cooperating and coordinating with others, within group competition is commonplace given that resources are limited. For instance, children may argue and compete with each other to decide who is going to eat the last cookie, or to decide whether they will play football (which is John's favorite sport) or volleyball (which is Robin's favorite sport). However, rather than arguing all the time, it is useful for human being to develop the capacity to judge accurately their own relative ability to compete with other group members and to behave accordingly. To do so, it has been hypothesized that adults and children use the information they collect by witnessing interactions between individuals to analyze and predict subsequent interactions involving either the same individuals or involving only one of those individual and a new one. In this context, the aim of our study was to explore whether and how children and adults are able to take advantage of the information they gathered from witnessing interactions between given pairs of individuals, by presenting them with new interactions between known agents. Put simply, if individuals see A dominating B, B dominating C and C dominating D, will they infer any dominance relationship between B and C, even if they never saw B and C interacting?

To explore this possibility, children and adults were presented with pictures of children who are at the zoo. We specified participants that at this zoo, children always have to be in pair. In each pair, conflicts between the children occur and one of those always won: for instance, Jason (A) wants to see the giraffe whereas Mike (B) wants to see the elephant (figure 1a). Finally, they are going to see the giraffe, so Jason 'won' the conflict over Mike (A>B, figure 1b). The same outcome happens when they both want to get closer to the giraffe, to feed the giraffe, etc. Using this simple procedure, children were repetitively presented with 5 pairs of children whose interactions were characterized by an asymmetric relationship (A>B, B>C, C>D, D>E). In a critical test phase, children were presented with new pairs of children (B-D, A-D, C-E) and asked to predict who will 'dominate' in case of conflict, For example, they were told 'Look, this is B and D together. They both want to get closer to the lemur but only on can go because there is no so much space there! Who do you think will get closer to his animal?

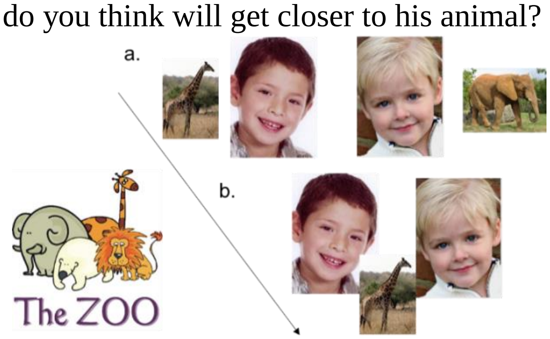


Figure 1: pictures presented to children to depicted the asymmetric interaction between Jason (one the left) and Mike (on the right)

In favor of our hypothesis, the results indicate that both children and adults were able to use information gathered from witnessing interactions to predict a conflict involving a new pair of individuals. However, whereas adults used information about both characters' losses and wins to predict the issue of a conflict involving a new pair of individuals, children use a simpler and less precise strategy : if an individual lost once, he is unlikely to win any conflict in future interactions. This finding thus suggests that even if children are clearly active in their interpretation of the social world, their ability to infer social dominance relationships become more and more complex and precise with age and cognitive development.

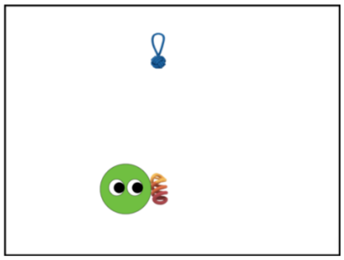
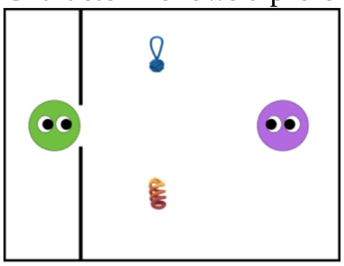
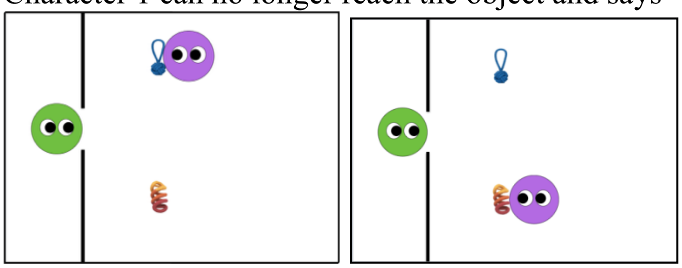
Infants' understanding of communication

Alia Martin, Post-Doctoral Fellow

What do infants understand about communication? Previous research has found that Infants are tuning into important features of the social world surrounding them from a very young age. For instance, infants prefer listening to speech sounds over other types of sounds from the time they are born! This sort of "bias" to pay attention to particular types of information likely helps to guide infants toward things they need to learn about — for example, identifying their own native language and the types of sounds it contains, or noticing the contexts in which people use different kinds of speech.

Interestingly, there is now evidence that infants recognize the role of speech in communication even before they are doing much talking themselves. In previous studies, 6- and 12-month-old infants watched a actor reaching for one object over another, 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 gave 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. It seems like infants understand that speech can be used to communicate between social partners, but they don't have any such expectation for nonspeech sounds at these ages.

This past year, we've been running a study to ask whether infants' expectation about the communicative capacity of speech applies to all social partners, or whether it's specific to their experience with the structure of human social interactions. Infants between 13 to 15 months of age watched a modified version of the communication study described above, but using animated shape characters with eyes instead of human actors. How abstract are infants' expectations? So far, when infants see one character produce speech, they do not expect a second character to provide the first character's preferred object. Follow-up studies are ongoing, but it's possible that infants at this age have particular expectations about the power of speech to communication information between humans.


Character 1 shows a preference for the orange object.

Character 1 can no longer reach the object and says “koba!” to Character 2.

Character 2 gives Character 1 the preferred or nonprefered object.

Infants’ inferences about emotional responses

Infants are bathed in a world of emotional information from the time they are born. However, research with infants has consistently suggested that until about 14 months of age infants are not particularly good at predicting others’ behavior based on their emotional expressions, and are better at doing so based on their previous actions! For example, if 6-month-old infants see an actor repeatedly reaching for one object over another, infants look longer if the actor later reaches for the dispreferred object, suggesting that they expected the actor to show a continued interest in one object. On the other hand, even at 12 months infants who see an actor repeatedly expressing happiness while looking at an object and unhappiness while looking at another do not show any expectation about the actor’s later interest in the objects. At 14 months, infants can predict someone’s interest in an object based on her emotional expression.

One possibility is that an understanding of emotion as directed toward particular things in the world is just relatively late to develop in contrast to some types of action understanding. Yet another possibility is that infants do have some understanding of emotion early on but aren’t using it to reason about interest in objects. Perhaps infants are able to use emotional information to reason about social interactions, however, since emotional expressions are communicative and frequently directed at people rather than things? In this study, 7- and 11-month-old infants watch simple sequence of events with 3 animated shape characters: a top character and 2 bottom characters. Infants first see 3 identical events where the top character responds to one of the bottom characters with a positive emotion, using positive tone and language ("Yay! I like you!") and then responds to the other bottom character with a negative emotion, using negative tone and language ("No! I don't like you!"). Infants then watch alternating events where the top character either dances with the "positive" bottom character and then with the "negative" bottom character. After each dance, we measure how long infants stare at the screen before looking away. Will infants make predictions about who the top character will affiliate with based on the emotional displays? This study is still new, but we look forward to finding out how infants respond! Thanks so much for your participation!

The role of hand movements in arithmetic

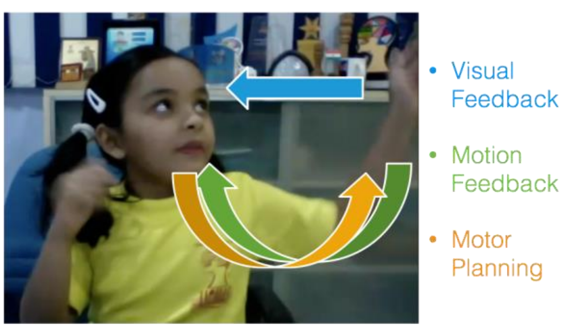
Neon Brooks, Postdoctoral Researcher

A child using an abacus in India.

Gestures and hand movements can have a profound impact on learning and problem-solving. In the study, we are investigating *how* hand movements can influence mathematical reasoning. We are interested in the effects of hand movements on math in two groups: school-aged children in India who use a *Mental Abacus* technique to perform arithmetic by imagining the movements of beads on an abacus, and school-aged children in the US who use conventional strategies to solve arithmetic problems.

On the basis of past research, we predicted that children who spontaneously used their hands would benefit from doing so in both groups: for the Indian children, these movements typically mirrored the movements necessary to move beads on an abacus, while in US children they typically represented the strategy of counting on one's fingers.

We were particularly interested in how hand movements come to influence children's reasoning. One possibility is that children receive feedback from producing the movements themselves: either seeing their movements or feeling them in space could generate new information that children can use to succeed on the task. Another possibility is that the critical aspect of these movements is the planning that goes on in the brain before they are produced: in this case, children should do just as well when we have them keep their hands still but allow them to plan movements, but do much worse when we force them to do a different task with their hands (tapping on a keyboard) while they are solving math problems.



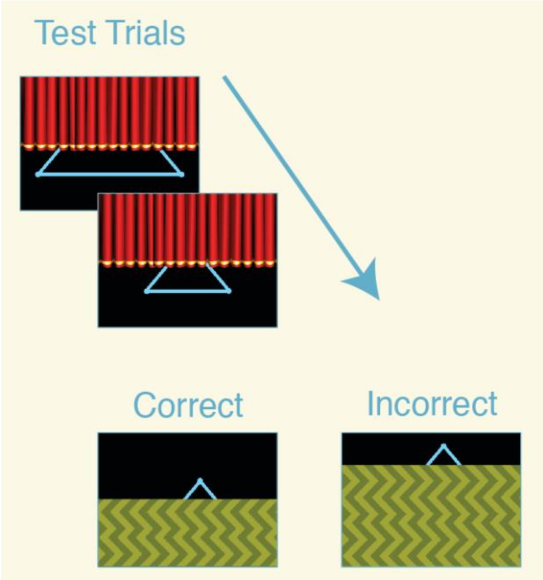
We found that both Indian *Mental Abacus* users and US children who counted on their hands showed the second pattern: they were able to solve math problems fine with a blindfold on, or with their hands still on the table, but performed much worse when they had to do a tapping task on the keyboard at the same time. By contrast, US children who did not count on their hands did not appear to rely on motor planning resources to do the task: they did just as well in the tapping condition as when they were allowed to move their hands freely.

These results suggest that across two very different populations doing math in two very different ways, the planning, but not the execution, of hand movements has a large impact on mathematical reasoning. This research gives us some insight into the ways that moving our bodies can influence thinking and learning.

Infants' detection of shape changes in triangles

Moira (Molly) Dillon, Graduate Student
Neon Brooks, Postdoctoral Researcher

Some geometric knowledge takes a long time to develop, such as explicit judgments about the properties of triangles. However, other geometric knowledge, such as an implicit sensitivity to changes in relative length, are present very early in development (e.g., see "Infants' detection of geometric properties" in this newsletter). Could early sensitivities to geometric information in infancy also support implicit knowledge about the shape properties of triangles when they're transformed?



In this study, we are testing whether 11-13-month-old infants recognize that the top corner of a triangle should move up or move down when the triangle is scaled up or scaled down respectively. Infants see only the bottom two corners of the triangle during the transformation, and they are then shown the top corner of the triangle either in the correct location or in the original, incorrect location. Since infants tend to look longer at things that surprise them, we hypothesized that infants would look longer when the top corner was in the incorrect location.

The first group of infants we tested showed the hypothesized pattern of looking! However, this finding was very fragile: When tested with any other change (e.g., a scale change of a different size; or, an angle change to the bottom two corners), infants did not detect a difference in the outcomes. We are now in the process of altering these animations to help infants represent the shape changes in a more robust manner. Check out our update next year!

Infants’ detection of geometric properties

Moira (Molly) Dillon, Graduate Student
Neon Brooks, Postdoctoral Researcher

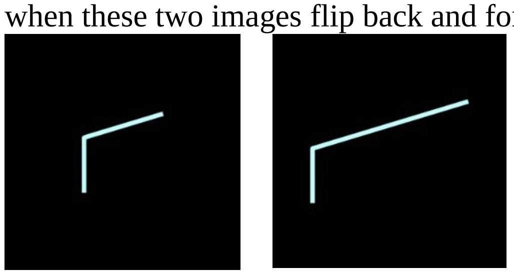
Infants’ brains come equipped with certain spatial abilities very early in development. One such ability is the recognition of objects by their shapes. But, what specific geometric properties are infants using, and how might this early sensitivity to geometric information form the building blocks of later geometric understanding?

In this study, 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 two figures changing shape, such as two differently shaped triangles. On the other side, there were two figures of the same shape but changing size, such as two similar triangles. We measured how long infants looked at the shape-change versus size-change image stream. Since infants tend to look longer at things they find interesting, we used this design to see whether infants detect and prefer shape changes.

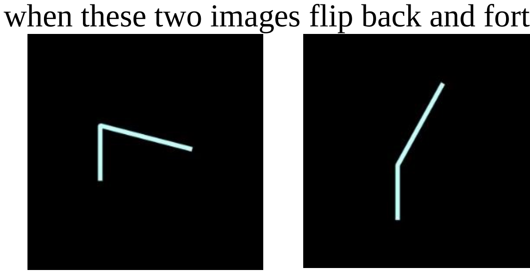
We completed four different studies using this paradigm in the past year! The first replicated our findings from last year that infants look longer at a triangle changing in shape. But, since we’re interested in the specific geometric information driving this preference, we conducted three more studies that isolated changes in relative length or angle. Infants detected relative length information, but showed *no* sensitivity to angle information! We think this insensitivity early in development makes sense when we consider that older children, up to age 12 years, have difficulty describing angles and their properties, but not relative lengths.

In addition to determining whether infants as a group detect these shape changes, we also measure individual preference scores for the shape-change stream. Families who participated in this study may get a call back from us in a couple months to see if such preferences are stable through infancy. Listen for our phone call!

Infants detect a change in relative length when these two images flip back and forth



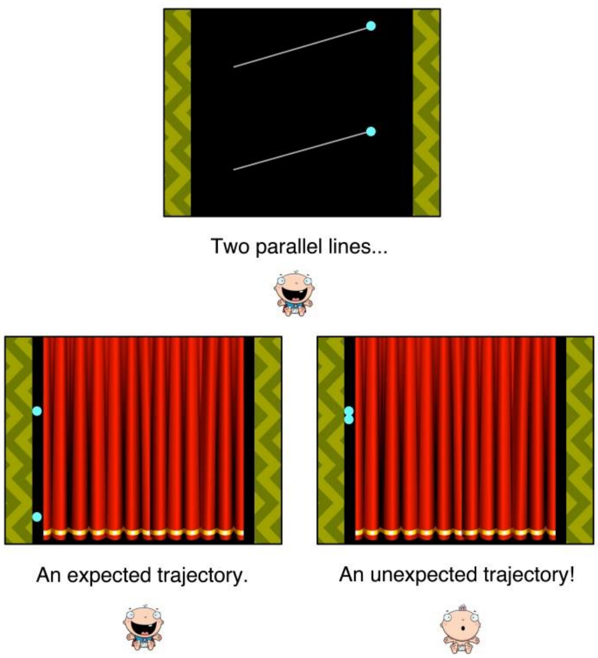
But infants do not detect a change in angle when these two images flip back and forth



Infants' inferences about parallel and skew lines

Moira (Molly) Dillon, Graduate Student

Can infants predict that, if extended, parallel lines should never touch, but skew lines should? Basic predictions about geometry are not only important for everyday interactions with the spatial world, but also for the comprehension of geometric concepts that are more abstract. By age four years, infants are able to explicitly judge that parallel lines should never touch but that skew lines should. Does this sensitivity emerge earlier? And if so, how abstract is it? In answering these questions we can determine how close implicit, early-emerging geometric sensitivities might be to the kinds of abstract and challenging geometric generalizations we ask children to learn much later in school.



Twelve- to sixteen-month-old infants participated in this study. They viewed an animation presenting two lines and balls that moved along the trajectories of those lines. After conveying that the balls always move along the trajectories of the lines, we presented either parallel lines or skew lines, we covered them with a curtain, and then presented two possible outcomes. One was expected (e.g., balls didn't touch after continuing the trajectory of parallel lines) and one was unexpected (e.g., balls touched after continuing the trajectory of parallel lines). Because infants tend to look longer at things that surprise them, we measured how long infants looked at the expected versus unexpected outcomes.

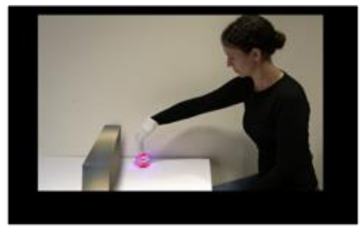
We haven't yet finished data collection on this study, but at the moment there appears to be a trend for infants looking longer at the unexpected trajectories. That being said, the animations we used require infants to hold a lot of information in short-term memory (sometimes we experimenters even forget which is the correct outcome!) so we are improving our animations to alleviate some of this memory demand. Look forward to our update next year!

Infants' reasoning about touching events

Neon Brooks, Postdoctoral Fellow

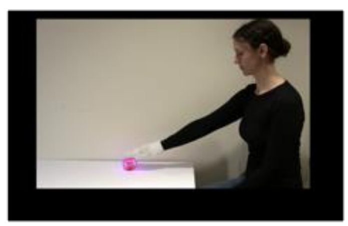
4-month-old infants can reason about the goals of other people: they expect a person to reach for the same object even if it changes position. However, infants only show this expectation once they are able to reach and grab objects themselves.

Research has not explored whether infants are able to represent goals in other contexts before they can understand reaches. In the current study, we are investigating how 3-month-old infants interpret action events in which an actor touches a toy to cause it to light up. Infants get a great deal of experience with touching objects before they are good at reaching and grabbing things, so we predicted that infants may see these actions as goal-directed even earlier than they do with reaching actions.

Efficient Reaching Condition Inefficient Reaching Condition

Infants watched scenes of an actor reaching over a barrier to touch a ball, causing it to light up. Then the barrier disappeared, and infants watched scenes where the actor reached directly to the ball, or continued to reach in an arcing motion as before. If infants see the actions as goal-directed, they should expect the actor to reach efficiently, and look longer when she continues to reach in an arc. In a control condition the barrier is behind the object, so we do not expect infants to make any predictions after the barrier is removed.

Inefficient Test Trial Efficient Test Trial

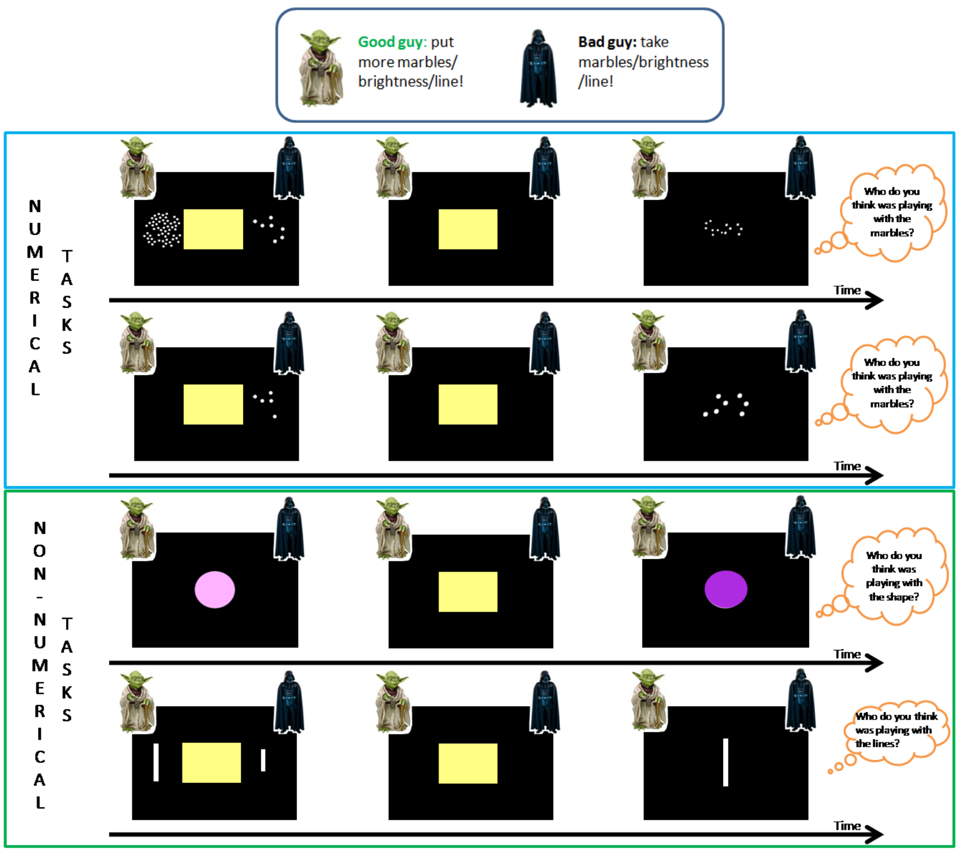
Results are still being analyzed and we are starting on a follow-up study where infants actually interact with the ball themselves before seeing the events. Stay tuned to hear how it turns out!

Expectations about numerical and non-numerical training

Ana C. Pires, Visiting Graduate Student
Moira Dillon, Graduate Student

Do children have expectations about the effects of cognitive training? This study investigated children's expectations about what might help them perform better in mathematics. Previous studies in our lab have shown that about 15 minutes of practice adding or comparing dot arrays based on their number improves both accuracy and speed on a symbolic addition test immediately after training. However, other research has shown that children's performance in school mathematics is affected by their expectations and motivations. Here we ask whether training on adding or comparing dot arrays affects children's performance of exact, symbolic mathematics simply because children who received this training approach a symbolic mathematics assessment with greater expectations and confidence. This question is important both for developing accurate causal theories of numerical development and for teaching mathematics in school.

Children were first asked to complete 2 assessments: one in which they answered 1- or 2-digit symbolic addition problems and a second in which they indicated which of two dot arrays was larger in number. Next, children saw practice trials from each of four training tasks that were used in the initial study showing positive effects of numerical training (see Figure below). After an introduction to each of the four training tasks in the original study, children were asked whether, after playing that training task for a while, they thought they would get more, fewer, or the same number of questions right on assessments (described above) and whether they would answer more quickly, less quickly, or in the same amount of time. Finally, as a manipulation check, children were asked to consider these same questions after a great night's sleep and their favorite breakfast, or after little sleep and no breakfast.



Children's expectations about training were systematic but did not align with the previously observed training outcomes, i.e., in general, they expected to improve in test accuracy by playing any training task. They did not take into account if they played numerical or non-numerical training tasks in order to improve on the numerical assessments.

These findings allow us to conclude that the connection between non-symbolic numerical practice (i.e., adding or comparing dot arrays based on their number) and improved performance on symbolic arithmetic is not due simply to children's expectations about training. This strengthens the causal link between such early-emerging representations in the numerical domain and the kind of numerical operations that children are expected to learn in school.

Lullabies and play songs

Samuel Mehr, Graduate Student

Around the world, parents sing lullabies to calm their infants and play songs to excite their infants. What do infants understand about how parents use these different types of songs? In this study, we introduced 15- to 18-month-old infants to two large animated characters (the "parents") and one small animated character (the "baby." In this summary we refer to babies participating in the study as "infants" and the animated baby character as "the baby."). Each parent took a turn singing a song while rocking back and forth with the baby. The songs were obscure lullabies or play songs, so that the infant observing the animated characters was never familiar with the song itself. So, what made the lullaby count as a lullaby, for instance, was that it was slow, soothing, and included words about going to sleep — *not* because the infant had already learned that this particular song was associated with soothing and sleeping. After each parent sang her song, the baby began crying and jumping up and down.

We tested which parent infants expected to approach the baby to calm him down. To examine this behavior, we used two standard measures from developmental psychology: anticipatory looking, where infants quickly glance at the event they think will happen next, and violation of expectations, where infants stare at unexpected events for long periods of time. If infants expect the lullaby-singing parent to comfort the crying baby, they should glace at that parent while the baby cries, and not to the other parent. Then, once the comforting action occurs, they should look longer at the animated events in general when the playsong-singing parent comforts the crying baby, but not to the expected event, where the lullaby-singing parent comforts him. The study is still in early stages, so we don't yet know if infants are consistently responding in this fashion to the study, but we will soon! Thanks to all of our wonderful families for participating!

Music and Social Cognition (3mo, 5mo, 10mo, 15-22mo)

Samuel Mehr, Graduate Student

Infants are avid fans of music, but little is known about what information musical experience provides to young listeners. In this series of studies, we asked whether infants selectively respond to adults with whom they share musical knowledge. We found interesting but obscure/unfamiliar songs and familiarized infants to just *one* song: either by teaching the parent to sing the song, or by giving the parent a small stuffed animal that played a recording of the song. Then, depending on age, we tested infants in one of several paradigms designed to probe infants' social responses to novel people who had previously sung the song the infant learned in the study.

The studies had three parts: an initial lab visit, a period of at-home exposure, and a follow-up visit. At the initial visit, parents were either given a music lesson or a musical toy. Parents also filled out questionnaires about demographics, arts activities, opinions about the arts, and infant behavior at home. After the initial visit, there was a 1-2 week period during which we asked parents to sing their song with their infant, or to play the toy for their infant. To help us keep track of how much exposure the infants had to the song, parents also completed a brief survey each evening. After 1-2 weeks, parents and infants returned to the lab for a follow-up visit, where we collected looking time data from infants in several ways, detailed below. In each case, infants saw two novel adults singing each of two songs. Critically, because we had randomly assigned infants to learn *one song or the other*, only one song was familiar to the infant at the time of testing.

3mo and 5mo infants

These young infants had the simplest test. After each woman sang, we showed infants videos of the two women side-by-side, standing silently, and tracked how long infants would look to each singer. We gave infants a maximum of 16 seconds to look. Our results indicate that at 5 months infants selectively attend to the singers of the familiar song, over and above the amount attributable to chance, and over and above any initial preference for one person over the other – but only when they learned the song from a parent, and not when they learned it from a toy. That is, despite comparable levels of familiarity with the song, from an attractive toy, those infants who didn't learn the song in an explicitly social context didn't display an attentional preference to the singer of the familiar song.

At 3 months, the results are a bit fuzzier. While these younger infants appear to show a preference for the singer of the familiar song in the parent-singing condition, their interaction with the toy indicated that they may not have realized that the musical toy was producing the song. So, even if we see a comparable result to the 5-month-old result (above), it won't be clear that the lack of attentional preference at test is because of the context of their musical learning – it might just be that 3-month-olds don't really understand toys. We are now planning a new study in which we are building musical mobiles, which this very young age group may be more familiar with.

10mo infants

Here, we took advantage of 10-month-old infants' interest in objects and reaching by giving them the opportunity to choose between objects associated with two new singers. As in the younger groups, first each of two women sang a song, only one of which was familiar to the infant. Then, we showed infants the two women standing together, each playing with an attractive toy (we used both stuffed animals and toy fruits). They smiled at the toy, showed the toy to the infant, smiled at the infant, and then pointed to a table in front of the infant, where two identical toys were sitting. At this point, the researcher gently pushed the infant's high chair forward so that he/she could choose between the two objects. We coded the number of reaches for each toy, the amount of time spent playing with each toy, and the duration of looking time toward each toy.

This study is still in progress, but preliminary results suggest that infants in *both* groups – parent-singing and toy-singing – show a stronger interest in the toys associated with the singer of the familiar song than the singer of the unfamiliar song! We don't yet know if this result will hold up, as we're currently only halfway done running this study. If it does, it may suggest that by 10 months of age, infants have learned that the objects their parents present to them are meaningful sources of information – or there might be some simpler, less interesting explanation, such as an increased interest in toys in the toy-singing group, primed by the infants' extra exposure to musical toys during the study.

15-20mo infants

In this oldest group of infants, we used a *selective pedagogy* paradigm to test whether infants would be more likely to learn a new action from a person who had previously sung a familiar song than from someone who had sung something else. We introduced infants to two research assistants in the lab who each subsequently sang a song. As in the above paradigms, only one song was familiar to the infant. Then, the research assistants demonstrated two different actions on a novel object, and gave the infant the opportunity to play with this object. We coded the number of imitative actions for each singer, as well as the amount of time spent imitating each singer. This study has only just begun, but we predict that infants in the parent-singing condition will be more likely to imitate the actions of the singer of the familiar song than the infants in the toy-singing condition. We'll keep you posted on the results!

Long term follow-ups

Lastly, we have begun running brief follow-up studies for many of the infants who participated in our music studies over the last year and a half, when they were 5 months old. The goal of these follow-up studies is to provide a manipulation check to the original findings, to determine (1) whether infants remember the song and (2) if so, whether they will display a social preference for the singer of a familiar song, even upwards of a year after the original exposure to the song. Infants whose parents sang in the original study are tested in the 10mo paradigm described above – if they remember the song, we expect a preference for the objects associated with the singer of the familiar song. Infants whose parents played a toy in the original study are given a quick discrimination task, where they play with two stuffed animals from the original study, only one of which is familiar to them – if they remember the toy's song, we expect a difference in looking time to each toy. The follow-up studies are still in progress, but so far it looks like infants do indeed have impressive memories for the song!

Importantly, infants' exposure to the song over the last 1-2 years differs widely between different families in the study. We were very interested to learn that everyone's participation in the study was a bit different: after the original study ended, some parents continued singing the song from the study for a long time, some parents sang it once in a while, and some parents didn't sing it at all. This means that the infants across the whole parent-singing cohort have a very wide variety of experiences with the song. This variety isn't present, though, in the toy-singing cohort, because the parents returned the toy to the lab at the end of the study, so we will likely see very different responses to the songs from the infants in each group.

What does it all mean?

While this line of work is just getting started, our first results suggest that infants attribute social meaning to the songs they hear from people, but that that social meaning is not necessarily present in the auditory signal of the song itself. If it were, we should see comparable levels of social attention at test regardless of how infants learned their songs (from a parent or from a toy). We didn't: 5-month-old infants who learned the song from their parents were more likely to attend to the singer of the familiar song than those infants who learned the song from a toy. We're following up on that striking result with the other studies detailed above, which aim to determine the degree and extent of that effect in different age groups, with different musical material and different testing methods. These studies are our current attempts to figure out how music works in infancy, which hopefully will yield clues as to how the human capacity for music came to be in the first place.
Last, and most important: A **huge** thank-you to all the parents and infants for their participation in our music studies!

For young infants, is music social?

Lee Ann Song, Honors Thesis Student
Sam Mehr, Graduate Student

Why has music persisted across time and culture in human societies? There is evidence suggesting that it may be because music conveys important social information, and that vocal song recognition may be one way infants identify who is in their social in-group. Previous studies in this lab have exposed infants to an original lullaby—either by way of a parent who was taught the song and instructed to sing it to their baby for a week, or by way of a singing stuffed animal, which played the song when squeezed. Interestingly, we found that at the second visit, the infants who had been familiarized to the lullaby by way of their parents singing paid more attention to a new singer of the familiar lullaby, whereas the infants who had heard the lullaby from a toy all week showed no preference for the new singer of the familiar lullaby. This suggests that it makes a difference whether infants learn a song from a social figure. But do babies simply like songs they've heard from their parents or is this a broadly social effect, such that live song exposure from *any* social partner induces a social preference for a new singer of that song?

This current study seeks to tease apart this distinction and investigates the effects of live non-kin musical exposure on infants' social cognition. It's a two-part study with a ten-day long break, during which the infant learns an original lullaby from a research assistant (not a toy or the parent) via daily Skype sessions to see if live, non-kin song exposure can induce the same selective attention effect as was seen in the parent-singing condition.

The families were sent home with an iPad and Skype-called for 10 minutes each day with the research assistant. During the Skype calls, the researcher engaged with the infant and sang intermittently. After 7-10 days, families returned to the lab for testing. Infants sat in their parents lap and watched a video of two new people singing each of the study's two lullabies—one of which was familiar to the infant. The two lullabies were very similar in timing and identical in lyrics but differed in their melody so to distinguish between the familiar and unfamiliar lullaby, babies must have recognized the difference in their melodies.

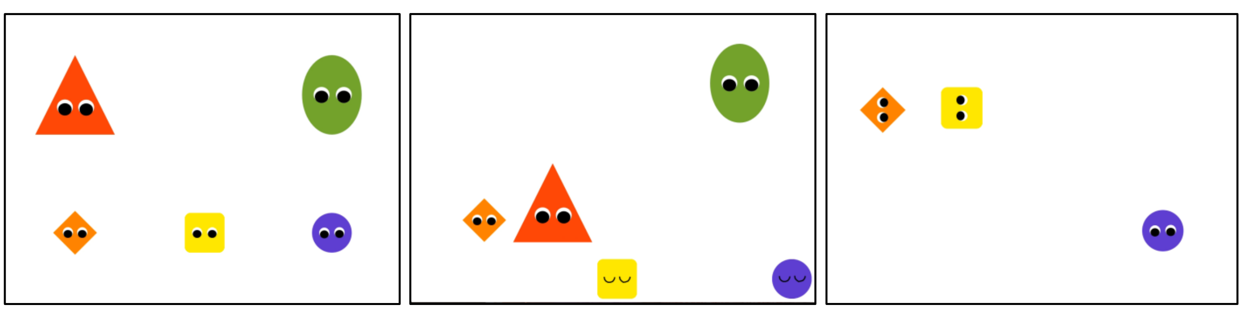
We did not find that infants who heard the song from the RA through Skype looked longer to the singer of the familiar song at test, suggesting that infants may attach more social significance to songs learned from their parents than songs learned from other social figures. However, there are many alternative explanations for these results. It is possible that concentrated virtual song exposure via Skype could not approximate the social effects of natural live song exposure, that the infants simply didn't hear the song enough times through Skype, or that infants could not learn the song through socially-contingent video.

A follow-up study is currently underway to test whether the infants from the study were able to remember the song they had learned through Skype many weeks after their first experiment. This time infants are shown two videos of the RA singing each of the two lullabies. We predict that infants will look longer to the RA singing the familiar lullaby. Future studies must parse whether infants' social preferences are guided by the social context in which they hear songs, the social relationship between infant and adult singer, or the medium through which the songs are transmitted. Though we did not find that infants used musical songs learned from unfamiliar singers to guide their social preferences for new people, infants' smiling behavior during Skype sessions suggests that singing through Skype can influence infants' affective states. In addition to its basic goals, this project provides an inquiry into the increased use of virtual communication and its consequences on early childhood development. Though video technology is becoming used more widely to teach and engage with young infants, so far, it seems that the most reliable way to influence infants' social and cognitive development may still be through live, intimate, and emotionally engaging interactions with their parents or primary caregivers.

Early understanding of social interactions & relationships

Annie Spokes, Graduate Student

In the past year, we have been working on a series of video animation studies looking at different social interactions and relationships. We showed animated shapes with eyes that were helping and nurturing each other or laughing and playing together to see how infants expect characters to interact. These studies included babies at 9, 11, and 15 to 18 months.



Animation Examples (from left): 1- Five characters in the video; 2- Example of a soothing event with red triangle soothing orange diamond; 3- Example of a test event with orange diamond & yellow square playing together

In one study with 15- to 18-month-olds, there were two large shapes that represented caregivers and three small shapes that represented babies. In the first half of the study, infants watch as each baby cries in distress, and one of the caregivers comes to soothe the baby. One caregiver helps two babies, and the second caregiver helps the third baby. Then, in the second part of the show, the babies now interact and play together. We alternated between showing two babies playing together who were helped by the same caregiver and two babies that were helped by different caregivers. We watched to see how long infants looked at these two types of events to see if they might look longer to one type. We found that infants at this age look much longer to interactions between babies with different caregivers, suggesting that they do not expect this interaction as much as interactions between babies with the same caregiver. We then ran another study where characters were laughing and playing together rather than being soothed, and infants no longer expected those who played with the same character to interact with each other in the future. There seems to be something unique to relationships that involve helping and soothing. We ran the same study with 9- and 11-month-olds and found that only the 11-month-olds seem to tell the difference between the social interactions in the test events.

We also ran a study with 15- to 18-month-olds with three caregivers and two babies: two caregivers soothed the same baby, and one caregiver soothed the other baby. In this study, infants are more surprised when caregivers with different babies interact as compared to the two caregivers with the same baby.

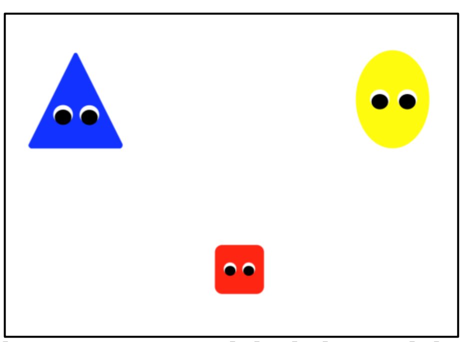
We are continuing studies with 11- and 15- to 18-month-olds to further explore these helping and nurturing relationships. For example, one study involves laughing and playing again but changes the timing of the events. Before, one character would start laughing and then stop when another came up to her. Now, the other character approaches her and then she starts laughing. We want to see whether the timing changes how infants interpret these social interactions. 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!

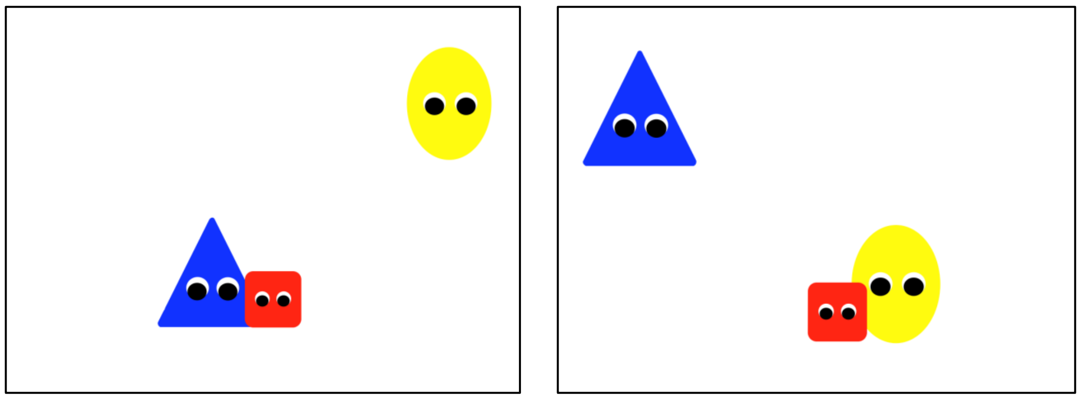
Understanding positive & negative emotions

Annie Spokes, Graduate Student

This new study started in the fall with 7- to 9-month-olds. The idea behind this study is to see how babies understand different kinds of emotions, like laughing versus crying. In addition to telling the difference between these two emotions, we want to see how babies interpret social interactions that involve these types of emotions. We do this with our usual animated characters (pictured below).



This show has three 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. This means that in one scene, the baby starts crying and then stops when the adult approaches, so it looks kind of like the adult is soothing the baby. In the other scene, the baby is laughing and then stops when the adult approaches. After showing these two scenes over and over until babies are bored, we then present the two adult characters and ask babies, "Who do you like?" We want to see if babies have a preference for the soothing adult or the adult who stops the baby's laughter. It took us a few different versions of this study before we finalized the animated show, so this study is still a work in progress. We look forward to sharing the results next time!



Animation Examples: Each adult character joining the baby character after the baby either cries or laughs. (Above) The three characters in their starting positions.

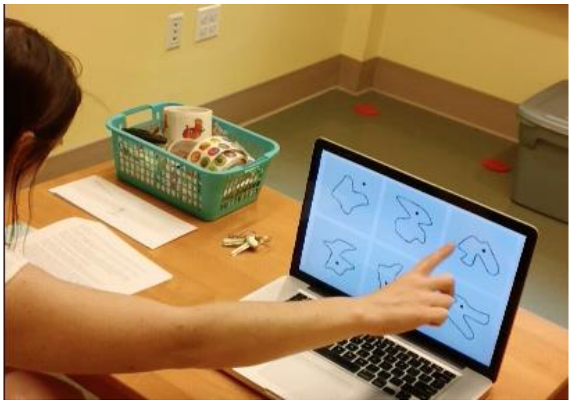
Working to benefit the self & others

Annie Spokes, Graduate Student

Examples from the Geometric Intruder Task

We ran a study this year with 4- and 5-year-old children looking at how much effort they are willing to exert to win prizes for themselves and other people. In this study, children play a geometric intruder game on the computer. We show them a group of six pictures that all have something in common except for one picture that does not belong. We ask them to point out which one is not the same as the rest. We have a big set of these games for them to play, but they get to choose when to stop. The more they play and get right, the more stickers they win. Sometimes children win stickers for themselves, and sometimes they win for other people.

In early versions of this study, we had children play the game once to win stickers for themselves or other people. More recently, children play the game three times: once for themselves and twice for other people. They play for family members—a parent or sibling, friends, or kids they have never met before. We are keeping track of how long kids play the game and how many they get correct so that we can look at how much overall effort they put in depending on who they are winning prizes for.



This study is based on a previous study with adults that showed that they were willing to sit longer in an uncomfortable position—a "wall-sit"—when winning money for people who were closely related to them. That study found a linear relationship between relatedness and how much effort people put in. Basically, they found that the more related someone is to you, the longer you will sit and the more money you will win for them, even without really knowing you are doing it.

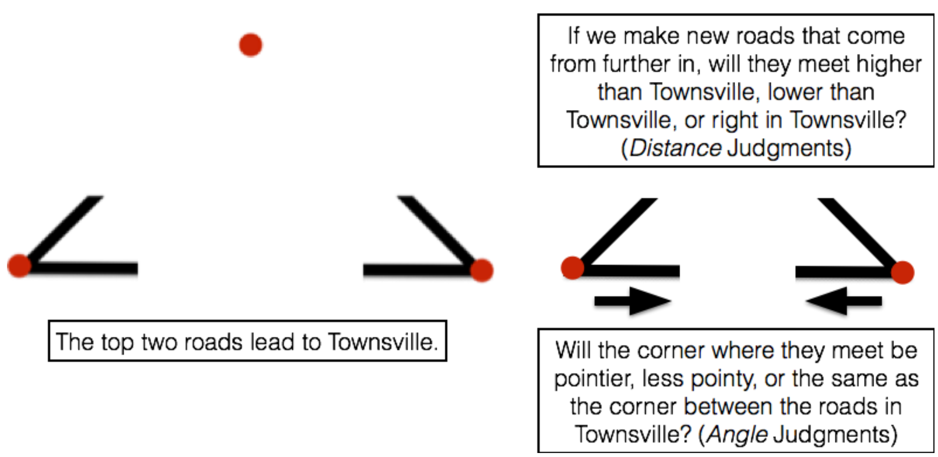
We are trying out this idea with children but using the challenging geometry game instead of a physical test. We have completed this study and are now in the process of analyzing how children played the game. We look forward to seeing what children do!

Thank you to all the children and parents who have been involved in this study!

The roles of language and gesture in reasoning about triangles

Neon Brooks, Postdoctoral Fellow

Our lab is interested in understanding how children come to understand geometrical concepts, starting in infancy and continuing into the middle-school years. One question we are interested in is why formal geometrical concepts like angles and their relation to side lengths are so difficult for children to learn and are often only mastered in early adolescence. One example of the types of problems children struggle with is "triangle completion problems": problems where children have to predict the location or measure of the 3rd angle of a triangle after seeing a transformation applied to the first two angles.



Past research has found that members of small Amazon tribes are able to make correct judgments on this task, so it is clear that adults can succeed even without training. But children get these problems wrong (especially *Angle* judgments) until they are about 12 years old. Interestingly, there is some evidence that using spatial symbols like maps can improve children's ability on similar tasks as young as six years of age.

In this research, we are interested how children reason about these problems and how using abstract symbols (like speech) or spatial representations like maps and hand movements, can help children reason about angles and distances. In our first step towards understanding this relationship, we are asking children ages 6-9 to explain their answers to these types of problems and analyzing the speech and gestures that they produce both when they get problems wrong and when they get problems right. We are finding that children use a wide variety of strategies to solve these problems, and we are hoping that close analysis of their speech and gestures will reveal some signatures of correct reasoning even among younger children.

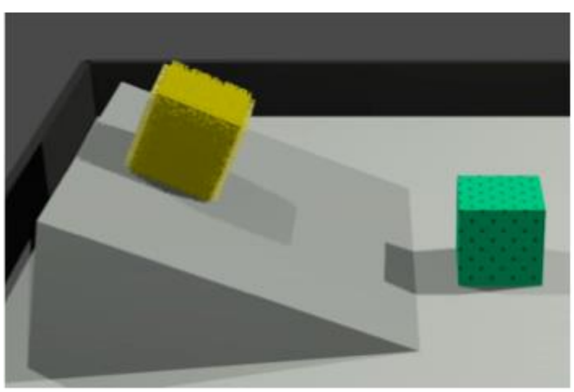
Effort, mass and efficiency

Tomer Ullman, Postdoctoral Fellow

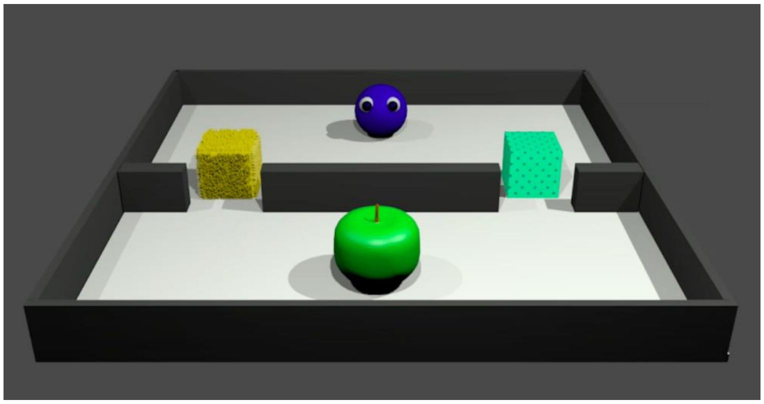
If you really wanted something, would you take the short way to get to it, or the long way? All else being equal, you'd probably take the short path. This isn't surprising, and even babies expect people to be efficient when heading towards a goal. But how do we know what counts as 'efficient'? Is it the shortest path? The least amount of time? Or maybe it's something more abstract?

At the heart of it, being efficient might mean spending the least amount of effort. Effort is a bit more abstract than time or distance, but it makes sense that babies would be sensitive to it. After all, sometimes the shortest path in terms of distance is actually really hard to go through!

In this study, we show young children a cartoon agent that really wants to get to an apple. We also show the children two blocks, green and yellow. One of the boxes is heavy, and the other one is light. Children discover this by watching videos of the boxes colliding and also by playing with real-world boxes that look similar.



After this setup, the children see the agent confronted with two possible ways of getting to its apple. Going down one path means the agent has to push the heavy box, going down the other path means pushing the light box. Where will children expect the agent to go? Will they be surprised if the agent decides to push the heavy box, spending more effort than it needs to?



This is a very recent study, and we don't yet have enough data to say for sure how children are behaving, but we're quite exciting to see how it turns out!

Adding and subtracting forces

Tomer Ullman, Postdoctoral Fellow

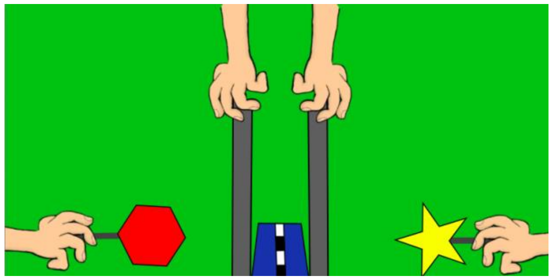
Around their first birthday, babies already know a lot about physics. By this age, if you let something go in front of their eyes and it seemed to hover in mid-air, they'd be quite surprised! This shows they know a bit about gravity, or at least that they expect things to fall down.

However, there's a lot we don't know about babies' understanding of the physical world. For example, as adults we pick up novel physical games and learn them quite quickly (think of two dimensional smartphone games and how different they can be from the real world). Can babies understand a novel physics environment?

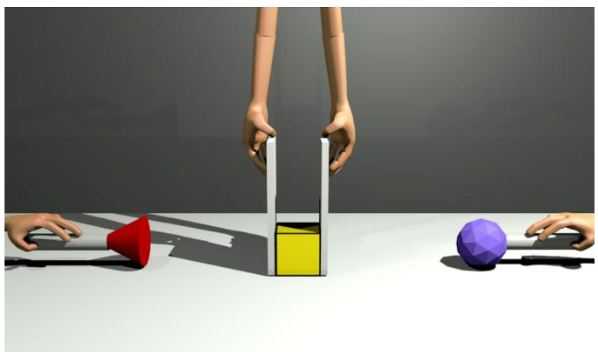
The ability to quickly understand new physics -- and our own world is 'new physics' for a baby! -- might be based on a rudimentary understanding of 'Forces', the same thing that shows up in Newtonian mechanics. And one of the most basic things about forces is that they can add and subtract. If you use a large force to move an object in one direction and another force in the opposite direction, the object won't move, even though two forces are acting on it.

Can babies understand that forces can add together or counteract one another? In this study we showed 10-12 month-olds a blue box falling down, simulating a sort of 'gravity'. The babies then saw an 'attractor' wand come from the top and slow the box down as it falls, or a 'repeller' wand that comes from the bottom and slows the box down. Both wands slow the box down, but because of their position one seems to attract the box while the other repels it, kind of like magnets.

We then put the blue box on the ground and showed both wands at the same time, on opposite sides. Where will the blue box go?



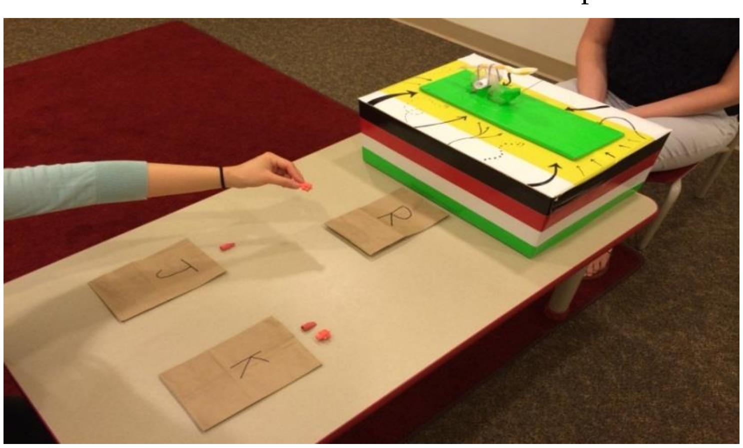
If infants saw the movies as 'attraction' and 'repulsion', they should expect the blue box to go towards the attractor wand and away from the repeller wand. So far, the results have been inconclusive. While there is not enough data to tell for sure, even if they are looking to the attractor it is a small effect. One possibility is that the infants need a more 3d environment to correctly attribute physics, and we've been making some more exciting videos in that direction:



Bribery

Natalie Benjamin, 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 that person’s behavior. As such, 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. We know that 5-year-olds will share significantly more with a partner who had higher-valued resources than with another partner who didn’t have the chance to reciprocate the gesture. But will children further understand that acting prosocially toward the correct person can tip the scales in their favor?



Children played with two adults (game owner & confederate). In the first step the child and the confederate each received two stickers, a high-valued and a low-valued sticker, and both were told to choose which one they wanted to keep for themselves and which one they wanted to give to the game owner. In the second step the game owner chose a partner to play a game with: she could choose either the child or the confederate. The crucial point of this task was that children knew in advance that the game owner was going to decide with whom to play in the second step. If children understand that they can influence the owner's decision by being nice to her, they will give the best sticker to the owner.

We ran this study with both 5- and 7-year-olds, and found that both of these groups of children are more likely to give away the high-valued sticker to the game owner in order to be chosen to play the game. Based on patterns it seems as though children learn this behavior throughout the study; therefore, we developed a subsequent version of the study, wherein we investigated whether children could exhibit this behavior more spontaneously. We utilized different pairs of toys with varying degrees of value, not just stickers, so that in each trial children had to assess the value of the resources and give away the higher-valued one in order to be successful. We also introduced children to the concept of this two-player game beforehand.

We ran this version of the study with 5-year-olds this year, and found that at 5 years of age children are able to discern which toy is the more valuable one, and are still more likely to give away that high-valued resource in order to be chosen to play the game! However, we also observed that 5-year-olds are still not displaying this behavior spontaneously. Therefore, we are currently testing 7-year-olds to see how they will behave in this situation. Thank you to all the families who participated in this study! We look forward to updating you in the next newsletter.

Generosity and the development of warm glow in young children

Kristin Leimgruber, Postdoctoral Fellow

Humans are incredibly generous—we give our hard-earned money to charity, spend our time volunteering to help others, and even donate our blood to those in need. We often do these things at a cost to ourselves and in ways that benefit people whom we may never meet. While the motivations underlying generosity greatly vary by individual and circumstance, research points to one side effect of giving that is virtually universal: doing nice things for others makes us feel good. In this study, we are interested in the age at which children might begin to experience this 'warm glow' after an act of generosity, and whether or not this increase in positive emotion is sensitive to the recipient's reaction to their donation.

We invited 4 to 6-year-olds into the lab to participate in a donation game. In this game, children divided balls needed to play with a fun toy between themselves and an adult experimenter who was seated in an adjacent room with an identical toy. The child and the experimenter also had access to a second, less interesting toy. After playing with both toys, children were told they could watch a 'live' video feed of the experimenter trying out both toys on a computer. In these videos, half of children saw the experimenter expressing enthusiasm for the fun toy that required balls (Positive condition), while the other half of children saw the experimenter reacting neutrally to the fun toy that required balls (Neutral condition). After witnessing the experimenter's preferences, children were given five balls to divide between themselves and the experimenter. Children used the balls they decided to keep before delivering the donated balls to the experimenter through a chute in the wall and watching her use them on the computer. Each child did this a total of five times, and all videos were pre-recorded.

Overall, we found that children shared more with the experimenter when she liked the game requiring balls (Positive condition) than when she didn't (Neutral condition), suggesting that children as young as four adjust the extent of their generosity relative to the preferences of the benefactor. In addition, we are able to measure how happy children were at various points during the test session by analyzing their facial expressions. Although we are still in the process of analyzing the emotional expression data, we hope our findings will shed light on the development of warm glow in children and the extent to which the preferences of the recipient impact children's feelings of happiness.

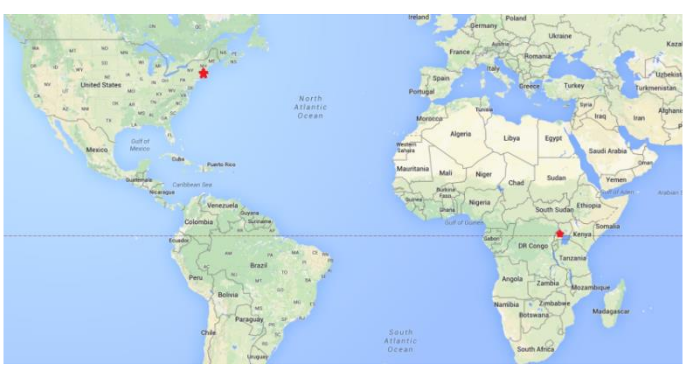
We look forward to sharing our final results with you and are very grateful to all of the families who participated in this study and made this research possible!

Experimenter in Positive condition

Experimenter in Neutral condition

Third party intervention: A cross-cultural study in Uganda and the United States

Ann Finkel, Honors Thesis Student



Every society has "norms of distribution" that determine how individuals divide up valuable resources such as food, land, and money. Of course, some people in every society will try to cheat, and the society thus needs a way of enforcing the norms. One way of doing this is by way of "third-party intervention" – that is, if Person A cheats Person B, an on-looker, Person C, may step up and intervene even though she was not harmed by the initial situation and even though she may incur a cost by intervening.

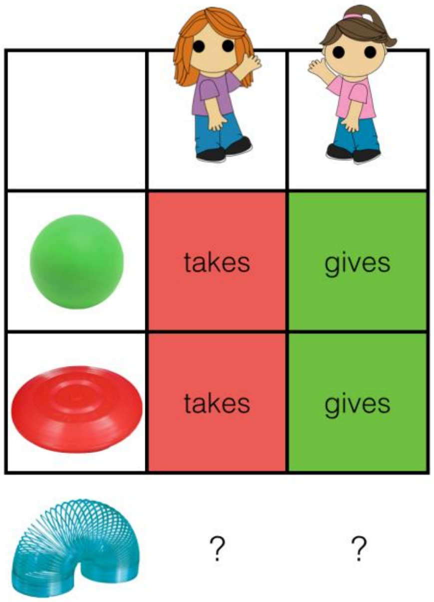
Third-party intervention has been well studied in in populations that are western, educated, industrialized, rich, and democratic (in other words, WEIRD). In order to investigate whether this tendency is universal or culture-specific, I performed a study in rural primary schools in Uganda, as well as in the United States. In Uganda a research assistant conducted the sessions in Rutooro (the local language), and in the U.S. I conducted the sessions in English. I told the child that yesterday two other children, Jane and Abby, came in and played this game, and today the child's job is to be the Decider. Half the time Jane wanted to divide the Skittles equally between herself and Abby, and half the time she wanted to keep all the Skittles for herself. For each distribution, the child then got to accept or reject. If she accepted, the Skittles were put in the bags for Jane and Abby to take home, and if she rejected, the Skittles were put into a black box for no one to take home. In the free condition, the child could accept or reject the distributions freely, without giving up any of her own Skittles. In the costly condition, the child had to give up one of her own Skittles in order to reject the distribution.

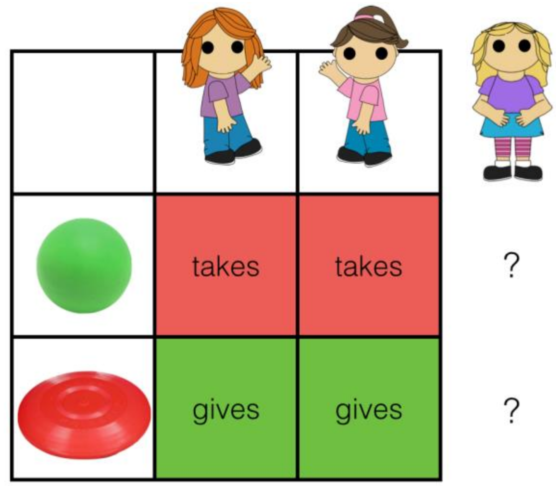
The results of this study showed that six and seven year-old children in the U.S. are more likely to intervene when the distribution is unequal than when it is equal, and this pattern becomes more dramatic as children grow to eight and nine years old. Children in the U.S. are more likely to intervene when they can do so for free, rather than when they have to pay a cost to do so. Ugandan children begin to differentiate between unequal and equal distributions a little later (around the ages of eight and nine), and again the pattern becomes more dramatic as children grow to ten and eleven years-old – but only in the costly condition. The oldest children are actually *more* likely to intervene when they have to pay a cost to do so.

Children in both cultures showed some amount of third-party intervention, which indicates that this behavior may have some evolutionary basis. However, there is a considerable amount of variation in the developmental patterns of third-party intervention between the cultures, which shows that this behavior is heavily influenced by culture.

Why did *that* happen?

Shari Liu, Graduate Student





When it comes to explaining and predicting cause-and-effect relationships in physical contexts, children are incredibly rational. They attend to the contingencies they see in the world (e.g., flipping this light switch makes the light turn on and off) and generalize beyond what they see to learn higher-order principles (e.g., light switches cause lights to turn on and off). Even pre-verbal infants seem to understand something about cause and effect. For instance, babies expect that one object must contact another in order to influence its motion.

Given that kids are tuned into the causal structure of their worlds, how do they use these capacities when trying to understand the causes of actions? People perform actions for a variety of reasons, and a wide range of variables (disposition, desire, belief) could be leveraged to explain them, making this a difficult problem to solve. In addition to our interest in how children make sense of the causal forces driving action, we were curious about how children might be influenced by their assumptions about people. Previous research suggests that kids assume that other people are competent and good—that is, they show an optimistic bias. How might kids reconcile this assumption with the evidence before them when these two things conflict?

To gain traction on this question, we presented 4-, 5-, and 6-year-old children with two patterns of evidence in the form of stories, one suggesting that something about the protagonists from the story caused the pattern of outcomes, and the other suggesting that something about the toys from the story caused the pattern of outcomes. The action outcomes were either positive (a generous act) or negative (a selfish act). After kids heard one of these two stories, they were asked why these outcomes happened—was it something about the person (e.g., "because she's (not) a nice person") or something about the world (e.g., "because the toy looked boring/fun")?

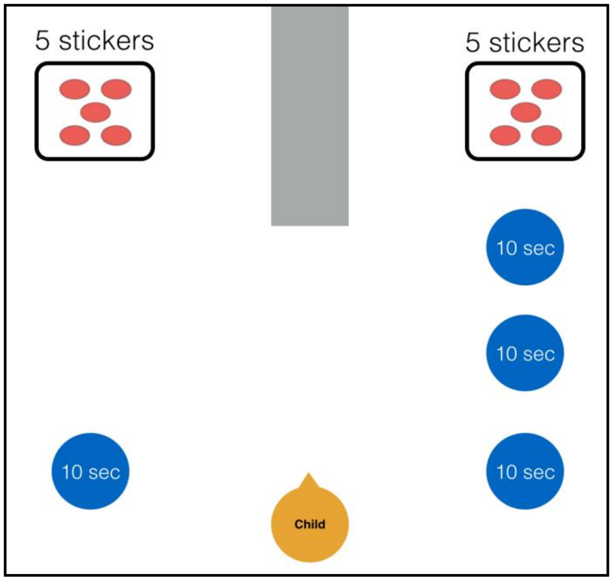
To see whether kids could extend the structure of the stories they heard, we also asked kids to predict what would happen next.

We found that children indeed exhibited an optimistic bias, selectively ignoring the evidence when it suggested that a good outcome was caused by the world and a bad outcome was caused by a person. However, they were rational in their predictions—that is, children seem reluctant to attribute a bad outcome to a character but were willing to predict that she would behave badly again. It appears that children's causal attributions about action are not as straightforward to study as we anticipated. One reason for this might be that the post hoc *reasons* for people's behavior are not as powerful for learning as the *causes* of behavior. Indeed, the *causes* of behavior are quite complex, and us adults in cognitive science are still trying to figure them out!

How do children make decisions about costs and rewards?

Shari Liu, Graduate Student

Since we have limited resources (energy, time) and cannot possibly pursue all goals at once, the capacity to reason jointly about costs and rewards is an important cognitive skill. Little work to date has explored how young children trade off between the resources required to attain an outcome and how rewarding that outcome is.



As a first attempt at exploring this question, we presented a series of choices to 3-year-olds. For some choices, the rewards were held constant but the costs varied (e.g. waiting 10 seconds for 5 stickers or waiting 30 seconds for 5 stickers). For other choices in the sequence, the costs were held constant and the rewards varied (e.g. waiting 10 seconds for 1 sticker or waiting 10 seconds for 5 stickers). So far, we find that kids are very sensitive to differences in rewards, consistently choosing the outcome with the higher rewards, but are not as sensitive to differences in costs.

There are a couple of ways to explain this finding. First, it could be that the way we conveyed costs to kids are not costly enough. Second, children demonstrate the capacity to turn any activity into a game, so perhaps they reappraised waiting into a rewarding experience! Third, it could be that children do not conceptualize their own resources (time, energy) as limited to the same extent that adults do. This possibility is interesting because other researchers have found that young children use costs and rewards to understand the actions of third parties. Could it be that children are more rational when thinking about and predicting the actions of others than they are when making decisions for themselves? We are currently exploring ways to more saliently convey costs to kids, and we're eventually interested in how children recruit their ability to reason about costs and rewards in order to help out other people.

Computing efficiency in infancy

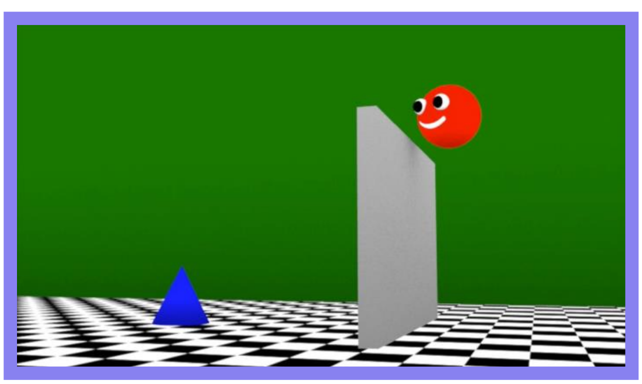
Shari Liu, Graduate Student

Previous research suggests that infants expect agents to pursue goals efficiently. That is, 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 think about efficiency in action—do they simply expect agents to follow curved paths around obstacles and straight paths in the absence of obstacles? Or are they paying attention to the specific features of obstacles and understanding an action in terms of *how* efficient or inefficient it is with respect to these features?

To ask this question, we designed two sets of movies for two groups of infants to watch. In one set of events, an agent pursues a goal by leaping over a barrier over and over again, always conforming the height of his jump to the height of the barrier. In the other set of events, the agent performs the same actions (backing up and leaping) but not with respect to any barrier. So in this first phase of the study, infants learn that either the character is rational or irrational.

Then, both groups of infants viewed another set of movies. These events featured the same (rational or irrational) character making efficient or inefficient leaps over a novel, low barrier. If babies are attending to the cost the agent takes relative to the specific obstacles in his way, then they should look longer when the agent takes an inefficient leap than when he takes an efficient leap over this new obstacle, even though they've never seen either event. Furthermore, only babies who learned about the rational agent should form this expectation, because the behavior of the irrational agent cannot be understood or predicted in terms of goal-directed action.

This project is currently in progress, but so far, our predictions are holding up. That is, it seems like our earliest capacities to reason about costs are continuous (*how efficient*?) rather than categorical (*efficient or inefficient*?) in nature. We are currently planning several follow-up studies that look at how infants *use* their ability to reason about cost for other purposes, like figuring out who is friends with whom.



How do children share resources that cannot be counted?

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 often share some of their 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? They might still share about equally, sometimes giving a little more than half and sometimes keeping a little more than half. Another possibility is older children might recognize they can be sneaky if half is difficult to discern and keep slightly more than half for themselves. To test this, we give children materials like sand that they later trade in for candies to take home, and ask them whether they would like to share some of the sand with another person.

Sometimes the sand is portioned into six little cups. If a child wants to share half of the prizes, she should simply keep three cups of sand for herself and give three cups of sand away. Sometimes, the sand is all in one big tub. In that case, it is more difficult to determine how much is half.

We predicted that older children would be more fair than younger children when the sand was easy to count (in little cups), but that they might be sneakier than younger children when the sand was in one big tub. However, we found that older children were more fair then younger children, regardless of how the sand was presented. This suggests children increasingly share with age, even when using non-countable items like sand.

Future planning and reciprocity

Kristin Leimgruber, Postdoctoral Fellow
Randi Vogt, Research Assistant

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 study, 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.

This study takes place over two separate visits, spaced 7-10 days apart. In the first visit, children play a series of short games designed to measure their ability to think about the minds of others and plan for the future. These activities include a delay of gratification game in which children choose 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 simulates packing for a hypothetical outing, a reverse planning game in which children deliver mail in a pretend neighborhood as efficiently as possible, and three problem-solving tasks in which children are presented with a problem and given the opportunity to solve it creatively after a short delay.

In the second visit, children play two rounds of a sharing game with two different puppets and two different sets of toys. Both rounds of the game start at Table 1, where the child has the opportunity to share balls needed to play with a somewhat attractive toy with a puppet. After the child and the puppet use their balls to play with the toy at Table 1, they move to Table 2 which holds a more attractive toy. In the Control round of this game, the number of balls that the puppet and the child get to play with at Table 2 are predetermined by a deck of cards; in the Test round of this game, the puppet gets to decide how to share the balls with the child at Table 2. In the Test round, the puppet always shares the same number of balls the child shared with her at Table 1.

We are interested in seeing if children are more likely to share at Table 1 when their sharing behavior can influence the puppet's behavior at Table 2 than when their sharing behavior has no bearing on the outcome at Table 2. Additionally, we are interested in how each child's performance on the perspective taking and future planning tasks relates to his/her behavior in the reciprocity game. We are currently in the early stages of data collection, but we expect our findings to give us insight into the development of reciprocity in young children and the cognitive abilities that make it possible.

Thank you to all the families who helped us in the piloting of our tasks for this study! We look forward to updating you with our results in next year's newsletter!

Reciprocal sharing in toddlers

Natalie Benjamin, 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 both 2.5- and 3.5-year-olds. In the study, we present children with a game apparatus (either a jingle box or a zigzag ramp), which requires golf balls in order to play with it. The child is introduced to two other players (puppets), and the three of them each get a chance to divide up eight golf balls between themselves and another one of the players. Each of the puppets plays with the child, and then the child plays with one of the puppets at a time. One of the puppets always shares the balls equally, keeping four for herself and giving four to the child. The other puppet never shares with the child, keeping all eight balls for herself. The child then gets to play with both puppets, one at a time. We are interested in seeing if children will share differently with the puppet who consistently shares with them than with the puppet who never shares with them at all.

After testing 2.5- and 3.5-year-olds, we found that neither 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 at this age they do not seem to be using this information to dictate their own sharing behaviors. We are currently testing 4.5-year-olds to see at what age this contingent reciprocity might emerge. Data collection is under way and we look forward to sharing our results with you!

Trust and resource distribution

Natalie Benjamin, Lab Manager

Many of our social relationships are based on reciprocity in various forms and domains. In order for reciprocity to occur, each party must trust that the other will return a favor or a benefit that is bestowed on them. Often we do favors for people with the mutual understanding that they will return the favor at a later time, and that we will benefit from the interaction as a whole. This study explores the extent to which children may trust another individual to repay a favor in the future.

In this study, we introduced 4- and 6-year-old children to an apparatus with trays that are filled with coins. The child plays with two different puppets, and all three players have their own banks, where they will put the coins that they get during the game. In the apparatus, each tray can have a maximum of four coins in it. If the tray is filled with all four coins, the child can push the tray across the table to their partner. The partner will then decide how to split the coins between herself and the child. One of the puppets splits the coins equally between herself and the child (two and two). The other puppet keeps all four coins for herself, and the child receives none. Children are then presented with trays that are full with three coins, and are given a coin and told that they can decide what to do with the coin: they can put the coin in the tray and push the tray across to their partner (who will then decide what to do with the whole tray of four coins), or they can keep the coin and put it directly in their own bank. We are interested to see if children will make different decisions based on which puppet they are playing with and how that puppet has acted toward them in the past.

After running this study with 4- and 6-year-olds, our results suggest that both age groups are more likely to push the tray of coins over to their partner when playing with the “trustworthy” puppet who shared with them in the past than when playing with the “untrustworthy” puppet who keeps all the coins for herself. Data collection is still under way! The results from this study will indicate whether children are able to distinguish between the two different conditions they are put in, and if they understand what is the most profitable action for them to take given the situation they are in. Thank you to all the families who participated in our studies this year!

Thank you to all the families who participated!

Our research is only possible with your support.

If you have any questions, want to refer a friend, or would like to participate in more studies, please contact us!

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