Harvard Lab for Developmental Studies

newsletter

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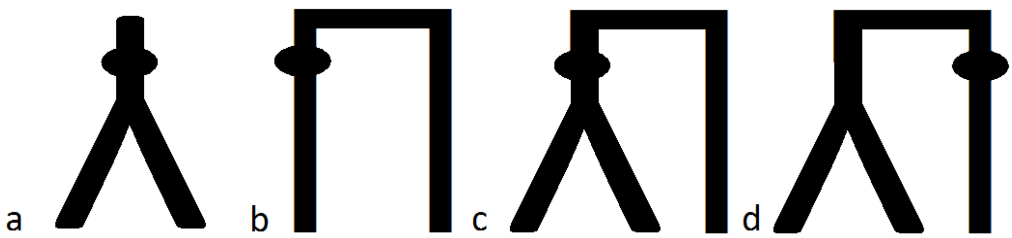
Developing Thoughts of the Possible and the Impossible

Brian Leahy, Graduate Student

Sometimes we don't know what's going to happen in the future. But sometimes we need to know what's going to happen in order to make good plans. When adults are uncertain, they often make flexible plans that take their uncertainty into account. For example, suppose a server at a restaurant takes an order for a cup of coffee. When he gets back to the kitchen, he forgets whether the customer asked for milk or cream. He might quite reasonably bring the customer both milk and cream. This is a flexible plan in the face of uncertainty.

This flexible planning has at least two parts. The server (1) recognizes his uncertainty, and (2) comes up with a plan that will work out either way. Recent research suggests that young children struggle with (1): they don't even recognize their own certainty. When they see more than one possibility on the table, they guess, and then assume that they know. They are not aware that they have guessed.

In an existing study, an experimenter dropped a ball into an inverted "Y" shaped tube (figure 1a) and participants had to catch it. Experimenters checked whether children covered both possible outcomes. 2.5-year olds usually did not, but 3-year olds often did.



But you can't really think about possibilities unless you can contrast possibility with necessity or impossibility. We developed tubes b-d to test whether children contrast possibility with impossibility. Circles in figures a-d show where balls enter the tube. Only outcomes below the circle are possible. In the critical condition c, participants must both recognize that there are two possible outcomes and rule out an impossible outcome.

In experiment 1, participants saw several trials with each tube. Both 3- and 4-year olds performed quite well on tube a. The critical tube c was not too much harder for 4-year olds, but was very difficult for 3-year olds, with more than half of our participants never figuring out which places they need to cover in order to catch the marble. This supports our conclusion that 3-year olds cannot tell the difference between the possible and the impossible. 4-year olds were much better, but there was still lots of room to improve.

In experiment 2 participants saw 16 trials with the critical tube c. After the 8th trial, we staged an intervention where we talked to participants about the tube, asking them questions about where the marble might come out, and drawing their attention to all the physical features of the tube that made the impossible side impossible. We wanted to see if this would help them figure out how to solve the problem. We found that four-year olds improved steadily across trials, performing very well be the end. But three-year olds hardly improved at all; their performance on the 16th trial was only slightly better than their performance on the very first trial. Again, it seems like three-year olds may not be ready to think about the possibilities yet.

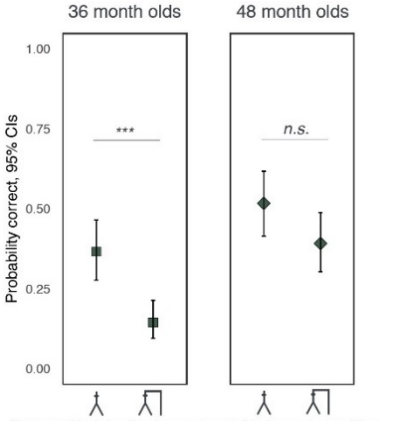


Figure 2. Model estimates and 95% CIs for each condition, grouped by age. There is a significant difference between conditions for 36 month olds but not for 48 month olds.

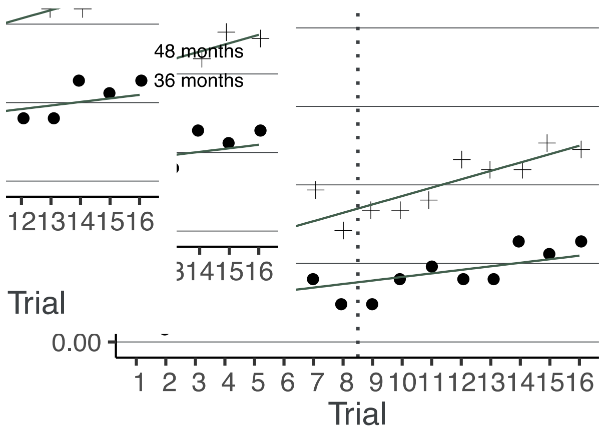


Figure 3. Proportions of correct responses by trial in experiment 2, broken down by age group. While both groups improved across trials, improvement was significantly more dramatic amongst 48 month olds.

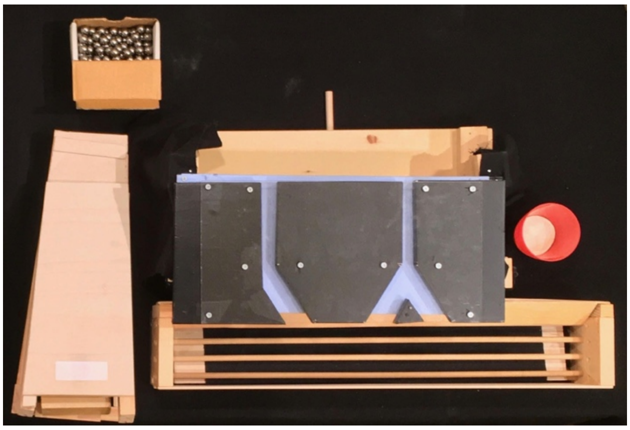
Thank you for your participation in these studies!

Distinguishing Certainty from Uncertainty

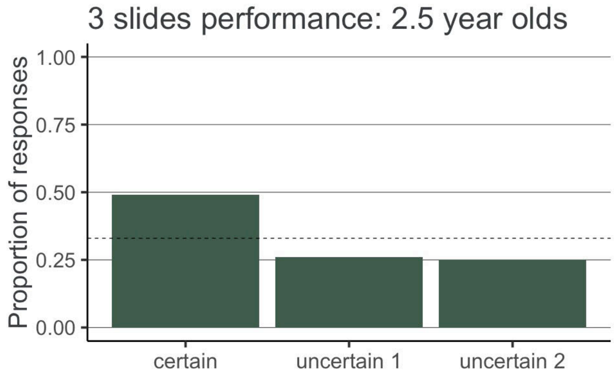
Brian Leahy, Graduate Student

Socrates was famous for knowing what he didn't know. Being a sensitive adult, a good advisor, a thoughtful discussant also requires recognizing when we really know something and when we can't really tell. Acknowledging our own ignorance is a social challenge, but there is evidence that young children have a hard time even *recognizing* their own ignorance. For example, in one experiment an experimenter shows a participant two toys—a toy dog and a toy cat—and says that one will be hidden in a box while the other will be put away. Then she shows the participant the box and asks if the participant knows what's inside. 3-year olds make a guess and tell the experimenter which toy is in the box. Follow up questions, like, "Do you know that? Or are you just guessing?" or "Do you want to tell my friend Max what's in the box?" reveal that 3-year olds really think they know what's in the box. 4-year olds are somewhat better; they seem to have a better handle on when they are guessing, and on when they don't really know what's in the box.

To further explore children's understanding of their own uncertainty, we developed the apparatus pictured below.



The experimenter sits at the top of this image, and the participant sits at the bottom. The experimenter will roll two marbles through these channels at the same time. It is the participant's job to put out a cup to catch a marble. If you catch one, you get to put it in the jinglebox, that long wooden box on the left side of the picture. There's a tilted xylophone in there, so marbles roll down and make a rewarding sound, so kids are pretty motivated to try to catch those marbles. The safe bet is on the channel that doesn't fork, since you know where the marble will come out on that side. The other side is risky: the marble might go left, and it might go right. But participants who make a guess and think they know what the outcome will be will have a hard time with this task: since they'll think they know where the chancy marble will come out, they have to choose between two known options. They will not reliably pick the certain side, but rather will alternate between the certain side and the risky side.



In our first experiment we tested 2.5-year olds and found exactly that. This aligns with existing data that 2.5-year olds make guesses and then treat their guesses like knowledge. We are currently running 3- and 4-year olds. We expect that 3-year olds will also struggle, picking the certain option only around 50% of the time. But 4-year olds may be better, may be able to recognize that they know where the first marble will come out but that they can only guess where the second marble will go.

Thank you for participating in this study!

Number and Executive Function

Deborah Zaitchik, Research Fellow

From two to five years old, children develop a rich concept of number. While most older two-year-olds can recite some part of the count sequence ("one, two, three, four"), these words have no numerical meaning (they're much like 'a, b, c, d'). It will take another year or two until children undergo the conceptual milestones that yield the numerical meaning of number words. We want to understand *why* this learning is so difficult and protracted. To that end, we are testing the hypothesis that this early number development makes heavy demands on executive functions (inhibition, shifting, and working memory). These general-learning mechanisms, centered in the prefrontal cortex, undergo significant growth during this period and continue to develop for many years.

Our study involves two 30-minute sessions with three- and four-year olds. In the first session we assess children's understanding of the meaning of the count words. Using a variety of counting games designed to engage young children, we assess their understanding of the following counting principles: *one to one correspondence* (knowing that each object in the set being counted is assigned one and only one number word); *cardinality* (knowing that the number word used to count the final object in the set equals the quantity of the set); and *successor function* (knowing that for any word *W* in the count list (e.g., "two"), the *next* word in the count list (in this example, "three") represents **the quantity represented by W + exactly 1.** In our games, we ask children to give us a certain number of toys, or to count, as high as they can, all the toys laid out in a row. In the second session, we play games that assess executive function skills. In one game, for example, we ask children to sort cards first by color, and then by shape. To perform well on this, they must *shift* to the shape sort rule and *inhibit* the color sort rule, maintaining the activation of the appropriate rule in *working memory*. Our question is this: will children's individual executive function abilities predict their progress in learning the meaning of the count words? We have already collected a sizeable sample of children in this study and run preliminary data analyses. These support the claim that individual differences in executive function do indeed predict children's progress in acquiring numerical concepts and procedures.

Development of Visual Working Memory Storage vs. Manipulation

Hrag Pailian, Postdoctoral Fellow; Sophie Ann Brown, Research Assistant

Many forms of problem solving in children's everyday lives require them to remember information and manipulate these memories over short periods of time. For example, when playing "hide-and-seek", children must remember which locations they have already searched, and which ones remain. Furthermore, this information must be constantly updated as children continue to search. This ability to actively hold information in mind and manipulate it is commonly referred to as "working memory". Working memory storage capacity for spoken and visual information increases dramatically between 4 and 11 years of age, regardless of whether children are remembering verbal information (like a list of words) or visual information (like an array of objects). Yet, not much is known regarding working memory manipulation capacity and how it develops across the lifespan.

In the current study, we sought to better understand the relationship between working memory storage and manipulation capacity for visual information using a variant of the "Shell Game". In this task, 6-to-8-year-old children were briefly presented with 2-4 color pom-poms, whose colors they were asked to remember, since the pom-poms would subsequently be covered by opaque cups. On some trials, the opaque cups remained stationary, and children were asked to point to the cup under which they expected to see a target color (e.g. "can you tell me where the blue pom-pom is?"). These trials tested children's ability to store information in working memory. On other trials, pairs of opaque cups swapped positions, up to 4 times. Once all swaps were completed, children were asked to point to the cup under which they expect to see a target color – based on the movements that had occurred. These trials additionally tested children's ability to manipulate information in working memory (update the location of each color as it is moved).

In so doing, we found that children's accuracy rates in the no movement condition were near perfect when remembering 2 or 3 colors, but lower for remembering 4 items. This suggests that their storage abilities have not reached full capacity, as previous work demonstrates that adults can store up to 4 items perfectly. More interestingly, we found that performance accuracy across decreased across conditions where the cups moved, and that this decrease was comparable to those observed in adults. These results depict separate trajectories for the development of working memory storage and manipulation, suggesting that these cognitive capacities may rely on separate resources. In future work, we aim to identify whether these manipulation limits generalize across different mental operations and modalities (e.g. mathematics, verbal comprehension, etc.).

Young Children's Acquisition of Logic: A Case Study of Disjunction and Modal Possibility

Anna Holiday, Research Assistant

It is widely debated whether animals and pre-linguistic infants have a language of thought that is qualitatively different to that of human adults. As such, the logical argument of the disjunctive syllogism ("A or B", "not A", "therefore B") provides a case study for weighing in on this debate, as it is easily computed by adults, yet requires sophisticated abstract and combinatorial thought. Mody and Carey (2016) investigated at what age children can reason through the disjunctive syllogism using a cups-task; the current study aimed to investigate the failures exhibited by two and a half-year-olds in reasoning through the disjunctive syllogism, and the difficulty presented by pre-school children in tasks that require the distinction of certainty from mere possibility. It was hypothesised that reducing the working memory demands of Mody and Carey's original cups-task, using the "channels-task" (as shown below), would improve children's performance.

We ran the channels-task on 2.5-year-olds and 3-year-olds. We asked the children to predict where a marble would certainly exit, after being rolled down various tubes, each of which held different probabilities of gaining the marble. In the three-channels trials (pictured on the left), children were presented with one tube that held 100% probability of gaining the marble, and one Y-shaped tube where each side had a 50% probability. In the four-channels trial (shown in the right), two marbles were simultaneously rolled down two Y-shaped tubes, with four possible exits (each holding a 50% chance of getting a marble). We explained and highlighted that one exit would be blocked, and as such the other side would have a 100% probability of getting a marble.

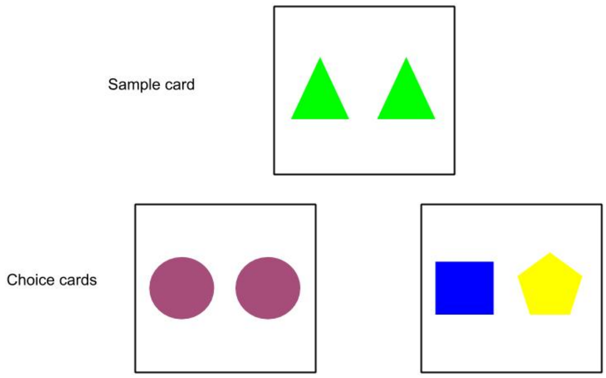
Our results from this channels study replicated Mody and Carey's (2016) findings; 2.5-year-olds failed at the four-channels task which investigated the disjunctive syllogism, and both ages demonstrated strikingly non-adult performance in the three-channels task, which explored modal reasoning. As such, there was no evidence suggesting that the reduction in working memory demands improved their performance. We considered whether this reflects a conceptual limitation, whereby children fail to represent each uncertain option and fail to distinguish between certainty and mere possibility. Although this needs further investigation, the current study provides further evidence that young children— and perhaps nonhuman animals— lack the abstract and combinatorial thought of human adults.

Matching Abstract Relations: What Makes it Hard?

Ivan Kroupin, Graduate Student

Relational reasoning is the ability to compare sets of objects not on the features of the particular objects but on the relations that hold within the sets. For instance, we can compare a solar system to an atom because the *relations* between their constituent parts are similar (a large central body which is orbited by smaller ones) even though the parts themselves do not resemble each other in the slightest (i.e. electrons do not look like planets). Humans are uniquely proficient at this kind of relational comparison - but how does this ability arise, and what determines how and when we use it?

Currently we are testing children on a task known as Relational Match to Sample: Children are shown three cards, each of which has two images. These two images are either identical in all respects (e.g. both green triangles) or different in some respects (e.g. a blue square and a yellow pentagon). The sample card (the one that is to be matched *to*) is either a 'same' card or a 'different' card while one choice card is always a 'same' card and the other a 'different' card. The correct choice card on any given trial is the one that has the same relation as the sample card.



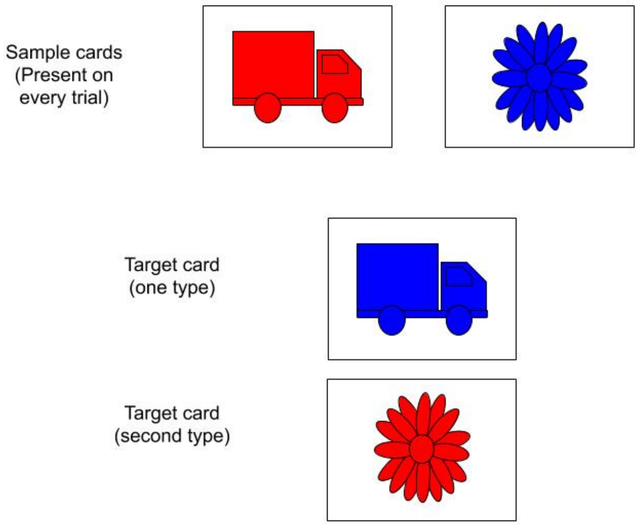
While this task may sound easy to us, it has proven surprisingly difficulty for children below the age of five. We are currently testing the hypothesis that part of this difficulty is children's tendency to focus on shape and color matches to the exclusion of other possible bases of matching, such that in RMTS they'll make approximate matches on shape or color (e.g. 'both cards have an object that is pointy') before considering matching on relations. To mitigate against this tendency, we have designed a task in which the objects on the cards vary only on size (i.e. the objects are either the same size or different sizes, but otherwise identical). The hypothesis is that this will prevent children making approximate shape and color matches and focus their attention on relations.

Data collection has only just begun so we cannot yet provide even preliminary results. However, *if* this approach does, in fact, improve relational matching in four-year-olds this will be important evidence of the *conditions under which* children tend to reason relationally or not. This has important implications in the long run for how we think about teaching abstract relational concepts to young children.

Investigating Children's Attention Regulation Abilities

Ivan Kroupin, Graduate Student

Executive functions (EF) are a group of top-down cognitive control processes critical for day-to-day problem solving, academic performance and, by extension of both, to life in general. EF shows a dramatic increase in the early years of life, and one developmental stage has been measured in previous literature by a task known as Dimensional Change Card Sort (DCCS). DCCS involves matching one target card to one of two sample cards on one of two dimensions, traditionally either by color or by shape. The bases of matching are confounded between the cards - sample cards match the target cards in shape but not color or vice versa. Once the child matches a few cards using one dimension, say shape, we ask them to play a new game and match on the other dimension, say color. Now children must change the rule they use and put the target card with the sample card which it *didn't go with* in the previous game.



This task has proven difficult for three-year-olds, with around half consistently continuing to use the old rule even though they were instructed to use the new rule. This failure to switch is a reflection of still-developing executive functions.

In our studies we have been investigating reasons *why* this switch may be so difficult for kids. In one study we modified the instructions during the procedure of switching between tasks to make it feel more like a story for the kids. The idea was that perhaps if we made the switch between games less arbitrary kids would better be able to follow along. This did not turn out to be the case.

A new study examines whether changing the dimensions on which the cards are sorted may make children switch more easily. Support for this idea comes from some findings that individuals are more likely to encode a dimension they are less familiar with (e.g. number of objects per card, in the case of kids) in a more abstract way. Encoding the rules of the game more abstractly has been shown to make switching easier. Testing in this study has only just begun and it is too early to report even preliminary results. However, *if* this approach does improve three-year-olds' performance on DCCS it will raise important questions regarding how development in EF is related not only to an increase in attentional 'capacity' but also changes in *the kind of things children pay attention to* across childhood.

Investigating Children's Counting Behavior

Ivan Kroupin, Graduate Student

Previous work has shown that children make an unexpected error when asked to count broken objects: When presented with a set of objects like the ones below and asked to count ("How many shoes are there?") children under the age of five tend to count all of the individual pieces. That is, in the case below they would answer "five" whereas adults overwhelmingly answer "three" or "two". Likewise, when asked to compare numbers of objects (e.g. 'are there more shoes on the right or on the left?') children will consistently say that there are more wherever the total number of objects is greater - in this case that three pieces of shoe (right) are "more shoes" than two whole shoes (left).

There have been a number of theories proposed as to why children make this error. One argues that children, unlike adults, have trouble spontaneously thinking of the objects in part/whole language (i.e. 'this is a piece of a fork' v. 'this is a whole fork') and it is this difficulty that leads them to count all of the objects. In contrast, we propose that children have no difficulty with accessing terms, but rather think of the task differently: For them whether an object is whole or broken may simply not be an important consideration in the context of counting – especially since counting for them is often an arbitrary activity done at the request of adults. In order to test between these hypotheses, we had children count and compare whole and broken objects in one of three different conditions. The first simply asked the question with no preparation (in order to give us a baseline to compare the other conditions to). The second tested the existing hypothesis by telling children first to point to "a whole [object]" (where [object] was whatever type of object that was presented in the current trial) and then to "a piece of [object]." If children's difficulty was with accessing these part/whole words this priming should increase their performance. The final condition tested the hypothesis we presented. Specifically, we told children a story about how the characters who had the sets of objects had a party and how they were going to use all of the objects to perform certain functions (spoons to eat ice cream, cups to drink juice out of etc.) Focusing on whether the objects were usable or not necessarily focuses attention on whether the object is whole or in pieces - it would be very difficult to drink juice out of a piece of a cup.

Results confirm our hypothesis: Children primed with the words 'whole' and 'broken' did no better than those in the baseline condition. In contrast, those who were focused on the usability of the objects almost universally counted like adults. This is very strong evidence that the reason children counted parts of objects in the first place had to do with the way they were interpreting the task put in front of them which differs from adults (e.g. asking 'why would this adult give me a fork broken in t*hree pieces* if they only wanted me to count *one*?')

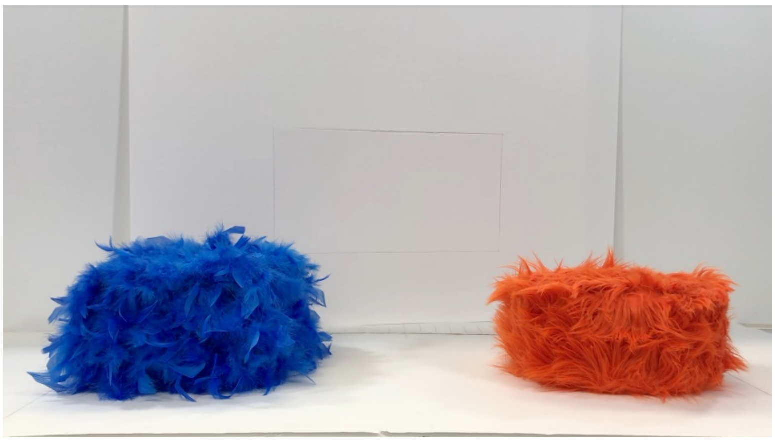
Infants' Inferences about Insides

Yiping Li, Research Assistant; Jonathan Kominsky, Postdoctoral Fellow

How do babies know when something is alive? When the whole world is new to you, and you see all kinds of things moving around, how do you figure out that the family dog is alive, but your tickle-me-Elmo toy, that makes noise and has fur, is not?

In this thesis project, we were interested in whether infants use information about cause and effect to determine whether something is alive. One of the big challenges was finding a way to tell when infants think something is alive at all, since they can't just answer questions. Earlier work found that infants believe living things to have certain properties. One of those properties is that living things can't be *hollow*. If an infant sees an object they think is alive, and then they are shown that the object is completely hollow, they are surprised and look at it for a very long time.

In this award-winning senior honors thesis (winning both a Department Thesis Prize and a university-wide Hoopes prize), we used this surprise to figure out when 10-month-old infants thought something was or was not alive. In the first experiment, we showed infants the two objects in this picture:



One had blue feathers, and the other had orange fur. One of these objects was shown moving around on its own, and the other one was *moved around* by a human agent. In other words, one was the cause of its own movement, while the other was a causal patient. Infants were surprised when the object that caused its own movement was shown to be hollow, but not when the causal patient was shown to be hollow. This tells us that infants use causal role to determine when something is alive.

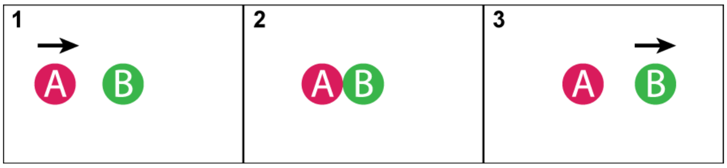
However, not all causal events are created equal. This particular causal event, where a human pushes and pulls the object around the stage, involves a constant application of force. Every part of the object's movement happens when the human is holding it. We were also interested in whether infants would make the same inferences when the objects were the agent and patient in a *collision* event, where there is only one moment of contact. 10-month-olds did not, which tells us that *just* being a causal patient in *any* event isn't enough to distinguish living things from non-living things. This was somewhat surprising, since there is some evidence that older children and adults make that inference without any difficulty.

But, what 10-month-olds don't know, they learn. This summer, Dr. Kominsky is following up on this work by trying to determine if infants learn to make this inference about collision events by 14 months of age, which will tell us whether the ability to identify living and non-living things *just* by causal role develops in infancy, or if it's something that develops much later.

Infants See the Same Kinds of Causal Events that Adults Do

Jonathan Kominsky, Postdoctoral fellow

Imagine an event like the one in the picture below. One object (A) moves toward another object (B) until they make contact, at which point A stops and B starts moving. Adults irresistibly see events like this as involving cause and effect, with A "launching" B (if you want to experience this for yourself, you can find videos of many events like this one on my website at https://www.jfkominsky.com/demos.html) Previous work has found that 6-month-old infants understand this as "A is causing B to move" instead of A and B just moving on their own, but younger infants do not.



In previous work, we found that 7-9-month-old infants are sensitive to the Newtonian physical constraints on events like this one. If object B moves in a way that is physically impossible based on the collision alone, infants treat it as a new and different kind of event. This year, we've been exploring (1) whether 4-month-old infants are also sensitive to these physical constraints, even though they don't seem to understand the cause and effect in these events and (2) whether 6-7-month-old infants still see these events with physical violations as A causing B to move, like adults do.

1) In our studies with 4-month-olds, we showed infants an event like the one above, and then showed them either an event that broke a hard Newtonian rule (such as B moving 3x faster than A, where Newtonian physics says the absolute maximum speed of B is only 2x faster than A even if A has much more mass) or an event that was equally different but physically possible (such as A moving 3x faster than B, which can happen if B has a lot more mass). The results suggest that 4-month-olds do not yet understand these physical constraints: They looked at both events for the same amount of time. It's hard to draw too many conclusions from that alone, but it's clearly different from what 7-9-month-olds do. That suggests that the ability to understand these physical limits is deeply connected to the ability to understand cause and effect in these events, rather than physics and cause and effect being two different things in the infant mind.

2) But do 6-7-month-old infants still see events with these physical violations as A causing B to move? Adults do. Typically, if B moves 3x faster than A in one of these events, adults describe it as A "triggering" B's motion. In some of my vision science work with adults, I've found that even in the visual system itself, these triggering events are still seen as causal. To study this with infants, we first show them an event like the one in the image above, except that B moves 3x faster than A. Then, we show them an event where the causal *roles* have been switched: B starts moving towards A until it makes contact, and then B stops and A starts moving. We have known for a long time that when you do this with physically plausible events, infants treat

it as new and different: They care that “A caused B to move” has become “B caused A to move.” This year, we found that you get the same pattern if you do this with triggering events. So, just like adults, even though there is a physical violation, 6-month-old infants see triggering events as “A causing B to move”. This suggests that the ability to see cause and effect in these events develops all at once around 6 months of age and doesn’t change much after that.

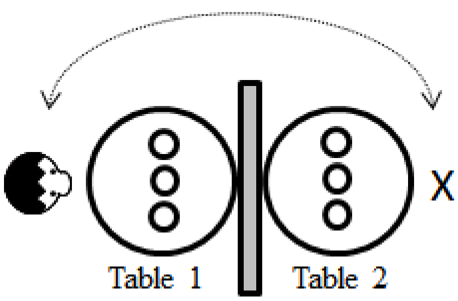
Coin Search Game: Spatial Frames of Reference

Peggy Li, Research Fellow

Remembering where things are in space and communicating to others where to find them are important skills that we need in our everyday lives. We can remember the location of things from our own perspective (to my left), by their proximity to other objects (next to the chair), or even using compass directions (on the south side). We are interested in how children typically remember locations and directions, and whether or not some spatial relationships are easier to remember than others.

In our study, we tested preschoolers who are just beginning to learn words like "left" and "right." The children watched as we hid a coin in one of three cups. Then they turned to face a second table, where they saw three more cups in the exact same arrangement. We asked them to find the coin in the same cup. But which one is the “same” cup? During one part of the study, children must use the landmarks in the room to find the coin (e.g., in the cup closest to the window). During another part, they must use the positions of the cups relative to their own bodies (e.g., the cup on their left). .

We want to know if one of these strategies is easier for children to learn than the other. In order to find out, we measured how quickly children n learn where to look for the coins. Our data show that children are capable of thinking about the hiding locations from their own perspective (i.e., using their own left and right, front and back) and from the perspective of the environment and ambient landmarks (e.g. closer or further away from the window). However, which perspective is easier depends on how far they are from the original table of cups. When further away, their own perspective becomes more salient. Our findings have implications on how to best teach children spatial words like "left" and "right."



BLURB with text taken from https://www.mos.org/living-laboratory/40-cups

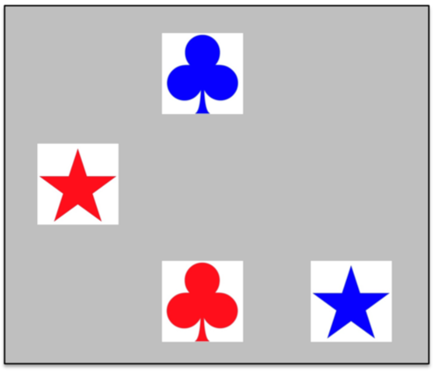
Understanding the Development of Complex Sequencing Abilities

Stephen Ferrigno, Postdoctoral Researcher

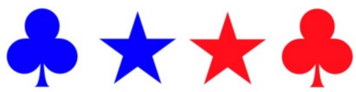
The ability to represent complex sequences is thought to be important for language development (grammar), as well as music and mathematics. However, it is currently unknown how or when children are capable of producing complex sequences outside of language. This study examines when children's ability to understand complex sequences develops.

The process of learning grammar is a slow process for children, and they continue to make grammatical errors and have trouble understanding some complex sentence structures quite late in development. Sentences like: "The cat that the dog chased ran away." have been shown to be especially difficult for children to understand. They contain a sequential structure that is called a center-embedding. One possible cause of this difficulty is the underlying sequential abilities needed to understand these sentences. Here we test whether children of different ages (3-6-years-old) can learn these sequences using pictures rather than complex sentences. This allows us to test if the difficulty in understanding these sentences could be due to their sequential abilities.

In order to test children's sequencing abilities, we had children play a computer game in which they had to touch pictures in a center-embedded order. In this example (below), two items (stars) are embedded inside other items (clovers) much like the types of sentences which are difficult for children to understand. Children were then shown new images to see if they used the same overall center-embedded with new, untrained images. So far, we have shown that between the age of 3 and 6 there are large improvements in the ability to produce these complex sequences. Furthermore, preliminary evidence suggests that this underlying sequential ability might be developed in children before they can understand or produce these structures in language.



Example of the touch-screen computer sequencing task.



The order children learn to touch the pictures.

What do Infants Infer about Lullabies?

Sam Mehr, PhD; Stephanie Atwood, Constance Bainbridge, Lab Managers;
Anna Bergson, Anya Keomurjian, & Brooke Milosh, Summer Interns

In previous work, we found that when adult listeners hear an unfamiliar song from another culture, they make accurate guesses as to what that song is used for in that culture (e.g., to soothe a fussy baby, to express love to another person, etc.). In these studies, we ask whether babies from 2-12 months share similar intuitions about music: when they hear a lullaby from a foreign culture, do they like it, and can they tell what it might be used for in real life?

Babies in our study watch animated characters singing lullabies and other songs from all over the world. While babies are watching the characters, we track where they look, as well as some physiological measures such as their heart rate and electrodermal activity (a measure of excitement level that can be detected through the skin). Our preliminary findings show that heart rate and electrodermal activity dropped significantly more in response to hearing lullabies relative to other songs in infants of all ages.

Now we are curious to find out if infants have ideas about what lullabies are used for in real life. To do this, we are running a follow-up study where we track infants gaze and physiological measures while they watch animated "adult" characters singing lullabies and other songs from all over the world and then interacting with a "baby" character. Here, we expect that if infants associate lullabies with care-giving, they might expect an adult character who sings lullabies to interact with a baby character more than an adult character who sings other kinds of songs.

This study is ongoing and we thank all the families who have helped with this study so far! We can't wait to listen to tunes with you again soon.

A 4-month old watches animated characters singing

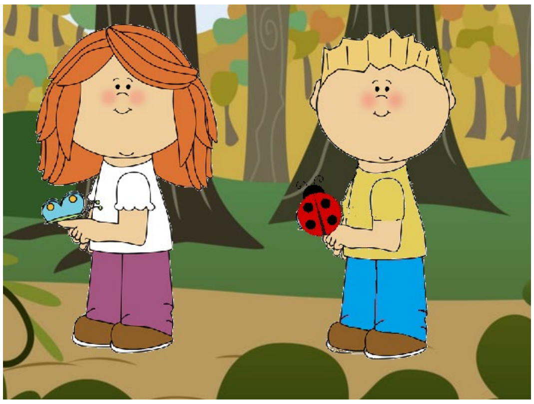
Mastering the Art of Conversation

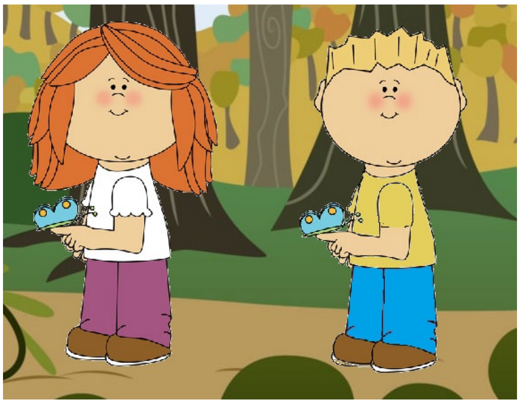
Simge Topaloğlu, Graduate Student

Effective communication requires that speakers closely monitor what their conversation partners are saying and modify their own utterances in such a way that they fit neatly into the ongoing discourse. We can observe an interesting example of this back and forth play in the use of the word *too*.

The use of this marker is appropriate – in fact, required –when a speaker says something that is parallel in content to a previous utterance made by their interlocutor. For example, if Speaker 1 says "I like apples," it is odd for Speaker 2 to reply merely with "I like apples." If Speaker 2 wants to make a statement that concurs with Speaker 1's statement like this, the preferred form would be "I like apples, *too*." This is because there is a pragmatic preference for marking what is already known in conversation. What the little word *too* does here is to connect the current utterance to the preceding utterance while at the same time acknowledging the already known piece of information provided by Speaker 1 (i.e., "You just mentioned you liked apples, and I like apples *just like you do*.")

When the statements are contrastive, however, it is perfectly OK to juxtapose them against each other, e.g., by saying "I like oranges" in reply to "I like apples," because the content of Speaker 2's utterance is novel here.





In this experiment, we attempted to find out whether 4-to-6-year-old English-speaking kids can also attend to the content of a preceding statement to organize their own response to that statement. We used pictures like the ones given above and asked the kids to describe what the second child did, after the experimenter described the actions of the first child. In such a context, *too* would <u>not</u> be used for the picture on the left, since there are contrasting actions here (e.g., Experimenter: "The girl found a butterfly", Child: "The boy found a ladybug") but it would be required in the second scenario (e.g., Experimenter: "The girl found a butterfly", Child: "The boy found a butterfly, *too*").

Our preliminary results have shown, however, that children in this age range do not consistently use *too* in these contexts and we hope to find out soon why this is the case.

This research would not be possible without the help of the children who took part in the study and their parents. Thank you so much for your participation, and we are hoping to see you in our lab for our future studies, *too*!

What Can Our Brain Waves Tell Us About How We Understand Negation?

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?

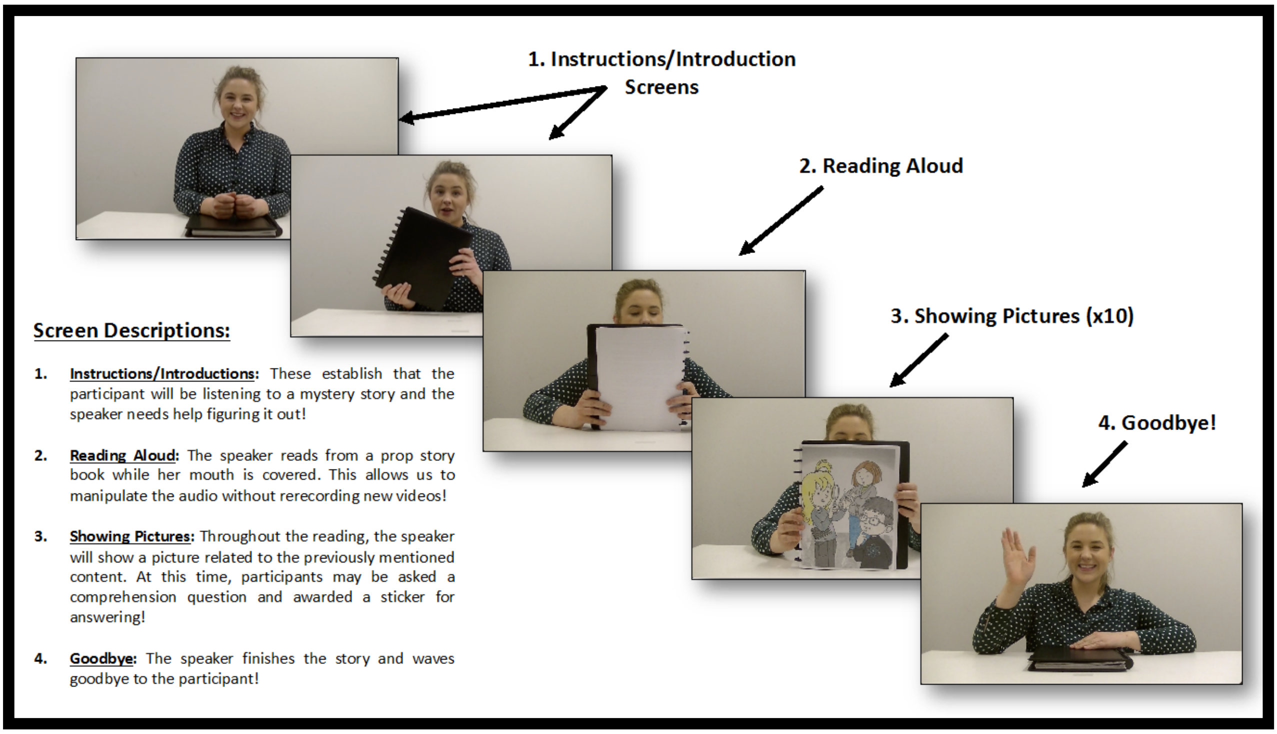
A key challenge for studying how we build up meanings to sentences we hear, is studying this process without interrupting it. However, we have an incredibly useful tool at our disposal called electroencephalography, or EEG. An EEG recording records electrical activity in the brain in response to different events, such as hearing a word! Studies using EEG with adults have discovered that there is a specific brain wave that happens when a person hears a word, called the N400 wave. The size of this brain wave changes depending on how easy a word is to understand and incorporate into a sentence! For example, when we hear "*people swim in the…"* we see a small N400 wave if the next word is *pool* and a large N400 response if the next word is *street.*

In an ongoing study we are using this wave to see how children and adults understand negation, or the word *no*. Specifically, we want to know whether listeners can use a word like *no* or *don't* to make predictions about the upcoming words in the sentence. In order to do this, we asked English speaking adults and 5-7 year old children to listen to a conversation between two aliens. One alien asks a 'yes or no' question about planet earth (e.g. *Do people swim here?*) and another alien answers (e.g. *Yes, people swim in the pool/street* or *No, people don't swim in the pool/street)*. Some answers are correct while others are false. We are most interested in how children understand the answers that are negated and false (e.g. *No, people don't swim in the pool)*. If children are able to use negation to predict upcoming words they should be surprised when they hear *pool,* eliciting a large N400 response. So far, very preliminary results suggest that children at this age might not yet be able to use negation to update their sentence predictions, however, data collection is ongoing!

Did You Notice That I Said of Wrong Word?

Anthony Yacovone, Graduate Student; Paulina Piwowarczyk, Maribelle Dickins, Research Assistants

In this study, we are investigating how adults and children understand language in real-time. As listeners, we must quickly turn incoming sounds into words and then use those words to build meaningful sentences! Previous research has shown that instead of just passively listening to people speak, we also actively predict what people are trying to tell us. This process of predicting upcoming words actually helps us understand people better and allows us to notice when people make mistakes (e.g. when they say the wrong word or mix up sounds). This project looks to understand how children's abilities to do this linguistic mind-reading (i.e. predicting upcoming words) compare to adults' abilities.



This study played a short story to adults and children while we recorded their brain activity using electroencephalography (EEG). Some of the sentences in the story were manipulated to have speech errors like "The books went all the way up to ***OF*** ceiling." We then looked at how participants' brains responded to these types of incorrect sentences. Previous research has found that children are less sensitive to these types of errors because they are a little bit worse at this linguistic mind-reading (relative to adults). We are still in the process of collecting data, so stay tuned to find out whether children and adults differ in their abilities to predict and recognize speech errors. Thank you for your interest in this study. If you have any questions, please contact Anthony Yacovone (anthony_yacovone@g.harvard.edu).

Can You Find the Frog with the Paperclip?

Anthony Yacovone, Graduate Student; Maribelle Dickins, Research Assistant

This study is part of a larger project that investigates the type of information that adults and children use to help them better understand language. In a typical conversation, there are many instances of ambiguous sentences like "Oh, look at the man with the telescope!" This sentence has two interpretations: 1) use the telescope to look at the man or 2) look at the man that has a telescope. Since both interpretations are perfectly fine options, it is impossible to tell which interpretation was intended without more information! Consider another example: "Find the frog with the paperclip!" This sentence still has two interpretations: 1) find the toy frog that has the paperclip or 2) use the paperclip to find the toy frog! In this example, the second interpretation seems very unlikely (e.g. why would someone use a paper clip to find things?!). Using our knowledge of what is likely or plausible in the world, we can reason that the speaker meant to instruct us to find the toy frog that has a paperclip.

We are interested in whether children can use this knowledge about what is more likely (e.g. using a paperclip to find things vs. having a paperclip) to help them decide between ambiguous interpretations. But before testing how children use this information about plausible events, we needed to systematically test that children and adults share similar intuitions about what is likely to happen in the world!

Consider the following

1. *Find* the frog by using the *magnifying glass* [Very likely]
   Find the frog by using the **paperclip** [Very Unlikely]

2. *Tickle* the frog by using the *feather* [Very likely]
   Tickle the frog by using the **mirror** [Very Unlikely]

In this study, we placed three objects (e.g. a magnifying glass, a paperclip, and a rock) in front of adults and children and asked them *"What can you use to find the frog?"* We then observed which object was selected to complete the task. We wanted to collect information about what children (aged 4.5-6) think about the likelihood of using certain objects to do certain actions like *tickling, finding, choosing, etc.* We found, unsurprisingly, that children and adults share intuitions about which objects should be used to perform certain tasks! Although, children were a bit more creative and often selected the wacky object (e.g. the rock) to perform the task (at least more than our adult participants did)! Thank you for your interest in this study. If you have any questions, please contact Anthony Yacovone (anthony_yacovone@g.harvard.edu).

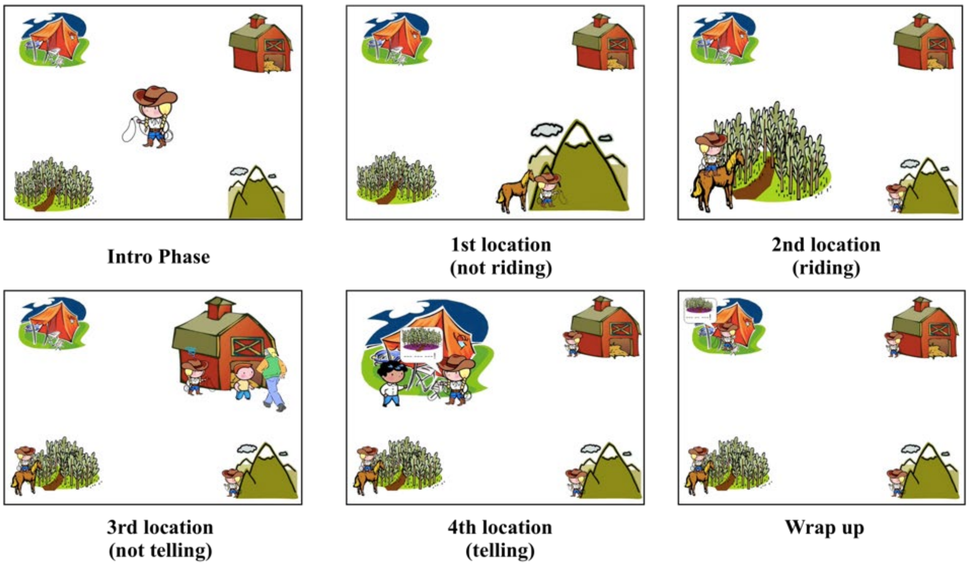
Where Did Emily Explain That She Rode Her Horse?

Anthony Yacovone, Graduate Student; Karen Andres, Harvard Research Assistant; Ian Rigby, Graduate Student at USC; Akira Omaki, University of Washington

This study is part of a larger study that I started with the late Akira Omaki at the University of Washington. This project investigates how children and adults interpret questions that have more than one possible answer.

Imagine hearing a story about a girl name Emily that rode her horse in the forest. After riding her horse in the forest, she goes to the campsite to explain to her friend that she had so much fun riding her horse in the forest!

This story has two main events: 1) *the horse-riding event* that happened in the forest, and 2) *the explaining event* that happened at the campsite. Imagine hearing the question, "Where did Emily explain that she rode her horse?" This question is ambiguous, as you could answer with "Oh, she explained at the campsite to her friend" or "Oh, she explained that she rode her horse in the forest!"



We are interested in which interpretation adults and children prefer after hearing stories like the one above. To test this, we played short cartoons to adults and children and then asked them ambiguous questions. We recorded participants' responses, which revealed how they ultimately interpreted the question. We are still collecting data, but it seems like adults and children prefer to interpret these questions as asking about where the *explaining event* happened (at the campsite) rather than where *the riding* happened (the forest). This type of research has also been done in French and Japanese, so we are excited to see how English-speakers' interpretations compare to those from speakers of other languages. If you have any questions, please contact Anthony Yacovone (anthony_yacovone@g.harvard.edu).

The Name Game

Maggie Kandel, Graduate Student

This study examines how children plan words and whether factors that influence the speed of adult word planning and articulation also influence child planning. The two factors that we are investigating are the codability of the referent (how many possible names can be applied to the image/concept being described) and word frequency (how often a word is produced or encountered in natural speech). The results of this study will be applied to investigate how language planning strategies differ in children and adults.

We are currently running five-year-old, monolingual, American English–speaking children in the experiment. During the experiment, children see images on a computer screen and are asked to name them as quickly as possible!

Prior to the child study, we ran a naming experiment with adult participants. We found that adult speakers are faster to name images with frequent names than infrequent names and are faster to name highly codable images (those with fewer name alternatives) than images with less name agreement; these results replicate previous findings from other labs.

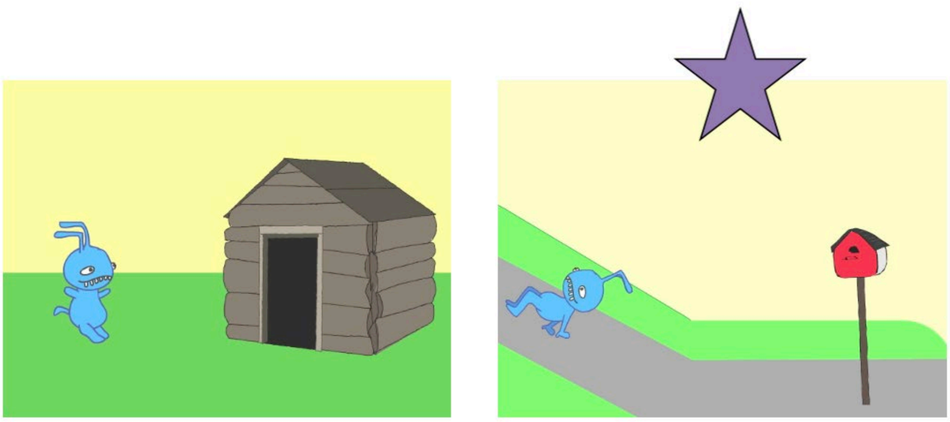
The children who have participated in the experiment so far have had no difficulty completing the task and naming the pictures. We will analyze the child naming response times once we have collected the full dataset–please stay tuned!

Action Events Study

Annemarie Kocab, Postdoctoral Researcher

The world provides us with a continuous, complex stream of experience. Yet, when we think or communicate, we readily break this stream into events. These linguistic descriptions can express information about different components of an action. For instance, a description of the Boston Marathon race might include information about a participant's manner of motion (the woman is **running**) or her path of motion (the woman is **ascending up** a hill). These components are described consistently across different actions (manners like running, skipping vs. paths like ascending, crossing). Moreover, these patterns in how events are described are observed across different languages. Linguistic theories have posited that these components appear to be universal because they reflect properties of our conceptual system. We are interested in whether children and adults are able to abstract two categories, manner of motion and path of motion, in a non-linguistic, implicit task when explicit attention is not drawn to these components.

In this study, your child saw a series of short videos. The videos all showed an animated character performing an action (a monster skipping around a phone booth, a monster crab-walking up a hill). Your child was randomly assigned to one of two groups: the *manner* condition or the *path* condition. Across pairs of videos, depending on the condition your child was in, either the manner remained the same (one video in each pair always showed a *skipping* motion) or the path remained the same (one video in each pair always showed an *around* path). During training, a colored star appeared over one video, either the one showing the same manner or the one showing the same path. On the last trial, your child saw a new pair of videos and asked to select which one they thought the star would appear on.



If these components reflect how we construe events, children and adults should be able to abstract them in an implicit categorization task that does not rely on language. Indeed, our preliminary results suggest that by the end of the experiment, both children and adults categorize videos according to the condition they were trained on (manner or path) even in the absence of any linguistic labels that could cue categorization.

Do Toddlers Adapt Their Word-Learning Strategies to Their Parents' Speech?

Joseph Coffey, Graduate Student

Children learn much about the world through guided play with their parents. We believe this is because parents and children spend a lot of time during play coordinating their attention on the same objects. This time gives parents the opportunity to share important information about objects with their children. In particular, children's language development has been tied to the amount of time parents spend in joint-attention with their children.

But young children have a hard time focusing on the same objects for too long, limiting the amount of joint-attention parents can achieve with their children. Prior studies have found that parents who prefer to follow their children's attention, such as by talking about objects children are already focusing on, achieve higher levels of joint attention with their children than parents who prefer to direct their children's attention, such as by trying to introduce new objects to their children while they are already focused on others. This difference in parental interaction predicts language outcomes, with parents who use more attention-following speech encouraging quicker development. This is likely due to the fact that attention-directing speech requires children to break attention from an object, figure out which object their parents want them to focus on, and re-establish attention to that new object. In contrast, attention-following speech only requires that children continue to focus on their objects, and as a result is easier to learn from.

However, we find cross-cultural differences in the prevalence of attention-directing and attention-following speech. Chinese caregivers, for example, make a much greater use of attention-directing speech with their young children than American mothers do, and yet it does not appear to result in worse language outcomes for Chinese children. Previous studies of joint-attention have focused almost exclusively on American families, who make use of more attention-following speech than attention-directing speech in general. It is possible then that American children find attention-following speech easier to learn from than attention-directing speech because it is the primary mode of instruction in their households. Chinese children may find attention-directing easier to learn from for the same reason.

In order to test this hypothesis, we are testing children ages 18-24 months in the Boston-area from English and Mandarin Chinese-speaking households. We record 15-minute play sessions between parents and children to determine the prevalence of attention-directing and attention-following speech, as well as the amount of joint-attention achieved. We then show children six pairs of novel objects, giving them one to play with and keeping one for ourselves. We either direct their attention by labelling our own object, or follow their attention by labelling theirs. After letting them explore both objects, we ask them to show their parent the object that was labelled. Afterwards, parents fill out a language assessment for their children in either English or Mandarin. We hope to find that American children and Chinese children show different performance on following and directing trials, and that these differences correspond to the amount of either type of interaction their parents engage them with.

We are currently in our piloting phase, and we hope to report our results in the next newsletter!

What Can Our Brain Waves Tell Us About How We Understand Words and Sentences?

Tanya Levari, Graduate Student

Studies using EEG with adults have discovered that there is a specific brain wave that happens when a person hears a word, called the n400 wave. The size of this brain wave changes depending on how easy a word is to understand and incorporate into a sentence. For example, when a word is very frequent, like “dog”, the n400 wave is smaller than when a word is less frequent, like “axolotl”. In addition, the wave is smaller when a word is very predictable and larger to words that are surprising! For example, imagine heading the following; “On a windy day Johnny liked to go fly his…” You wouldn’t be very surprised if the next word happened to be “kite”, but you would be very surprised if suddenly you heard “blimp”. The size of the n400 brainwave would show exactly that – the n400 wave would be smaller if you heard “kite” and larger if you heard “blimp”.

As part of the development of a project looking at language processing in children on the autism spectrum, we conducted EEG recording of several children as they listened to a story from Roald Dahl’s *Matilda*. We are looking at the brain’s response to each word in the story to see whether children’s brain waves, like those of adults, are sensitive to various word features, such as frequency and predictability. Eventually, we will be comparing the response patterns in typically developing children to children on the autism spectrum in order to better understand whether children on the autism spectrum differ in how they make linguistic predictions.

Training Childrens’ Understanding of the Base-10 Structure of the Number System

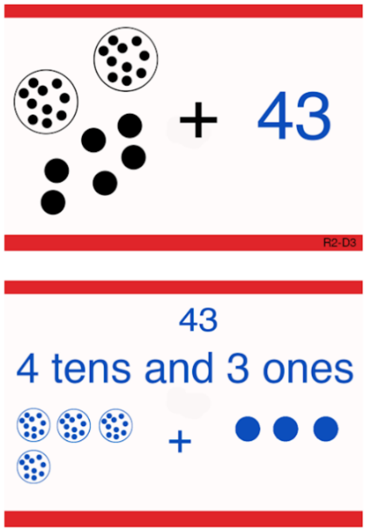
Akshita Srinivasan, Graduate Student

In school, one of the most important mathematical skills taught to children is arithmetic. However, arithmetic can be really hard for kids to learn unless they master the base-10 compositional structure of the number system. Number words in English are not that transparent in revealing this structure. For example, the number ‘twenty-five’ is actually made up of two tens and five, but the number word ‘twenty’ does not automatically signal that it is made up of two tens.

In order to facilitate this understanding among 6-7-year-old children (who are on the threshold of arithmetic instruction in school), we are developing a game for them to take home and play with an adult or an older sibling. In this game, children will play with a board and some cards for a period of two weeks. Based on the numbers on the cards, they need to move a token on the board in order to perform addition. For example, in the cards shown below, they will first find the number in black (26) on the board by counting by tens. Then, they will add the number in blue (43) to it, by leveraging its compositional structure (43= four tens and 3 ones). With a battery of assessments before and after this training, we will measure if our games promote school relevant arithmetic learning.

We are in the phase of piloting the game and the assessments. We hope that our game will help children encode numbers in a manner that makes school-based learning easier for them. Stay tuned for the findings from this study!

90	91	92	93	94	95	96	97	98	99
80	81	82	83	84	85	86	87	88	89
70	71	72	73	74	75	76	77	78	79
60	61	62	63	64	65	66	67	68	69
50	51	52	53	54	55	56	57	58	59
40	41	42	43	44	45	46	47	48	49
30	31	32	33	34	35	36	37	38	39
20	21	22	23	24	25	26	27	28	29
10	11	12	13	14	15	16	17	18	19
	1	2	3	4	5	6	7	8	9



Using Language to Reason About Objects in Infancy

Gabor Brody, Graduate Student; Athulya Aravind, Postdoctoral Fellow

This study investigates infants' ability to recruit linguistic information to reason about unseen objects. In the study, 10- and 13-month-old infants are shown videos of a person with an opaque box. The person looks inside the box and describes its contents using different verbal frames, which lead to different expectations about how many objects are in the boxes. For instance, she may say, "Look! An apple *and* an apple!", in which case we expect two objects or "Look! An apple! An apple!", in which case we may expect only one. The box is then opened to reveal an outcome that is either consistent or inconsistent with the verbal framing. If the infant looks longer at outcomes that are inconsistent with the framing, for example, a one-apple outcome after an *and*-framing, we can reason that they are forming expectations based on language alone, an impressive feat for babies who are producing very little language!

Data-collection for this study is still ongoing, so we look forward to reporting the results in the next edition of the newsletter!

Do Children Prefer Those Who Display Affiliative Cues?

Ashley Thomas, Postdoctoral Researcher; Caitlin Connolly, Research Assistant; William Pepe, Lab Manager

Imitation Condition 1: One puppet imitates, one puppet doesn't

Previous studies have shown that infants prefer individuals who are involved in social interactions. This project looks at two cues of social affiliation: imitate and comforting. We are interested in whether infants distinguish between targets of affiliative cues (e.g. someone who is imitated or comforted) and actors who display affiliative cues (e.g. someone who imitates or comforts).

We show infants videos of one experimenter and two puppets. In one video one of the puppets comforts the experimenter and the other does not; in one video one of the puppets is comforted by the experimenter and the other is not; in another video one of the puppet imitates the experimenter and the other does not; and in the last video one puppet is imitated by an experimenter and the other is not. After infants see each video we ask whether they prefer one of the puppets by measuring which puppet they reach for.

Preliminary results suggest that infants prefer puppets who imitate over those who do not, prefer puppets who are comforted over those who are not; have no preference between puppets who comfort and those who do not; and prefer puppets who are *not* imitated over those who are imitated.

This study helps add to the existing literature about early social evaluations and social development.

Next, we are researching whether infants prefer those who synch up their actions with an experimenter over one that does not.

To the left is an example of an imitation video.

Young Toddlers' Understanding of *More*

Athulya Aravind, Postdoctoral Fellow

Certain words in our language are appropriate for use only if our audience already knows some piece of information. One of the earliest words children produce—'more'—is one such word: a sentence like "I am going to have some more" is appropriate in a conversation only if the listener already knows what I had before.

In our study, we probe 18-month-olds' sensitivity to this requirement on audience knowledge. Toddlers saw videos of an animated character with two sets of food items. He first announces that he is going to have one of the two food items ("I'm gonna have some cookies!") and approaches that food item. Later on, he has a choice between the same two food items, and he announces either, "I'm gonna have some!" or "I'm gonna have some more!"

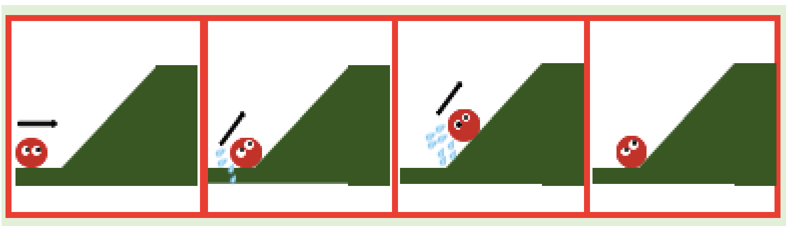
(i) I'm gonna have some berries!

(ii) I'm gonna have some/some more!

Although the content of the character's speech doesn't specify what he will eat, in the case of *some more*, we expect that he will approach the same food item as before. We asked whether 18-month-olds form the same expectations by seeing if they *predictively* looked at the same food when they hear a "some more" sentence compared to "some. Preliminary results suggest that at this age, they do not: they looked equally at both food options irrespective of the language the character used.

Training Social and Moral Reasoning

Brandon Woo, Graduate Student



Past work in this lab has developed games to improve children's ability to reason about number. In the present study, we are examining whether a game focused on social evaluation may improve 6- to 7-year-olds' ability to reason about social and moral problems. In the game, children see social scenarios and are asked to determine who's nicer.

We are currently developing these games on social evaluation and are developing assessments involving social and moral problems (e.g., evaluation, distribution of resources, emotion recognition, emotion prediction, etc.). Everything for the present study is in the piloting phase, and so, we are unable to comment on trends in data.

Preferences for Helpers vs. Imitators

Brandon Woo, Graduate Student

Early in development, infants appear to prefer interacting with: (i) an individual who helps others over an individual who is unhelpful; and (ii) an individual who imitates others over an individual who acts in a way that is unlike others. In the present study, we are examining whether 15-month-old infants will still prefer a helpful individual over an unhelpful individual, even when other individuals have been unhelpful. In the study, infants see a character that tries and fails to access a resource. A group of characters is then unhelpful by pushing the resource further away from the first character, whereas one character is helpful by pushing the resource towards the first character. We are looking at whether infants will reach to a character from the group vs. the one helpful character. Although most infants have been reaching to the character from the group, it is important to note that we are still piloting this study and may modify videos before running a full sample of infants.

Evaluations of Helpers Based on Their Mental States in Means-End Sequences

Brandon Woo, Graduate Student

Early in development, infants appear to prefer interacting with individuals who help others over individuals who are unhelpful. The present studies aim to examine whether infants can reason about what would be most helpful to a character in a means-end sequence (i.e., when a character does something as a means to an end; in order to do something else). .

In two studies, infants see two boxes, each with a unique toy. In the first few trials, a protagonist tries but fails to open one box. Two helpers help the protagonist to open the box, and the protagonist grasps the toy inside. Following these first few trials, infants see the two toys switch positions, such that the original box that had been opened now contains a new toy, and the other box contains the original toy. After the switch in toy positions, the protagonist jumps between the boxes, as though calling for attention. One helper opens the original box with the new toy, whereas the other opens the second box with the original toy. In each study, we assess infants' preferences for the two helpers.

The critical distinction between the studies concerns the helpers' perceptual access to the toys. In Study 1, the boxes are transparent and the helpers are present as the toys switch positions. By contrast, in Study 2, the boxes are opaque and the helpers are absent as the toys switch positions. Thus, although infants know of the switch in toys in both studies, they can only accurately reason that the helpers have knowledge of the switch in Study 1.

In Study 1, 21/24 fifteen-month-old infants reached for the helper who opened the new box with the original toy. These data suggest that infants evaluate helpers based on whether they help with the end (the original toy), not the means (opening the original box), of the original means-end sequence. Data collection for Study 2 is ongoing.

We are now running 7-month-olds in the same stimuli that we used with 15-month-olds in Study 1. We are interested in whether they will also evaluate helpers based on whether they help with the end vs. the mean. Although 7-month-olds thus far are reaching for the helper who opened the original box, despite the contents being different, it is important to note that data collection has only recently started for 7-month-olds and we are unsure if this pattern will hold.

Common Ground in Conversation

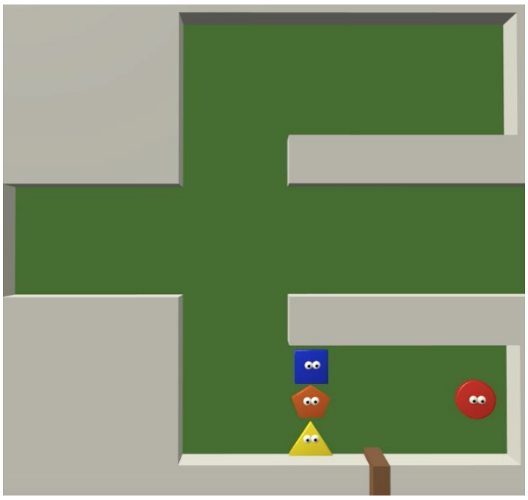
Brandon Woo, Graduate Student

In everyday conversation, people can use words like "it" (pronouns) as substitutes for other words (e.g., to say "I ate it" vs. "I ate a hotdog"). Importantly, the use of pronouns may only make sense when two speakers may both know what the pronoun refers to.

In the present study, we are examining whether 4- to 5-year-olds are sensitive to the use of pronouns in conversation. We are showing children stories in which a character experiences something and shares the information with others, and we are asking children who may have had prior knowledge about the first character's experiences based on the way that the first character shares information. We are still piloting this study to make sure that stimuli are understandable for children, and so, we are unable to comment on trends in data.

Inferring Goals from How Characters Navigate Space

Brandon Woo, Graduate Student

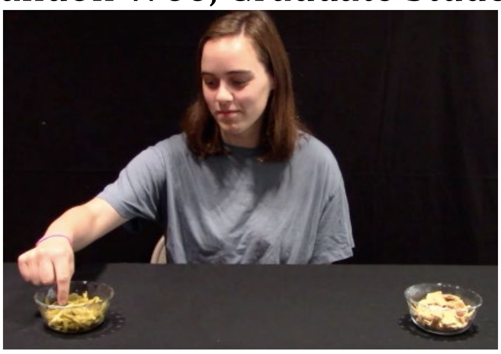


Past work has proposed that people think others should behave efficiently according to what they know of the world. In the present study, we are examining how 15-month-old infants understand what others' goals are from how they navigate space.

In the study, infants see a character work hard to get to three other characters. Before the first character can get to the others, though, the other characters move to different locations in the space that are not immediately visible to the first character. We are looking at which of the three other characters infants think the first character most strongly prefers depending on how the first character navigates the space. We are still piloting this study to make sure that stimuli are okay for infants, and so, we are unable to comment on trends in data.

Expectations of Similarity Between the Self and Group Members

Brandon Woo, Graduate Student

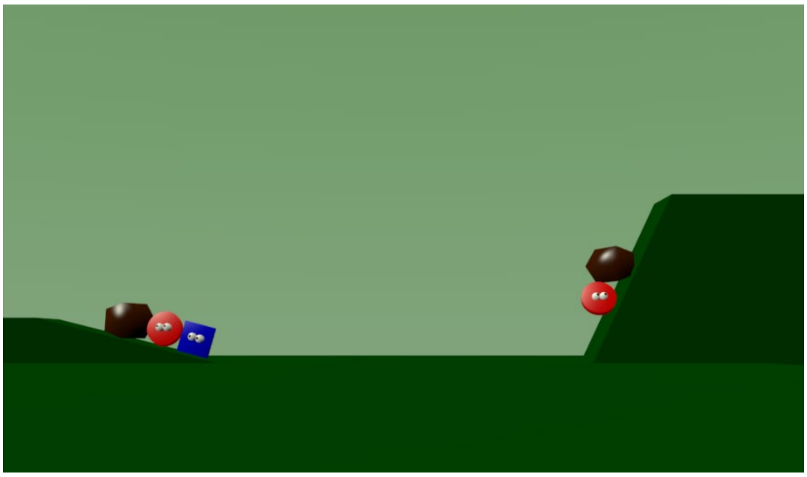


Past work has demonstrated that infants are sensitive to a person who speaks English vs. a foreign language, and that adults think people in their social group are more like them than are people outside of their social group. The present study aims to examine whether infants may also think people in their social group (as marked by language) are more like them than are people outside of their social group.

In the present study, infants receive crackers and green beans, and we examine which they prefer. We then show infants an English and a Spanish speaker, who either both share infants' food preference, or share a preference for the food that the infant did not choose. We are examining whether infants expect the English vs. the Spanish speaker to share vs. not share their food preference. Everything for the present study is in the piloting phase, and so, we are unable to comment on trends in data.

Expectations and Evaluations of Effortful Helping

Brandon Woo, Graduate Student

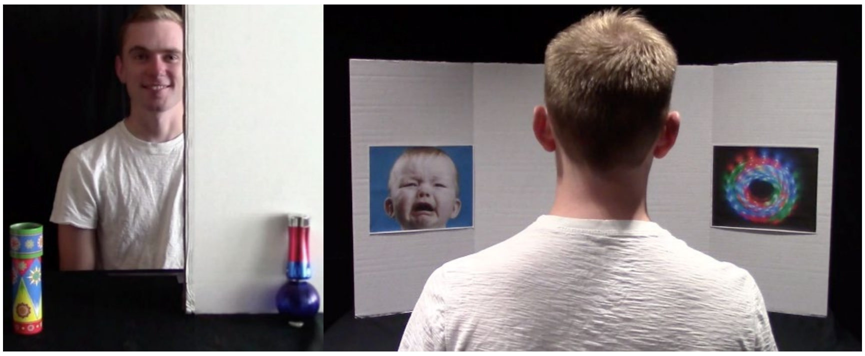


Early in development, infants appear to: (i) prefer interacting with individuals who help others over individuals who are unhelpful; and (ii) understand that steep slopes take more effort to climb than less steep slopes. The present study aims to examine whether 16-month-old infants think someone should help someone when a task requires more vs. less effort.

In the study, infants see one character try to climb a steep hill while another character tries to climb a less steep hill. A third character will help the character at the steep hill by pushing it up, whereas a fourth character will help the character at the less steep hill by pushing it up. We are examining whether infants expect the characters to help at the steep vs. the less steep hill, and whether infants prefer a character who helps at the steep vs. the less steep hill. Everything for the present study is in the piloting phase, and so, we are unable to comment on trends in data.

Emotion Understanding and Perspective Taking Between and Within Groups

Brandon Woo, Graduate Student



Early in development, infants (raised in the Boston area) appear sensitive to accent, preferring to look at individuals who speak English in a North American accent vs. in a French accent. This is suggestive that infants may have some sensitivity to social groups. The present study aims to examine whether 19-month-old infants reason about others' emotions and perspectives differently depending on whether someone speaks English in a North American vs. in a French accent.

In the present study, infants see an actor who either spoke English in a North American vs. in a French accent. The actor then: (i) makes emotional vocalizations at different objects, which sometimes correspond with an emotional vocalization (e.g., "aww" and a picture of a crying baby) and which sometimes do not (e.g., "aww" and a picture of a light-up toy); and (ii) looks at a display that includes two objects, one of which is visible to both infants and the actor and one of which is only visible to infants. We are using an eye tracker to examine whether infants' look at objects in the scenes differently following an emotional vocalization and speech depending on the actor's accent. Although 19-month-olds thus far are looking more quickly at a visible object than a nonvisible object when the actor's accent is French vs. North American, it is important to note that we are still piloting this study and may modify videos before running a full sample of infants.

Improving Social and Number Learning with Games in Preschool Children

Chrissie Carvalho, Postdoctoral Researcher; Laura Mullertz, Sara Dublouk, Elisa Mello & Caitlin Elizabeth Connolly, Research Assistants

We have designed and are currently evaluating a new game-based intervention aimed at improving children's learning both of school mathematics and of mental state concepts that are an essential part of *learning to learn.* Preschool is a crucial time for learning language and other school-relevant skills building on core cognitive systems for representing number and social systems. Interventions during this time may help to notably increase school readiness, particularly in numerical/mathematical and socio-cognitive domains. In spite of the theoretical support in favor of such interventions, as well as the relevance of socio-cognitive and mathematical concepts to success in both school and life, few previous preschool interventions have focused specifically on these domains. Here, we ask whether card and board games that exercise intuitive math and social concepts enhance children's learning in school. We have previously conducted similar studies focused specifically on number and geometry abilities as a large-scale RCT in preschool and elementary school classrooms in India and Uruguay. These studies indicated potential benefits in school-based numerical and geometric abilities, leading us to develop social games to be tested in comparison with the number games already used in previous studies.

In this home-based intervention study, children are invited to visit the lab and bring home either a number or social game to play with their parents (Figures 1-2). We conduct pretest and post-test assessments focused on number and social abilities in order to assess children's command of these school-relevant concepts before and after undergoing the game-based intervention. Over the course of the two to three weeks between visits, children are encouraged to play as much as they like and parents are requested to report the child's gameplay progress regularly.

We predict that children trained on the social cognitive games will show greater gains in social cognitive skills, including mental state reasoning and action prediction, from pretest to post-test, relative to children trained on the math games. We also predict that math-game trained children will show greater gains in math skills, on tasks that exercise intuitive, verbal, and symbolic numerical reasoning. We are currently in the process of collecting data for this experiment and are excited to learn more about the efficacy of game-based interventions in these domains, given that there have been few preschool-targeted interventions with a similar focus. Pending the results of this experiment, we hope to continue improving these games and creating accessible materials that can be used widely for classroom-based interventions or supplementation to regular preschool coursework. We will soon begin testing these materials in the field in collaboration with public preschools in Bahia-Brazil—the region with the worst school performance in the country—in the hopes that our efforts will positively impact early education in Brazil.

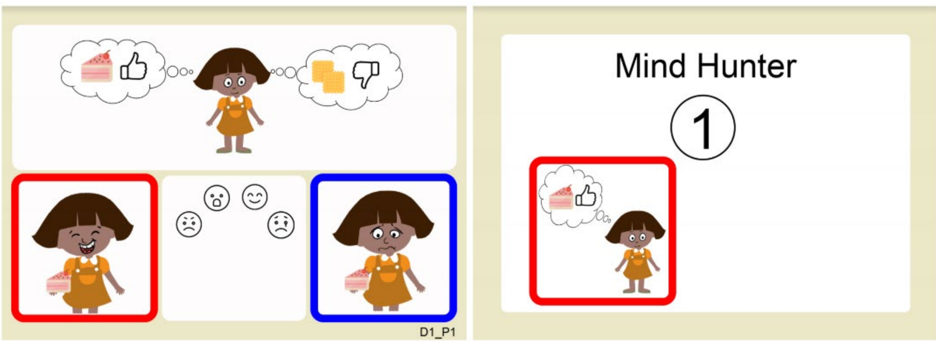


Figure 1 - Mind Hunter challenges children to perform and interpret mental states, perceptions, desires, beliefs, and intentional actions. The top of each two-sided card depicts a character who has a belief or a desire, which the child must reason about using either perceptual information or emotion, or interpreting symbols. On the bottom of the card, the character stands between two goal states, one depicted in red and the other in blue; children sort the card by the color of the image that depicts the character's likely goal or action. The back of the cards indicate the correct answer with a red or blue circle.

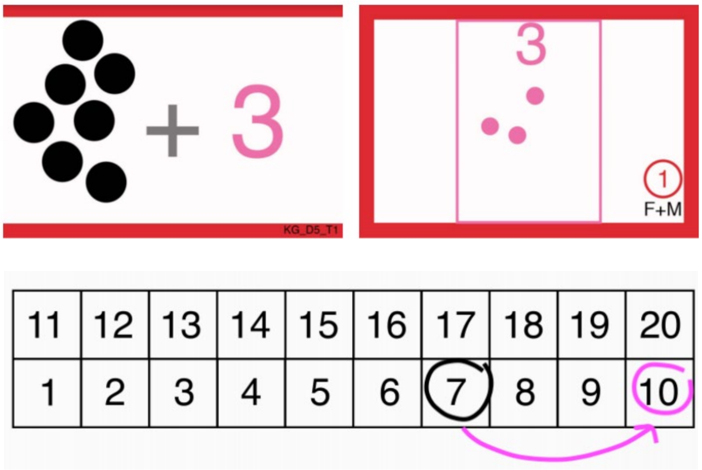
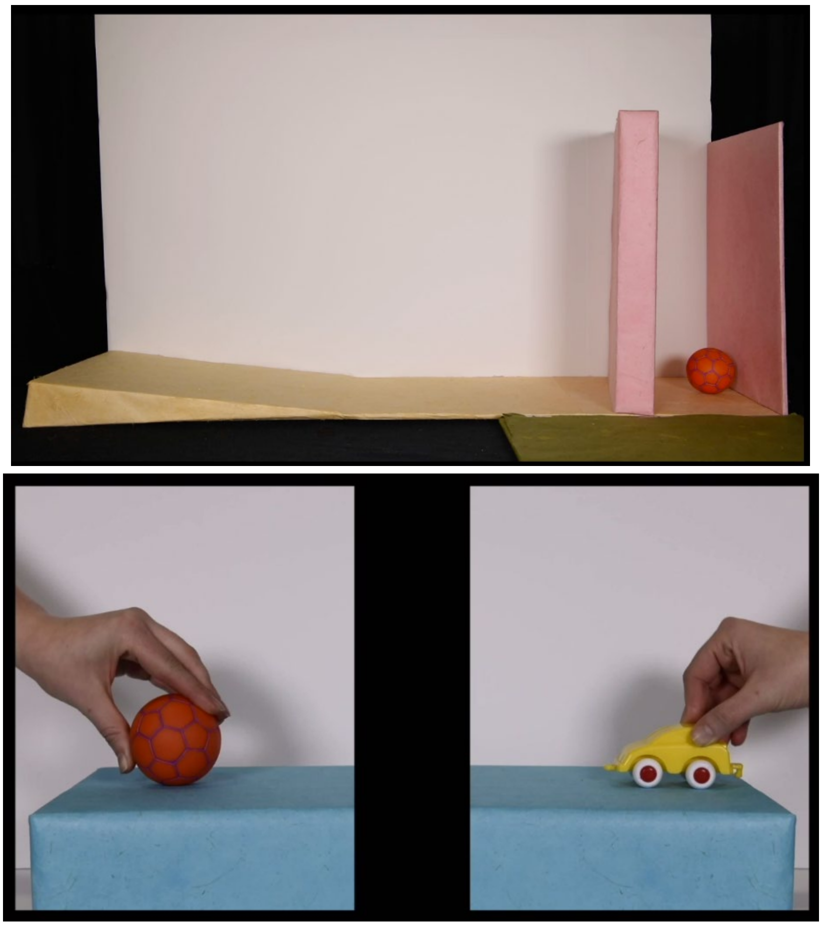


Figure 2 - *Number Chase* is an untimed board game exercising counting, exact addition, and operations using the base-ten structure of the number system. Children locate 7 on the board (7 black dots) and move forward 3 spaces (pink 3 - also illustrated on the back of the card with 3 pink dots).

Learning from Surprise: Attending to Relevant Actions

Emily Walco, Graduate Student



When a baby is born, there is so much going on in the world around them that it can be overwhelming. Without some way to prioritize what to learn from, babies might not be able to learn anything at all. Researchers have proposed that seeing something surprising, specifically seeing an object act in a way that is unexpected, can act as an indication that there is more to learn. Previous studies with older babies have found that when babies see an object do something surprising, they choose to explore that object more, and that they explore it ways that are consistent with what they had just witnessed. If they saw the object roll through a wall, they were more likely to try banging it, and if they saw the object hover in midair, they were more likely to try dropping it.

The present study built on this finding by testing much younger babies, 6-month-olds. We showed them these same surprising events, but instead of giving them the objects, the infants watched another person explore the objects. The question was whether babies would look to the action that would give them more information (the person interacting with the toy that surprised them, and either dropping or banging it) even before they have the dexterity to explore the objects in this directed way. Because this study is still in development, we do not know what the findings are yet, but we are continuing to explore this phenomenon in babies of all different ages, as well as bonobos to see how humans and apes might learn differently!

Learning from Surprise: Selective Exploration

Emily Walco, Graduate Student

When a baby is born into the world, there is so much going on in the world around them that it can be overwhelming. Without some way to prioritize what to learn from, babies might not be able to learn anything at all. Researchers have proposed that seeing something surprising, specifically seeing an object act in a way that is unexpected, can act as an indication that there is more to learn. Previous studies with 11-month-olds found that when babies see an object do something surprising, they choose to explore that object more, and that they explore it ways that are consistent with what they had just witnessed. If they saw the object roll through a wall, they were more likely to try banging it, and if they saw the object hover in midair, they were more likely to try dropping it. This study seeks to replicate that finding, since it has only been discovered one time in one lab so far!

In the present study, we show 11-month-olds a series of videos where one object does something surprising and another object does something that is not surprising. The babies are then given two minutes to play with the two objects. Our main questions are how much time they choose to spend exploring each object and what they are doing with the objects while they interact with them. Because this study is still in development, we do not know what the findings are yet, but we are continuing to explore this phenomenon in babies of all different ages, as well as bonobos to see how humans and apes might learn differently!

How Context Affects Infants' Memory

Gabor Brody, Visiting Researcher; Athulya Aravind, Postdoctoral Researcher

There is much literature on infants' object memory showing that infants can remember different aspects of objects when they are hidden for short periods of time. For example, they can remember what objects look like, what category they belong to, how many of them were present in a scene. Most of these studies look at the different aspects of this capacity in isolation. For example, some studies focused on infants' memory of the visual features of objects but not to memory of location; while others were investigating the limitations of the system (what is the maximum number of objects that infants can remember) while not focusing on the memory of visual features. Interestingly some evidence shows that infants might have trouble remembering some different aspects of objects simultaneously. In a recent study, infants who encountered an object in a communicative context (when an experimenter was talking to the infant and pointing to the object) forgot its' location but remembered what it looked like. In contrast when they encountered an object in a non-communicative context (when the experimenter was trying to reach for the object, while not communicating to the infant) they did the opposite: forgot what it looks like but remembered its' location.

In the current study we were interested in whether these context effects could be extended to remembering how many objects were present. This question is important because from some theories on object memory it follows that memory of the number objects is privileged, and infants should always remember it no matter the context of the presentation. To go after this question, we showed infants videos where sets of objects were hidden behind an occluder after communicative or a non-communicative presentation. After a short time during which the objects remained hidden, we showed one of three outcomes by revealing what was behind the occluder. In the "no change" videos we showed the same exact objects we hid. In the "object change" videos we changed the objects (e.g. changing 2 balls to 2 apples), but number of objects remained the same. Finally, in the "number change" videos we changed the number of objects (e.g. changing 2 apples to 3 apples) but kept the objects the same. We keep showing the last frame of these videos until infants look away, so we could measure how long they kept attending to the videos. If infants look longer at the last frames of "object change" or "number change" videos compared to the "no change" videos, that would show that they remembered the object or number respectively, as the longer looking would probably imply surprise.

After finishing the group with 24 infants we found that irrespective of the context infants remembered what the objects were, but they seemed to forget how many of them were present. They looked longer at the "object change" videos than the "no change" videos, but this wasn't true for the "number change" videos. This is a surprising finding given that we know that infants can remember the number of objects in other studies, but altogether it might imply that the number of the objects in a scene might not have a privileged role in infants memory.

An example of a communicative "object change" video. First the experimenter pointed to the ducks. Then for a short time the ducks were hidden behind the blue occluder. At the end of the video the it was revealed that the ducks were changed into balls.

Five-Month-Old Infants Preferences for Responsive Caregivers

Rhea Howard, Graduate Student; Annie Spokes, Postdoctoral Researcher

In these studies, 4.5 to 5.5-month-old infant participants watched short video animations of caregiver-baby interactions. In the videos two large shapes represented "adults" and a small shape represented a "baby." Each shape had eyes and was a bright color to make them easily distinguishable. Infant participants saw the "baby" shape cry and one of the two adult shapes approached and comforted the baby, while the other adult shape moved away from the baby. Participants watched this interaction four times. Afterwards, the two adult shape came onto the screen for 45 seconds. We were interested in whether infants would look longer at the adult shape that had comforted the crying baby. At this age, infants tend to look longer at things that they prefer. If infants looked longer at the responsive caregiver, this would be evidence that they are able to track the relationships between these characters and that they have a preference for the more helpful character. In previous studies, we have found that 5-month-old infants do look longer at the more responsive caregiver. However, in this most recent study we did not replicate this preference. We are currently following up on this work to investigate more fully whether 5-month-old infants do have a preference for more responsive caregivers, and if so what specific cues about the characters infants are using to distinguish between these characters.

Inferences about Caregiver Gender at Fourteen Months

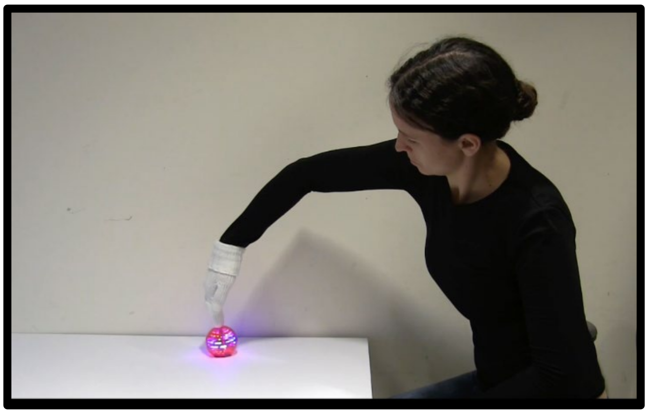
Rhea Howard, Graduate Student; Annie Spokes, Postdoctoral Researcher

In these studies, 13.5 to 14.5-month-old infant participants watched short video animations of caregiver-baby interactions. In the videos two large shapes represented "adults" and a small shape represented a "baby." Each shape had eyes and was a bright color. One of the adult shapes had a male voice, and the other adult shape had a female voice. At the start of the video, each of the adult shapes introduced themselves to the infant participants. After the characters introduced themselves, the "baby" shape cried and one of the two adult shapes approached and comforted the baby. In the next clip, the baby cried again, but this time the other adult comforted the baby. Infant participants saw the male-voiced adult shape and the female-voiced adult shape each comfort the crying infant twice. At this age, infants tend to look longer at events that they find surprising. We wanted to know whether infants would find it more surprising if a baby was comforted by a male character over a female character.

These studies are currently ongoing, however we do have preliminary data that 14 month olds who are themselves primarily cared for by female caregivers find it more surprising when a character with a stern male voice comforts the crying infant instead of a character with a cheerful female voice. Interestingly, babies are equally unsurprised when a cheerful male character or a stern female character comfort an infant. These results suggest that when a male character is friendly, infants do not have an expectation that the female character is more likely to comfort. However, if the male character is stern, infants do have an expectation that the female character is more likely to care for an infant. Currently we do not have enough data from infants who are coparented or who are primarily cared for by male caregivers to be able to draw conclusion about their expectations about caregiver gender or how temperament might play into their inferences. We are looking forward to continuing to collect data to untangle what expectations babies may - or may not- have about who is likely to care for an infant.

What do Pre-Reaching Babies Know About Reaching?

Shari Liu, Graduate Student

Humans engage in a lot of goal-directed actions: cooking, dancing, acting, reading, buying, throwing, pulling, climbing, and more. Mechanisms that help us understand the structure of these actions is essential for understanding and learning from others. Previous research from our and other labs suggests that giving babies action experience boosts their action understanding. This series of studies asks whether infants really need to experience a particular action themselves in order to understand it in other people.

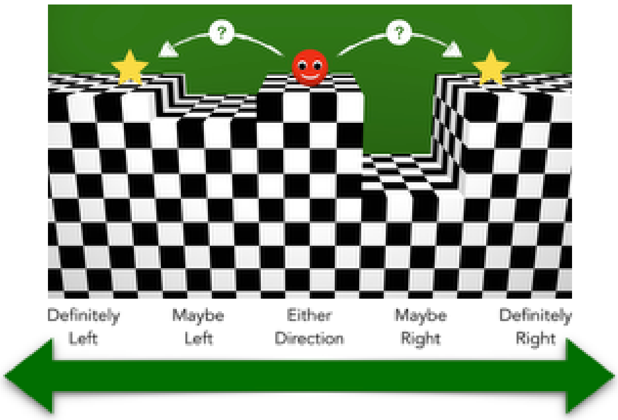
In particular, we were interested in whether 3-month-old infants, who are about 1-2 months away from reaching for, grasping, and manipulating objects on their own, understand that reaching is an intentional action. In the past years, we tested this by asking whether these infants expect a reach to be efficient, a key signature of intentional action. We presented 3-month-old babies with an actress who reached over an obstacle either caused the object to change color by touching it, or picked up the object with her hand. Then, we removed the barrier. Given that the actress is going to reach again for the object, how will she direct her reach: the same way that she did before (inefficiently), or by reaching straight across the area where the barrier used to be (efficiently)? If 3-month-old babies interpret reaching as a goal-directed action, then they, like older infants, will look longer at an inefficient than an efficient reach. We found that 3-month-old infants expect reaching to be efficient both when the actress caused an interesting change in the object, and when she picked up the object, though their expectations were weaker in the second case. Further experiments manipulating the cause and effect relationship between the hand and the object showed that infants only showed expectations for efficient action when the person's actions caused the object to change on contact.

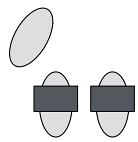
This year, we tested this same idea by asking whether infants see reaches as directed towards a particular goal object. We presented 3-month-olds with an actress who reached for one object over another (e.g. a bear, over a ball). Like in the experiments above, her hand caused the object to change state: The object illuminated and made a sound. Then, the objects switched locations. Where will she reach: For the same object she did before in the new location, or for the new object in the old location? If 3-month-olds interpret reaching as directed towards a specific goal, then they, like older infants, will look longer when the person reaches for the new object. So far, we have found that infants indeed follow this prediction, but these results are preliminary. Stay tuned next year for more!

These findings are important for several reasons. First, they show that infants do not need any motor experience reaching for objects (which babies do not reliably start doing until ~5 months of age) around a barrier (which babies do not master on their own until 8-10 months) in order to expect that agents plan their reaches to be as efficient as possible towards particular goal objects. This finding actually makes a lot of sense, given the wide range of human actions—we need to be able to understand what others are doing in order to learn new actions from them! These experiments have been running for almost 4 full years, and we are currently finishing the last experiment in this series.

Infants' and Children's Understanding of Probability and Risk

Shari Liu, Graduate Student





As adults, we understand that one reliable way of learning what someone likes (e.g. apples) is how much of a cost she's willing to pay for them ($1? $12? a trip to the store? climbing a tree? 10 bananas?). Our previous studies showed that even 10-month-old infants have this intuition: Given that a character was willing to jump a bigger barrier, climb a steeper hill, or jump across a wider cliff to get to one goal than another, infants expect the person to value that goal more.

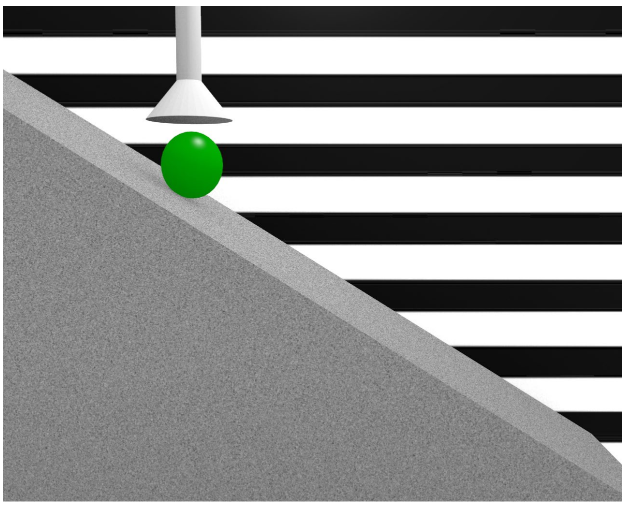
Here, we are interested in another variable relevant for people's decision-making: risk. Intuitively, if someone is willing to pursue a goal even if they're not likely to get what they want, or they're willing to enter a potentially dangerous situation to achieve this goal, we get the impression that the value of the goal must outweigh the risk that people take to achieve it.

We tested these intuitions in infants and young children. In one line of experiments, we showed 10 and 13-month-old infants that an agent is willing to jump a deeper cliff to reach one of his friends over the other. The agent then alternatingly chose either the higher-value friend (for whom he expended more risk) over the lower-value friend (for whom he expended less risk), or vice versa, while we measured infants' attention. We reasoned that if they can infer value from risk, then they will look longer when the agent chose the lower-value friend. We found an interesting age effect: 10-month-old infants looked equally at the two outcomes, and 13-month-old infants looked longer at the less likely outcome. We then tested the same-aged infants in a simpler task, where an agent had a choice to jump a deeper or shallower cliff to reach the same goal, and found that both 10-month-old and 13-month-old infants are surprised to see the agent take an unnecessarily risky action. These findings tell us that infants understand the actions of agents by assuming that agents make plans based on variables like effort, risk, and value. We are also asking older children, from 5 to 8 years of age, what they think of these situations by asking them about the emotional states of the characters acting, and asking them to rate their own uncertainty about where the character will go next.

In a second line of experiments, we are asking older children (5 to 8-year-olds) to reason about the probability of a person achieving their intended goal. In this study, characters have the choice to randomly draw a ball from one of two boxes. The colors of these balls, and their proportions, vary: For example, imagine that there are 99 blue balls and 1 white ball in Box 1, and 1 red ball and 99 white balls in Box 2. You know that the person doesn't care about white balls, but you don't know whether they like blue or red balls more. Imagine that the character gives up an almost certain chance of drawing a blue ball, in order to pursue the almost impossible outcome of drawing a red ball. Intuitively, we get the impression that the character strongly prefers red to blue. But reverse the choice (the person chooses the 99% blue box over the 1% red box), and her preference is less clear: Is she choosing the blue box because she's motivated by the high probability of winning something, or because she prefers blue balls to red? The question is whether children have the same intuition. We are only starting data collection now, so stay tuned next year for more results!

Infants' Understanding of Inclined Plane Mechanics

Shari Liu, Graduate Student



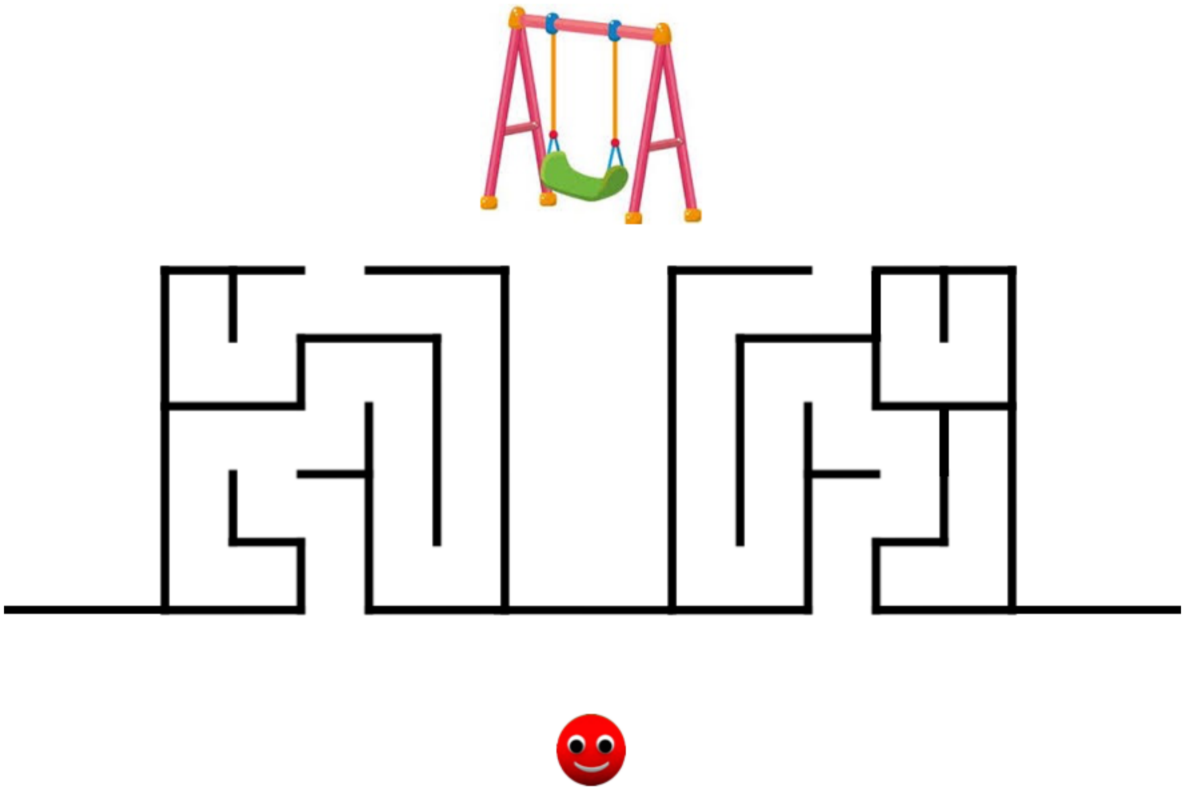
As adults, we understand that if a ball is dropped in the middle of a slanted plane, it will speed up as it travels down the plane, and we'd be surprised to see it slow down as it's rolling down, or speed up as it rolls up the plane. Past research shows that it takes infants until about 7 months of age to arrive at this intuition: When 5-month-olds see a ball accelerate up vs accelerate down a tilted plane, they look equally to these two events, but 7-month-olds look longer at the event that violates physics (the ball that speeds up as it travels up the plane). This past year, we have been re-running these studies in 7-month-old infants using new, animated events, and our new eye-tracker.

You might be curious about why we're running a study that has already been run before. This practice is called replication, and it is vitally important for scientific progress. In order to discover new things about the world, scientists often have to think outside the box and be open to findings they don't initially expect. The point of replication is to see whether these findings are reliable and robust (e.g. showing up under a wide variety of circumstances), fragile (e.g. only appearing under very specific conditions), or the result of random chance. The balance between confirmatory research (where we have strong predictions about the results) and exploratory research (where we have no idea what will happen!) is the foundation for scientific progress, allowing us to push forward from what we know, while still leaving room to discover completely new things.

Data collection is still ongoing, so stay tuned next year for the full results from this study!

Lazy Agents: Children's Reasoning About the Cost of Making Decisions

Shari Liu, Graduate Student

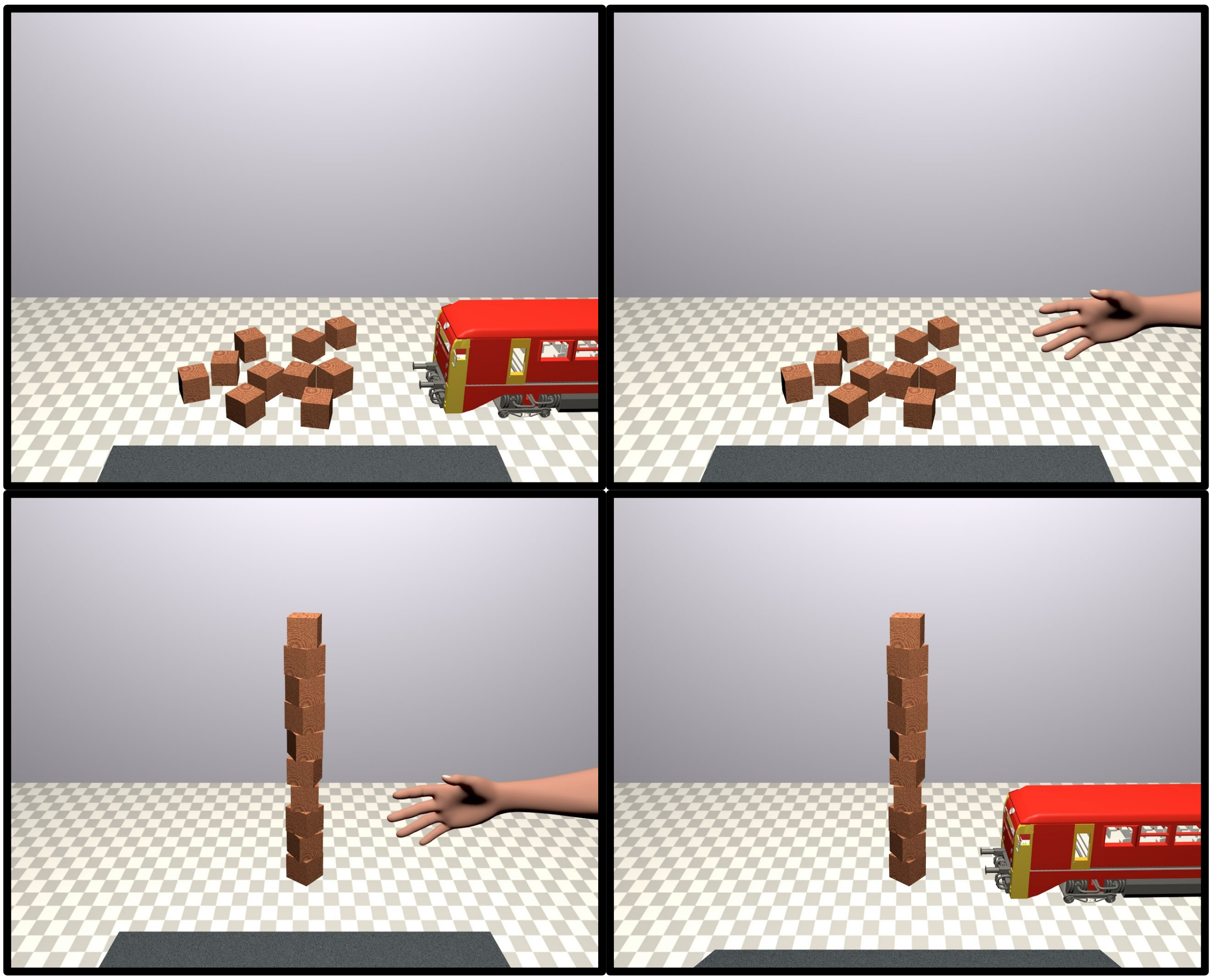


Making decisions is hard! Not only do actions differ in how much effort they require to carry out (e.g. time, energy), but how difficult they are to plan (e.g. complicated versus simple sequences of action, brand new versus habitual actions). While past experiments show that children understand physical effort, we are curious about whether they also know about mental effort.

To ask whether children understand the cost of planning actions, we ran a series of experiments where 4- and 5-year-olds were introduced to agents who faced choices that differed in complexity. In one experiment, we tested whether children understand that some actions are harder to plan than others. They saw that an agent could travel through either a less or more complex maze in order to reach a goal, and that the agent wanted to reach this goal as quickly as possible. They were then asked to help the agent by choosing a maze for him to travel through. We found that children were more likely to choose the less complex maze and understood that these were easier to travel through. In another experiment, we found that if the goal of the agent is to get better at going through mazes, rather than to get through them as quickly as possible, children respond differently: They choose the easier and harder maze at equal rates. These results indicate that children understand that making decisions is hard, but that sometimes, thinking hard is worthwhile (e.g. when you want to learn something!). We are currently following up these results with further studies asking about whether children understand that people can be mentally but not physically tired, and physically but not mentally tired. Stay tuned next year for more results!

Hands and Trains: Infants' Understanding of Different Kinds of Causes

Shari Liu, Graduate Student



From a young age, infants treat hands as different from other objects: They seem to understand that hands can do special things that other objects cannot. In this study, we are interested in exploring whether infants have the intuition that hands can perform effortful actions, like moving and manipulating objects, while objects like trains cannot. We invited 13-month-old infants into the lab and showed them animated movies of hands and trains interacting with blocks. First, infants saw a pile of 10 blocks scattered in a pile. Then, either a hand or a train entered the scene, and moved towards the blocks. Next, a barrier came up, covering the pile of blocks, and the scene paused for a short or long amount of time. Lastly, the barrier fell, revealing a tall stack of 10 blocks. The question is whether infants are more surprised to see the train produce this outcome than the hand, and whether they have expectations about how long it will take the hand to produce this outcome: For example, are they surprised to see the hand stack the 10 blocks in 1 second, versus 5 seconds? This study is just starting, so please check back next year for more results!

Children's Knowledge of Plants

You-jung Choi, Postdoctoral Researcher

Throughout evolution, humans and animals alike have foraged for food and been faced with the crucial task of distinguishing edible plants from poisonous ones. Given the high stakes, it is likely that animals, including humans, possess cognitive systems promoting rapid and effective learning to identify, categorize, and reason about plants. Nevertheless, the existence, properties, and development of such systems have been little studied.

The present research aims to fill these knowledge gaps. We tested whether children's abilities to perceive, categorize, and learn about plants are supported by a system for representing a fundamental property of all living plants: plant forms are organized around a skeleton with a primary vertical axis and roughly symmetrical branching roots and branching limbs. Due to constraints on how plants grow, capture energy from the sun, and distribute water and chemicals throughout their bodies, they have a distinctive skeletal structure. The present research tested whether children are sensitive to this structure and use it in categorizing plants by species.

Specifically, in this study, four- and five-year-old children received two tasks: an internal structure task and a categorization task. The internal structure task examined whether children can infer the correct skeletal structure of trees, leaves, and geometric shapes from their outlined shapes. Children saw a target outline shape and were asked to find the correct "inside" of the target (Fig. 1a & 1b). In the categorization task, children were asked whether they could find a plant from the same species as a target plant based on their properties including shapes, venation patterns, edge pattern, and colors (Fig. 2).

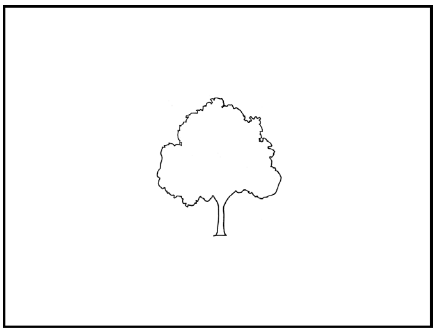


Fig. 1a. An example of a tree trial's target stimuli

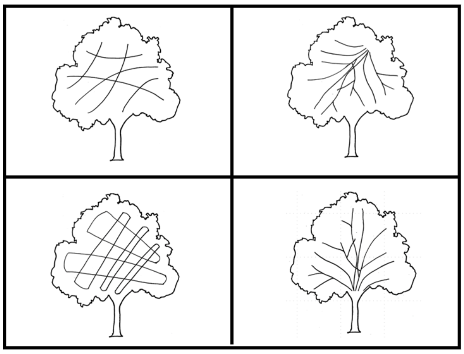


Fig. 1b. An example of a tree trial's four options: simple distractor, orientation distractor, complex distractor, correct skeleton (from top-left, top-right, bottom-left, to bottom-right)

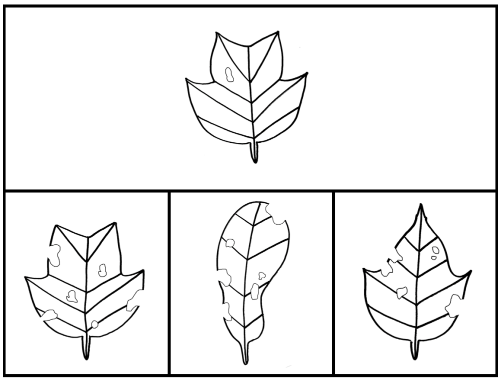


Fig. 2. An example of a shape single-group trial stimuli (a target on the top and three options on the bottom)

Given the evolutionary importance of plants, it is theorized that children will indicate a better understanding of the plants in comparison to geometric shapes. However, if children are equally sensitive to the internal structure of plants and artifacts, then that could mean either 1) experiences or education equalized the distinct systems for this age group, or 2) humans might have one system for both. To examine these alternatives, we might need to examine younger age groups in the future.

In the categorization task, if children understand the essential properties of leaves (such as shapes, venations, and edges), they will categorize leaves based on the properties mentioned. Furthermore, if children understand the hierarchy of certain properties in differentiating leaf species, they should treat the property cues differently. Because leaves change color, a color cue is less important than a venation cue in determining a leaf's identity, when these two cues conflict, children should use the venation cue to categorize leaves while ignoring the color cues.

We are only beginning data collection, so look out for the results from this study on next year's newsletter! Thank you again so much for your participation!

Infants’ Sensitivity to the Canonical Orientation of Plants

You-jung Choi, Postdoctoral Researcher

Humans interact with a multitude of different kinds of objects, but until the industrial revolution, the most crucial kinds for people to know about were animals and plants. To survive, humans had to distinguish and classify animal species into those that are used for work (hunting, farming), those providing food or clothing, and those that prey on humans and must be avoided. Previous research reveals that very young infants are sensitive to the canonical orientation of animals’ faces and bodies. Similarly, are infants able to recognize the canonical orientation of plants?

The plants on which humans forage vary greatly in size and shape, but all grow upward toward the sun and send roots downward for water, nourishment, and stability. Thus, plants, like animals, have a privileged vertical orientation. In this study, we aim to examine whether infants prefer canonically oriented plants prior to experience with plants. Specifically, we test whether five- to six-month-old infants prefer to look at plants, human body parts, and artifacts in their canonical vertical orientation, relative to inverted or horizontal orientations, as they do for faces.

Five- to six-month-old infants saw six pairs of images of two identical plants, two human body parts (e.g., a hand), one human face, and one artifact (a milk bottle) with the images displayed at orientations of 0°, 90°, or 180°. Each infant will be randomly assigned to one of two orientation conditions: 0° vs. 90° (horizontal condition) or 0° vs. 180° (vertical condition). The procedure of these two conditions is the same except for the orientations of the paired stimuli.

Fig. 1. An example of the tree with leaves trial in the horizontal condition.

Since plants grow vertically, with stems growing upward and roots growing downward, if infants are sensitive to the canonical orientation of plants as they are faces, they will look longer at upright plants and the face but not the body parts or the artifact.

We have just begun data collection for this study but stay tuned! Thank you for your participation in this study!

Our research would not be possible
without the participation of families like yours!

We thank you for your interest in our lab
and hope to see you again soon!