Newsletter 2018

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Contents

Understanding Social Interactions

Narges Afshordi, Graduate Student

Imitation is ubiquitous in human life. By copying those around us, we learn, we bond and we fit in. We also notice when other people imitate each other. Can infants do this too? In this study, we show three-, four-, and five-year-old children three characters, one of whom copies the actions of another. For instance, the woman in the center in the figure below, Jenny, moves her leg like the woman on the right, instead of moving her head like the one on the left. After children watch a few of these animations, we show them one that is incomplete. Here, Jenny watches the other two do different things but doesn't do anything herself. The child's job is to predict who she will copy. We also ask another question: Which of the other two women does Jenny like best? Adults have the intuition that if we imitate someone, we probably like them. We ask children this question because we are interested in seeing whether they are also able to use imitation as a clue to people's feelings towards each other, in this case, thinking that Jenny likes the person she copies more.

Our current findings suggest that children as young as three years can succeed at this task, but three-, four-, and five-year-olds all do much better if we give them some hints along the way. This suggests that while they can infer who likes whom and whom Jenny will copy in the future, it is also not the easiest task for them to accomplish. Thank you for your participation!

Who do kids root for—the winner or the underdog?

Narges Afshordi, Graduate Student

In this study, we are interested in exploring how three-, four-, and five-year-olds think about social dominance. One simple definition of the dominant person in a pair of individuals is the one who usually wins zero-sum fights. In other words, if one party typically wins arguments and conflicts, we think of them as being dominant to the other party. In this study, we want to see if preschool-aged children also think this way. To do this, we tested whether children think the person who was dominant and won the conflict in one situation would win again in a new situation. We showed them videos of two puppets who both wanted the same thing, for instance, to sit on a cool bench. Even though they both tried to sit on it, one of them won and managed to push the other one off the bench (picture on the left below). In the second scene, the puppets were both interested in playing with the same toy. They both reached for it and started struggling over it. However, we stopped the video before kids could see who won (picture on the right below), and we asked children who would take the toy.

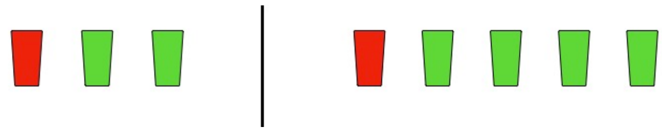
Interestingly, children were random in their responses overall. This means that some children thought the dominant character from before would win, while others thought the subordinate character would win. When we asked them to explain why they chose the character they chose, some children referred to the dominant character being stronger, and others thought the other one deserved a turn because he didnot manage to sit on the bench. Overall, this suggests young children, as a group, are torn between predicting consistency of actions (i.e. thinking whoever won before will win again) and hoping for a fairer outcome (i.e. thinking the other person deserves a chance).


Distinguishing Certainty from Uncertainty

Luisa Andreuccioli, Research Assistant

Acknowledging our state of certainty (e.g. “I know that I know”) or uncertainty (“I know that I don’t know) is something that adults usually do spontaneously and automatically; but, when does this ability develop in children? Previous studies have shown that when children are shown two objects (a frog and a train) and one of these is secretly hidden inside a box, three-year-old children *wrongly claim to know* which object is hidden inside, thus failing to recognize their own ignorance (or uncertainty).

In this study, we investigated whether young three-year-old children are aware of the uncertainty of a definite object being in one of several possible containers. In one condition we presented children with five cups, four of one color (e.g., green) and one of another color (e.g., red, see picture below). On each round, the children saw one sticker hidden in the red cup, and a second sticker hidden in one of the four green cups. The children could choose one cup only. If three-year-old children can distinguish the certainty of the the red cup having a sticker from the uncertainty of any of the green cups having a sticker, they should pick the red cup. The other condition was identical, except that the multi-cup condition had 3 cups, not 5.



We found that when the children were asked to search for the sticker among five cups, they picked the red cup *almost* 90% of the times, suggesting that they did have greater certainty about the red cup having a sticker than about any of the green cups having a sticker. In the three-cup condition, they chose the red cup around 50% of the time, which is still more often than chance (i.e., there are three possible choices, so chance is 33%). This suggests that even though this condition was harder for them than the 5-cup condition, they were still relatively more confident about finding the sticker in the red cup than in any of the green cups.

Though we are not sure why children found it easier to pick a certain cup when searching for the sticker among five cups, one possibility is that the higher number of cups made it easier for children to gain insight into their state of uncertainty with respect to the location of the sticker in the green cups. Regardless of this, these results show that young three-year-old children are able to indirectly acknowledge their ignorance about something by choosing a certain option.

Previous research has shown that such an ability is crucial for many aspects in a person's life, from successful social interactions to successful academic performance. We look forward to replicating and following-up on these results in order to find out more about young children's abilities to recognize their own certainties and uncertainties.

Understanding "not"

Roman Feiman, Postdoctoral Collaborator and Anna Holiday, Research Assistant

This study investigates the age at which children understand the concept of "not", and if they can use process of elimination as a logical tool to reason. In this study, infants were shown a puppet, Bobo, being hidden in one of two opaque cups. However, the hiding took place behind a screen so that they did not know which cup Bobo was in. The researcher looked into one of the cups and said "He's not in here!", and we then recorded where infants first searched to find Bobo.

We ran this study with English-speaking 18-month-olds, and found that that they perform at chance in this game, so they are equally as likely to look in both cups to find Bobo. This suggests that at this age infants do not yet understand the logical concept of "not" and simply guess where he must be. In order to make a cross-linguistic comparison, this study has also been run with Hungarian-speaking infants using the word "nem". Surprisingly, Hungarian children were successful at this task and outperformed English-speaking children. It is unclear whether "nem" can be directly compared to "not", therefore we are interested in conducting a follow-up study using "no" to see if this will improve English-speaking infants' performance on this task!

Baby Newton: Infants' Understanding of the Physics of Collision Events

Jonathan Kominsky, NIH Postdoctoral researcher

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. Previous work has found that infants also see causality in these events starting about 6-7 months of age.

In our recent work, we have found that infants are sensitive to the Newtonian physical limits on these collision events. Most people do not know it, but there is an absolute speed limit on B: Even if A has infinite mass, B can never move at more than double the speed of A. If you show 7-9-month-old infants an event where B moves 3x faster than A, they treat it as being different from an event where A and B move at the same speed. If you change it so that A moves 3x faster than B (which is totally possible if B is very heavy), they treat it as being very similar to an event where A and B move at the same speed.

Similarly, B cannot move at a more than 90° angle relative to A. 7-9-month-old infants treat these 90° violation events as different from events where B moves in the same direction as A, regardless of what direction A is moving in.

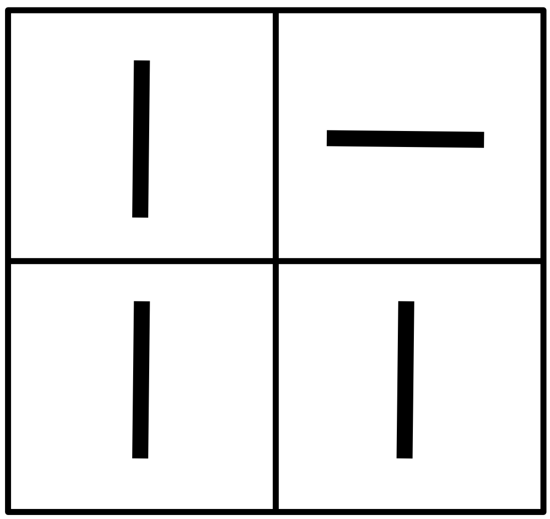
In our ongoing research, we are now looking at two different questions. The first question is a follow-up to these findings. The patterns we find could be explained by infants being sensitive to physical constraints, or they could just be treating the physical violations as *non-causal* events, that is, they see the objects as moving completley independently. To test this, we are seeing if infants distinguish these physical violations from obviously non-causal events, such as ones in which there is a long pause at the moment of contact, or when A stops and B starts moving without them ever coming into contact at all.

The second question is what infant expect A and B to be able to *do* in these physical violation events. Do they expect B to be able to move on its own? Do they expect it to be able to replace A as a causal agent? We are testing this by showing infants these physical violation events, and then showing object B either changing direction on its own, or simply showing an even in which B causes A to move. If infants find this surprising, it suggests that they don't think B can move on its own based on these physical violations alone.

Abstract Thinking in Three-year-olds: Difficult or Irrelevant?

Ivan Kroupin, Graduate Student

Any time we face a problem we can think about it in many different ways. For instance, imagine you are given a deck of cards and asked to sort hearts with hearts, spades with spades, clubs with clubs and diamonds with diamonds. You may think of this task in terms of an abstract category (e.g. 'a game of sorting suits'), but you could also think about it in a more concrete terms (e.g. 'this is a game of sorting hearts, spades, clubs and diamonds'). Previous research has shown that thinking about a task in an abstract sense makes it easier to flexibly direct attention and switch between rules. Young children have difficulty with this kind of attentional flexibility - potentially because they fail to think of tasks in abstract categories.



A trial of odd-one-out. Children are asked to pick 'the one that is different' (here the top right)

The odd-one-out task tests whether children tend to see stimuli in terms of abstract terms or focus on the individual objects: Thinking of the task as 'a game about line orientation' (where 'line orientation' is an abstract way of thinking about the stimuli) makes the odd-one-out task very easy. In contrast, if you think of the stimuli concretely, e.g. 'four lines on a page', the correct answer may not be obvious. At age three children have a hard time with the odd-one-out task, suggesting they're thinking about it in concrete terms.

The aim of this study is to see whether this tendency to think in concrete terms is a result of three-year-olds being *unable* to think about the task in abstract terms, or whether it simply doesn't occur to them to do so. In order to test this we give children several modified odd-one-out sets where one of the lines can be spun around. We then ask them to make the movable line 'the same' or 'different' from the rest of the lines. The hypothesis is that, if children can represent the task in an abstract way but simply don't expect this to be an important way of thinking about the problem, then practicing with spinners will help them succeed. If, on the other hand, children *cannot* think in these abstract terms the spinner training should have no effect.

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.

Preliminary 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 were about as perfect as four-year-olds can be in counting and comparing like adults would.

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.

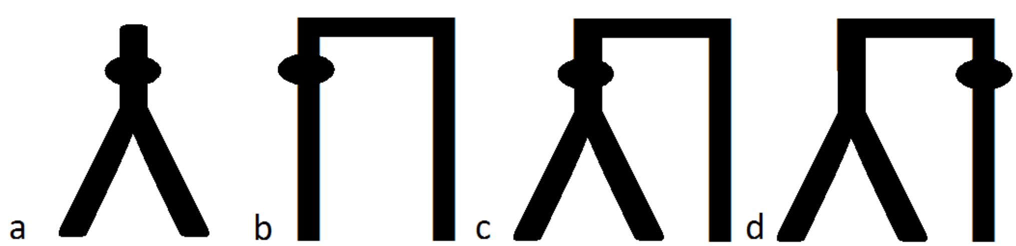
This flexible planning has at least two parts. The server (1) recognizes his uncertainty, and (2) comes up with a plan that will work out either way. Recent research suggests that young children struggle with (1): they don’t even recognize their own certainty. When they see more than one possibility 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 a) 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.

So far it looks like our results on the Y-shaped tube are similar to the findings from the existing study. But the critical condition c tells a different story. Few 3 year olds recognize where they need to put their hands in order to catch the marble here, though more than half of 4 year olds do.

Thank you for your participation in this study!



Number and executive function

Deborah Zaitchik, Research Fellow

From two to four 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, those general-learning mechanisms that, centered in the prefrontal cortex, undergo significant growth during this period.

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 number N in the count list, there is a next number, N+1, that is exactly 1 greater than N). 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, such as inhibitory control and working memory. In one game, for example, we ask children to sort cards first by color, and then by shape, which requires that they inhibit the color sort rule. Our question is this: will children’s individual executive function abilities predict their progress in learning the meaning of the count words? We have just begun data collection for this study, but stay tuned!

What’s in a name?
Learning how proper names refer

Jincai Li, Visiting Fellow and Elizabeth Chalmers, Lab Manager

At birth, we are all given a name, which often, but not always, follows us through life. When people use your name, they refer to you. But what is the mental link that ties a name to a person and allows it to refer?

Several proposals have been made for how we link names to referents. One well-known proposal contends that a name gets its referent through a definite description and when a speaker uses a name, they refer to whoever uniquely satisfies the description associated with it (the “descriptivist view”). Another popular theory proposes that a name refers to a person because it was linked to him/her in the initial act of naming, and this link is then passed down through a community of speakers (the “causal-historical view”). Past work with adults shows a consistent preference among East Asian participants to agree with the descriptivist theory, while Americans generally endorse the causal historical view. A previous study conducted by our lab with school-aged children in the United States and China found that this cross-cultural difference is present by age 7, suggesting that this cultural difference may stem from early socialization rather than from formal education.

For our current study, we want to explore further the factors causing these cross-cultural differences. We believe that cross-cultural differences in perspective taking may have an influence on people's intuitions about how names refer, so we developed a study with three different conditions designed to show how children track different perspectives. There was an ambiguous condition where children's responses depended on which theory of reference they are using, to confirm our findings from the previous study. We also included two unambiguous conditions: one where children had to track the knowledge state of a person inside the story (i.e. the character has different amount of knowledge about the events than the child does), and one where children had to track the knowledge state of someone outside of the story (i.e. the character has the same knowledge as the child). We are interested in seeing if children can accurately track these different perspectives.

We are currently testing 7 and 8 year old children in this study, and while it's too early to draw any conclusions, we look forward to sharing our results soon!

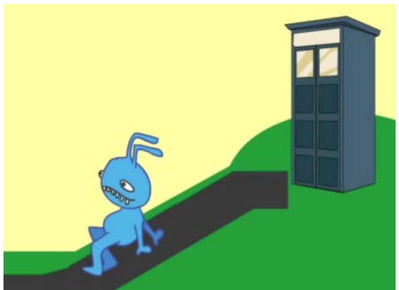
Learning what Verbs might Mean: Does "Gorping" mean hopping or entering?

Melissa Kline, Postdoctoral Researcher

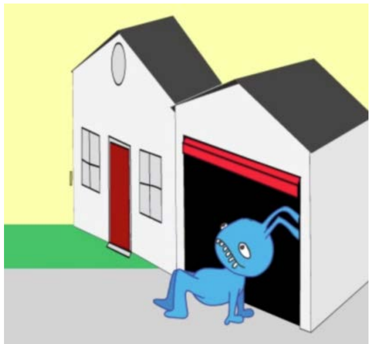
Thank you so much for participating in the "Learning Verbs" study with the Harvard Lab for Developmental Studies! We are very grateful for your time and participation – this research would truly not be possible without you.

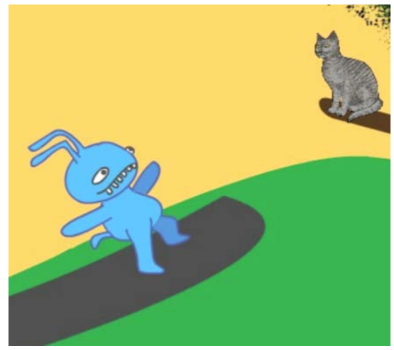
Our participants, aged 2-3 and 4-6 years, have been playing a game that's designed to help us understand the guesses that children make when they learn a new word. Oftentimes, just seeing an example might not be enough: If you see a character hop around the tree and you hear "gorping", does gorping refer to the circling or to the hopping? Most adult native speaking English users guess that it's more likely to mean hopping, because there are many verbs in English that has meanings like this. But if they are asked to learn a bunch of verbs which all turn out to have meanings like ascend, descend, and enter, adults will quickly adapt and start to guesses that the next new word also refers to a path.

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



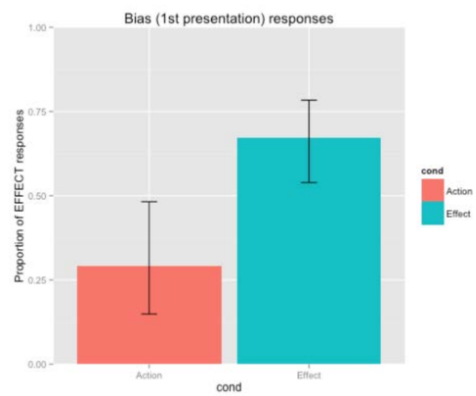
Then, they would see two choices: either a new scene that kept the manner (crawling) the same, or one that kept just the path (ascending/climbing the hill):





After seeing several of these movies, it turns out that children begin to shift their guesses: if they see lots of verbs (gorping, pilking, mooping) that turn out to refer to ways of moving, they guess that the next verb will also refer to a way of moving; if the verbs are used to refer to directions or paths (going up, down, around), they guess the next verb will refer to a path as well.

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



Thank you again so much for your participation!

Communicating from Scratch

Annemarie Kocab, Postdoctoral Researcher

The goal of this research is to better understand how humans turn their thoughts into words, and use those words in sentences to communicate with others. Understanding how people communicate different kinds of information using a novel medium gives us insight into how humans are capable of creating language and the processes involved in creating such systems.

In this study, you and your child were asked to play a matching game. Your child went in one room, and you went in a different room. You were able to see (but not hear) each other on a TV screen. You were asked to communicate using your hands, and not your voices. Both of you saw the same set of four pictures. One person was asked to describe a target picture to the other, who picked the picture they believed matched the description. Each person took a turn being the communicator and the listener.

We expect that most pairs will converge on a shared system for successful communication by the end of the session. We also expect to find a difference in the speed of convergence depending on which kinds of pictures each pair saw. We expect that groups will have an easier time communicating the kind of pictures they saw more of initially, but have a harder time communicate new, different kinds of pictures.

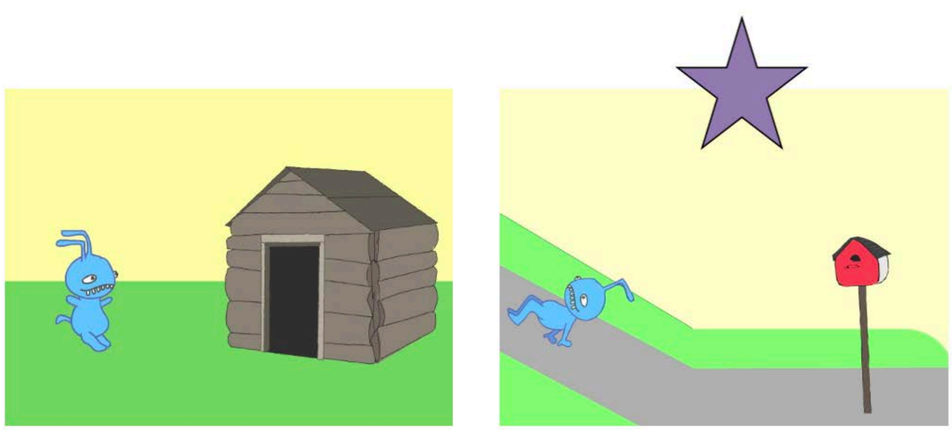
We look forward to sharing our results in the next newsletter. Thank you!

Motion Events and Concepts

Annemarie Kocab, Postdoctoral Researcher

Motion events in the world can include different activities taking place over space and time. When we linguistically describe these events, we often include information about different components, like the manner of motion (the woman is **skipping**) and the path of motion (**up** a hill). Many linguistic theories posit that these components are crucial to our conceptualization of events. We are interested in whether children and adults are able to abstract these two categories in a non-linguistic, implicit task when explicit attention is not drawn to these two 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, depending on the condition. 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 do indeed guide how we construe events, children and adults should be able to abstract them in an implicit categorization task that does not use language. Indeed, preliminary results suggest that by the end of the experiment, both children and adults categorize videos according to the condition they were trained on, either manner or path, even in the absence of any linguistic labels that cue categorization.

What can our brain waves tell us about how we understand words and sentences?

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 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”.

While we know a lot about this brain wave in adults we don’t know whether kids have a similar brain wave and, if they do, whether it’s size also changes depending on how frequent or predictable a word is. In my study, children came in and were set up for an EEG recording! We recorded their brain waves while they listened to a story from Roald Dahl’s *Matilda*. We were looking at their brain’s response to each word in the story to see whether children’s brain wave responses, like those of adults, are sensitive to various word features, such as frequency and predictability. So far, we have found that children are indeed sensitive to both! In fact, they seem to be even more sensitive to frequency than adults. Thank you to all of the families that participated and to all the kids that got their hair gooey in order for us to see their brain waves!

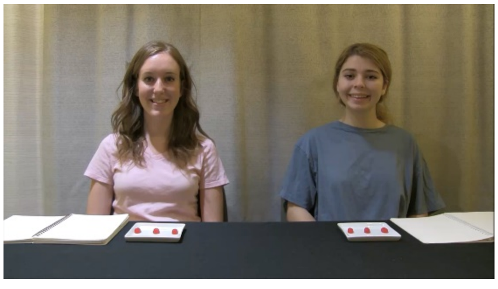
Understanding of the Effect of Sharing Experience

You-jung Choi, Postdoctoral Researcher

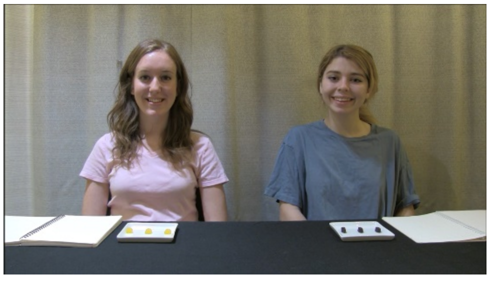
As social beings, people tend to want to be together, live together, and work together. Even children have been shown to prefer an option to work together rather than alone, and this is a unique tendency of humans that differ from other primates. We are interested in the basis of this preference. Why do people want to bond? Maybe it is due to our tendency to be naturally cooperative, or because people earn specific benefits through being together; therefore, leading them to remain together. We suggest that being together provides an opportunity to share experiences and that sharing amplifies these experiences, causing people to want to be together to share their experiences. Previous studies indicate that sharing does intensify adults' tasting or visual experiences in both positive and negative directions. Then, do infants understand that sharing intensifies an experience, and can they use that understanding to predict someone else's future behaviors?

To ask this question, we first show infants two types of videos involving two female actors. In the shared video, a target actor (E1) and another actor (E2) have a plate in front of them with the same type of food (A) on it. They reach for the food and eat it at the same time. Then, both actors will indicate that they like it by saying "hmm, I like it." In the other event, the non-shared event, both actors have plates of different types of food (B and C) in front of them. E1 will reach for the food (B) and eat it, and enjoy the food while E2 reads beside her, thus not be sharing the experience of eating the food. Then E2 will eat the other food (C) and enjoy it while E1 reads beside her. Then, infants watch that the test events in which E1 is alone at the table and has to make a choice between food A and B. Each test trial shows her choosing either the food in which she shared the experience with E2 in the shared event (A) or the food that she did not share in the non-shared event (B). If infants are able to understand that sharing intensifies the experience of liking food, then they will expect E1 to choose the food that was shared rather than non-shared in the test, causing infants to demonstrate prolonged looking time in response to the non-shared test event. This study is ongoing, but some preliminary pilot findings suggested that babies tended to expect that the target would prefer the shared over the non-shared food. We expect that this study will shed light on our understanding of the development of the impact of togetherness on experience, which might be one of the reasons why people remain together.

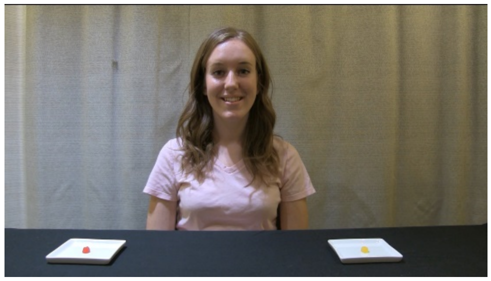
We appreciate all the babies and parents who have helped with this study. Thank you so much!



Shared event



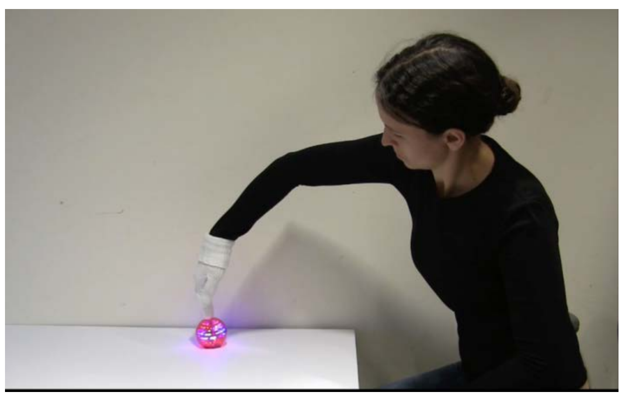
Non-shared event



Test event

What do prereaching babies know about reaching?

Shari Liu, Graduate Student



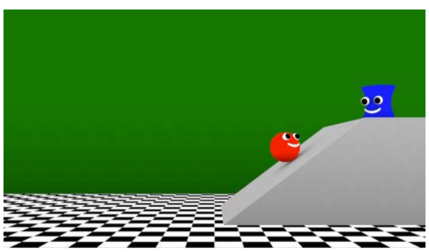
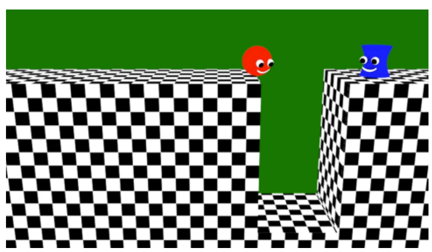
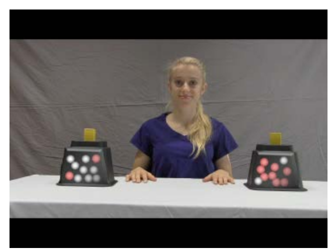
Humans engage in many goal-directed actions: cooking, dancing, acting, reading, buying, throwing, pulling, climbing, and more. Mechanisms that help us understand the structure of these actions is essential for understanding the behaviors of others, and for learning novel actions from others. Previous research from our lab 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 typically do not engage in goal-directed reaching, understand that reaching is an intentional action. 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 more weak 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.

These findings are important for several reasons. First, they show that infants do not need any motor experience reaching around a barrier (which babies do not master on their own until 8-10 months) in order to expect that agents plan their reaches to be as efficient as possible. Second, they show that infants do not need any motor experience with reaching at all in order to interpret reaching as a goal-directed action. This finding 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' Understanding of Physical Effort, Risk, and Value

Shari Liu, Graduate Student

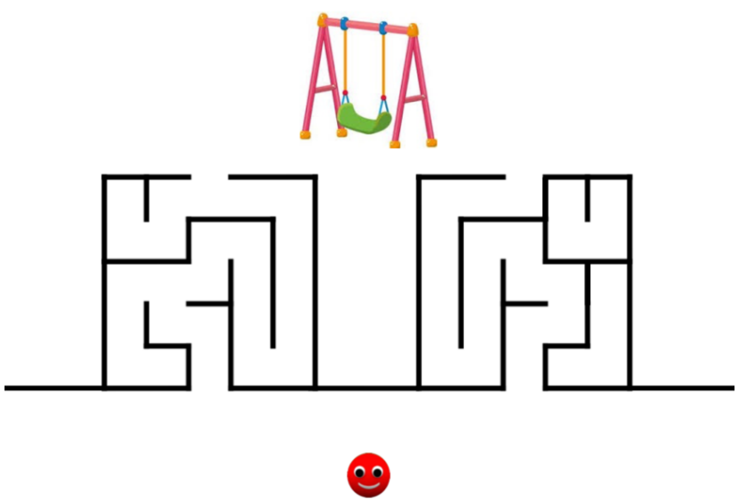
As adults, we understand that one reliable way of inferring someone's desires (e.g. how much she likes apples) is how much of a cost she's willing to pay for them ($1? $12? a trip to the store? climbing a tree?). While previous experiments have shown that babies know something about the goals of agents and the effort associated with actions, prior to this work, it was an open question whether they, like adults, understand that people plan over these variables.

In one line of experiments, we showed 10-month-old infants that an agent is willing to jump a higher barrier, climb a steeper ramp, jump a wider cliff, or 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 effort or risk) over the lower-value friend (for whom he expended less effort or risk), or vice versa, while we measured infants' attention. We reasoned that if can infer value from effort and risk, then they will look longer when the agent chose the lower-value friend. In cases where we varied the amount of *physical effort* that the agent expended for the two goals, we found that 10-month-old infants looked longer when the agent chose the goal for which it expended less effort (the less likely outcome). In cases where we varied the amount of *risk* (i.e. the depth of cliff that the agent was willing to jump over), 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. These findings are important for several reasons. First, they tell us that infants understand the actions of agents by assuming that agents make plans based on variables like effort, risk, and value. Second, they suggest that infants think about physical effort in terms of force and work, rather than in terms of other simpler variables like distance and time. We are currently following up on these findings by asking whether infants' physical understanding (e.g. their expectations about whether balls roll up vs down ramps) predicts their psychological understanding (e.g. how hard an agent has to try in order to climb a ramp).

In a second line of experiments, we showed 10-month-old infants that an agent had a preference (e.g. for red balls over white balls), and was faced with a choice between two actions: one action had a higher probability of giving her the object she prefers (e.g. randomly drawing a ball from a box containing 8 red and 2 white balls), and the second action that had a lower probability (e.g. drawing from a box containing 8 white and 2 red balls). We found that infants looked longer when the person acted irrationally given her preference, choosing the action that is less likely to generate the object she likes. Our results are preliminary, so stay tuned next year on more findings from this line of work!

Lazy Agents: Children's Reasoning about the Cost of Planning

Shari Liu, Graduate Student

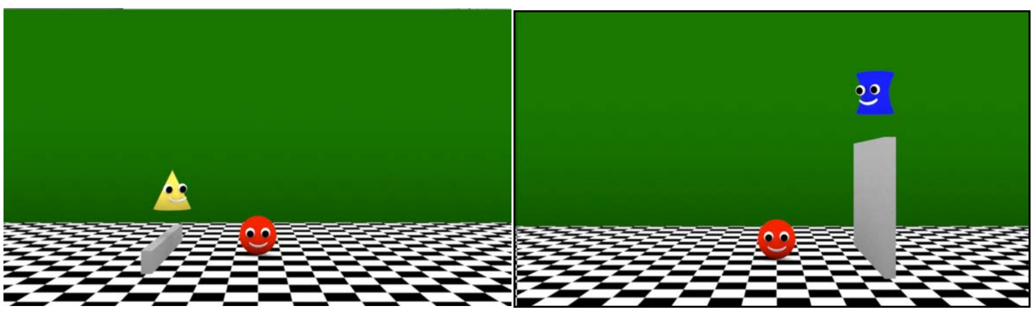


Making decisions is hard! Not only do actions differ in how much effort they require to carry out (e.g. time, energy), but how difficult they are to plan (e.g. complicated versus simple sequences of action, brand new versus habitual actions). While past experiments show that children understand physical effort, were 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 children were introduced to agents faced with choices that differed in complexity. In one experiment from this series, we tested whether children understand that some actions are harder to plan than others. They saw that an agent could either travel through a less or more complex maze in order to reach a goal, and 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. We are currently planning follow-up experiments that ask whether children understand that sometimes, thinking hard is worthwhile (e.g. when you want to learn something!). So far, our findings show that children, by age 4 or 5, appreciate the role that mental effort plays in how people make decisions.

Children's Understanding of Effort and Social Value

Shari Liu and Annie Spokes, Graduate Students

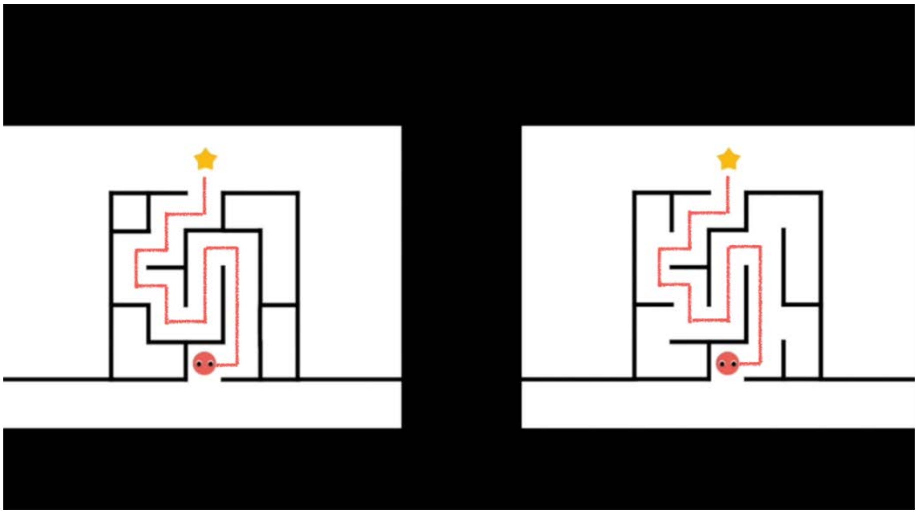


When we think about favors like giving someone a ride to the airport or helping them move apartments, we typically assume that they involve close friends or kin. One reason for this assumption is that we are more willing to expend great effort for people with we value highly—people we like or are related to. Parallel research with infants suggests that this assumption—agents expend effort for goals they find worthwhile—is at the core of our reasoning about others' actions. We were curious about whether children organize their understanding of the social world around the same principle.

In order to ask whether children use the effort people take towards others to infer social closeness, we showed them animations wherein two cartoon shapes—Triangle and Square, pictured above—were willing to take different amounts of effort for a third cartoon shape--Circle. For instance, Triangle was only willing to jump a lower wall for Circle, whereas Square was willing to jump over a higher wall. After watching these displays, we asked children (1) which agent Circle liked more and (2) whether Circle would take different amounts of cost by jumping over walls of different heights to reach Triangle or Square. We found that children expected Red to reciprocate in kind the degree of effort that it received, but they responded randomly when asked which one Red likes more. We are currently planning follow-up experiments to find out whether children truly believe that the effort of a person towards another is uninformative about how much the recipient of these actions likes the actor, or whether the stimuli we borrowed from studies of infant cognition are in some sense too simple for these sophisticated older kids. Stay tuned for new findings in next year's newsletter!

Infants' and Young Children's Understanding of Choice Structures

Shari Liu, Graduate Student

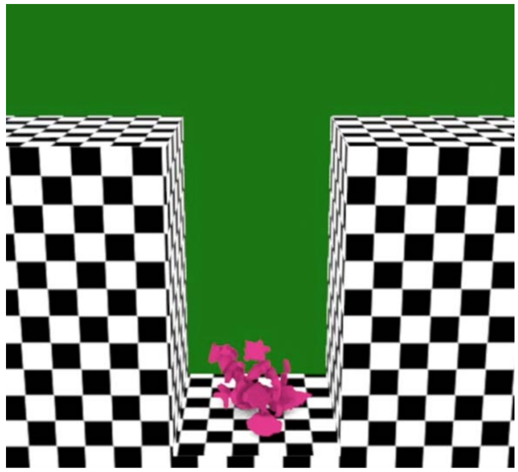


Our interpretation of an action depends critically on the context in which the action takes place. For example, if someone reaches for an apple, can you tell whether they like apples? They probably do, but more information would be helpful. In particular, it would be helpful to know whether the person chose the apple over something else, or whether reaching for it was the person's only option.

This project studies the origins of this understanding in infants and young children using eyetracking. In these experiments, we show participants videos where an agent moves through mazes towards a goal. Participants always watch the videos in pairs, and each pair of videos displays the character moving on the same trajectory. However, these two actions do not look the same to adults: In one video, it appears as though the agent makes choices between different turns to travels through the maze, and in the other video, the agent has no choice but to follow the only path available through the maze. We are interested in whether participants distinguish between these two events and look longer at the more complicated action structure, where the character appears to choose a particular sequence of movements. We are only beginning data collection, so look out for the results from this study on next year's newsletter!

Infants' Understanding of Falling and Shattering

Shari Liu, Graduate Student



In the first months of life, infants expect objects to be solid (objects cannot pass through each other), continuous (objects don't blip in and out of existence), and subject to gravity (unsupported objects fall down). Beyond these expectations, little is known about how infants think about the ways that objects *change*: in particular, how solid objects break and shatter. This project investigates whether infants understand that objects that fall from greater heights tend to shatter more than objects that fall from smaller heights.

One experiment in this project first familiarizes 10-month-old infants to a ball that rolls off the edge of a cliff, falls, and breaks into 5 pieces. Infants then watch two events in which the ball shatters into 50 pieces: after falling a very short distance, or a very long distance. If infants understand that objects that fall from greater heights shatter more, infants should be surprised by the video in which an object completely shatters after only falling a short distance. So far, that is exactly what we find: Infants look longer when an object that shatters far more than it should, given what they know about the object and given the height from which it fell. These results are only preliminary, so we will look forward to reporting the results from a series of full experiments next year!

Connecting Numerical and Geometric Intuitions to School Learning in Mathematics

Adrian Maries, Graduate Student; Olivia Fiske, Research Assistant; Caitlin Elizabeth Connolly, Research Assistant

In school, children are taught important mathematical skills such as counting, arithmetic, and the geometric properties of shapes. Basic research in our lab and others has shown that at the core of these later-developing mathematical abilities might be early emerging, unlearned cognitive abilities with dedicated sensitivities to numerical and geometric information. These abilities allow adults, infants, and non-human animals to guess the approximate number of individuals in a group and to differentiate between objects and visual forms based on their angles, lengths, and topologies.

In this study, we aim to test directly whether short-term training of our early emerging numerical and geometric skills using simple card games might improve school-relevant mathematics outcomes for children, like performance of symbolic arithmetic and judgments of shape properties. We bring children in the lab and and show them and their parents how to play the games (Figures 1–4), which they take home with them and play for two to three weeks, keeping track of their progress. With a battery of assessments before and after the training, we will measure if our games promote school-relevant mathematics achievement in the short term.

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

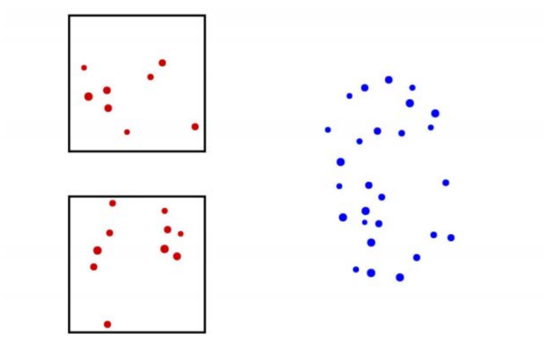
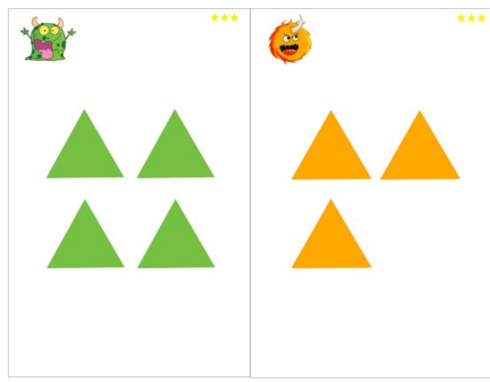


Figure 1: Children sort cards that present red and blue arrays of dots based on the color of the more numerous array.



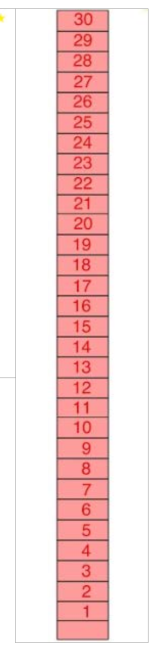


Figure 2: Children exercise small number comparison and addition by moving game pieces along boards [right] based on the numbers on cards they draw as a result of spinning a spinner. Cards with a friendly monster [left] move the game piece up the board and cards with a mean monster [middle] move it down.

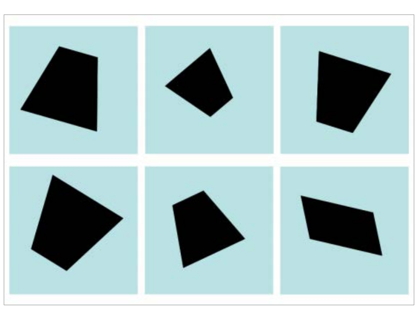


Figure 3: Children find one of six figures that is different from all the others based on a particular geometric property.

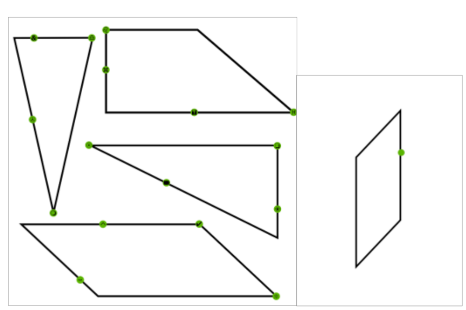
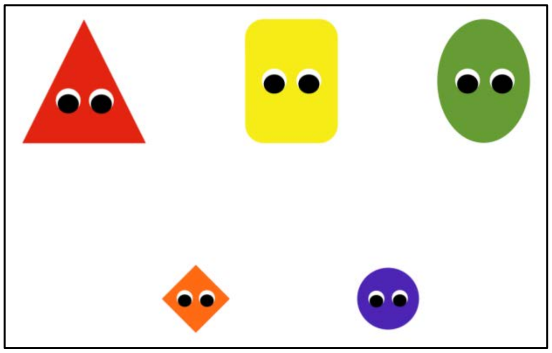


Figure 4: Children first match a shape such as a parallelogram displayed on a card [right] to one of a number of shapes on a much larger mat [left] on the floor and then match a spot on the shape on the card to one of several spots on the same shape on the mat.

Early Understanding of Social Interactions & Relationships

Annie Spokes, Graduate Student

We have been continuing a line of research asking how babies think about and understand the people around them and how people are connected to each other in social interactions and relationships. We show babies animated shapes instead of people in these studies (pictured below). With 15- to 18-month-olds, we completed six experiments, and we found that babies at this age expect characters with a mutual social connection to get along and look longer when they see characters without a social connection hanging out.



Animation Example: Picture of the study with three adults and two babies.

This year, we continued this line of research by studying babies at 11- and 12-months-old to test when this understanding might emerge. The results from these experiments suggest that younger infants may be able to track these social relationships, but it may be more challenging for them to keep all five characters and three relationships in mind than it is for older infants.

These studies had five shapes, or "characters." In one of the experiments, there were two little shapes ("babies") and three big shapes ("adults") as shown above. In the first videos, babies saw that each baby cried, and one of the adults went to the baby, made a soothing noise, and rocked with the baby. Two adults soothed one baby, and a second adult soothed the other baby. Next, the big shapes played together—either two that soothed the same baby or two that soothed different babies. We watched to see how long babies looked at these two types of videos to see if they might look longer and be more surprised by one social interaction.

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

What Do 14-month-olds Think about Gender & Caregiving?

Annie Spokes, Graduate Student

Even though babies may not know their own gender, they may still be able to categorize the people they see according to gender. We are interested in how babies around 14 months think about gender in social interactions that they see frequently in their daily lives: caregiving, or adults (usually parents) taking care of babies. In this study, we used animated videos with small shapes as “babies” and big shapes as “parents.” First, each adult came out to introduce themselves by talking, and there was one with a male voice and one with a female voice. Then, a baby shape entered the scene and began to cry. In alternating videos, each of the adults responded to the baby in turn by approaching and making a soothing noise, and we measured if babies were more surprised by one of these videos by how long they watched each one. Do they look longer when a male comforts a baby or when a female comforts a baby, or might they be expecting either or both of those scenes equally? If your baby participated in this study, you may remember wearing noise cancelling headphones during this study so you could not hear the voices. We think it is possible that the experiences babies have might shape their expectations in this study, so in addition to the video, this study involves a written survey asking questions about which adults babies spend time with on the average week. Perhaps the gender of their primary caregiver matches what they expect to see in the animations.

We have tested a group of babies that have female primary caregivers and found that they looked much longer to male caregiving. We are still collecting data to measure the expectations of babies who have male primary caregivers or who spend roughly equal time with two caregivers of different genders. We cannot wait to find out! *We appreciate all the babies and parents who have helped with this study. Thank you so much!*

Five-month-old Babies Attend to Responsive Caregivers

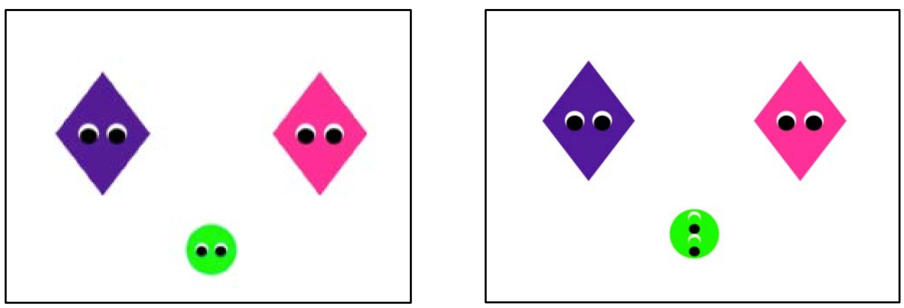
Annie Spokes, Graduate Student & Tara Venkatesan, Yale Undergraduate

In this set of studies, we are interested in learning about how babies think about caregivers and caregiving behavior. In the first study, infants watched short animations with three colored shapes. Two of the shapes were "parents," and one was the "baby" (pictured below). One of the parents responded to the baby's cries, and the other one ignored the baby's cries, moving away from the baby. We then tested whether babies around this age preferred one of the parent shapes by seeing how long they looked at each of the parent shapes to measure their preference. We found that at five-months-old, babies looked more to the responsive parent!

To follow up on this finding, we ran a second study, where we showed similar animated videos but instead of a "baby," there was a toy (pictured below) that made an exciting noise: a siren noise from a fire engine. Then, the "parents" either responded to or ignored the toy, in the same way as the first study. We wanted to see if babies still preferred someone responsive or if they only do so when there is a baby involved. We again measured how long babies looked at each of the parents when they were alone, and this time, we found that babies looked equally to both parents, no longer showing a preference for the responsive one.

We then ran a third study where the small shape made the noise of a baby giggling or a baby fussing instead of a baby crying, to see if infants prefer the shape who responds to any noise from a baby. In this case, babies looked equally at the test video to the shapes who previously moved toward or away from the baby, suggesting there may be something special about a baby's cries that signal a meaningful relationship between a parent and child.

We are now running a final study that returns to a baby crying in order to replicate the effect from the first study, using new colors and shapes of the characters and beginning with adults saying hello. We look forward to sharing about the results of this final experiment once data collection has finished. *Thanks to all babies and families who have been helping with this research!*



Left: A still image of the animations from the first and third studies, which had two "parents" (red and purple diamonds) and one "baby" (green circle). Right: A still image of the animations from the second study, which had the "toy" (green circle) that made a siren noise, and the shapes on the toy were scrambled.

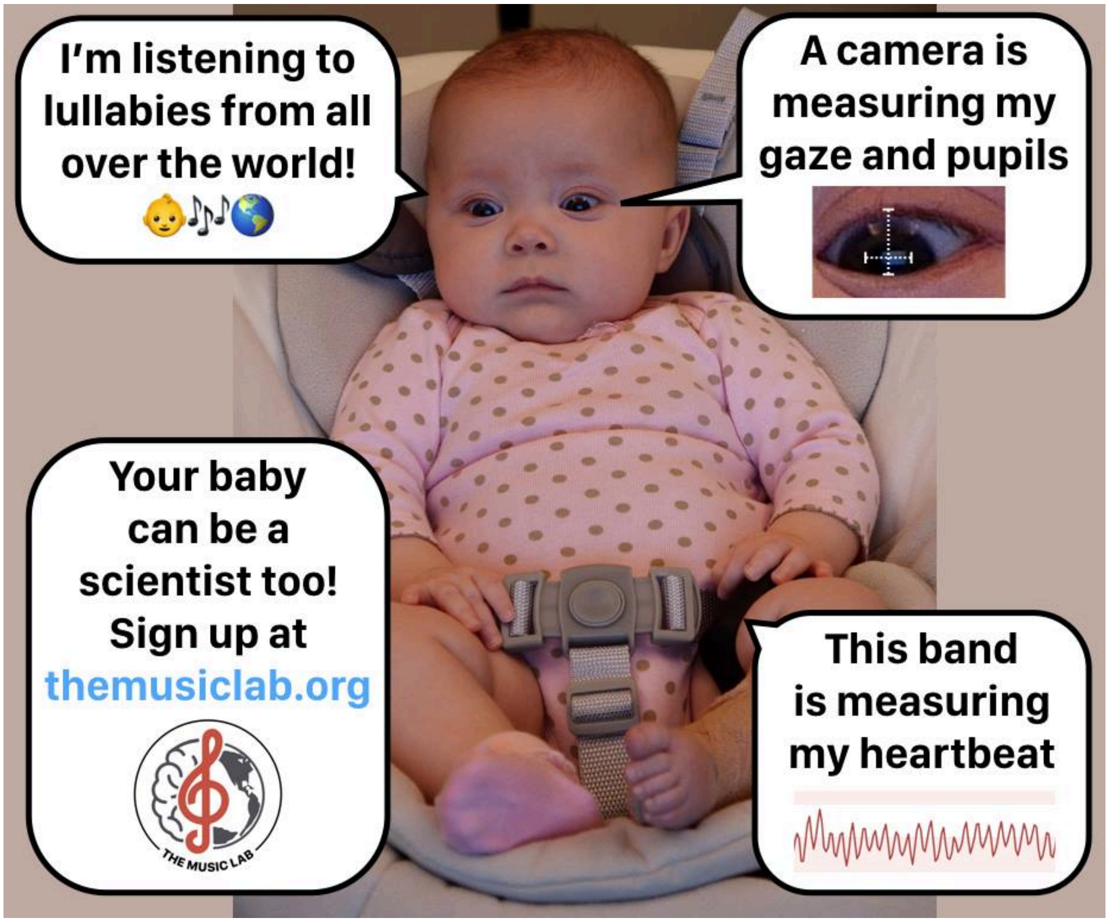
Can infants tell the difference between lullabies and other types of songs?

Stephanie Atwood & Constance Bainbridge, Lab Managers
Alma Bitran, Mila Bertolo, Kelsie Lopez, Julie Youngers, & Dylan Xing - Interns

In previous work, we found that when adult listeners hear a 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 this study, we ask whether babies share similar intuitions about music: When infants hear a song from a foreign culture, can they tell whether or not it's a lullaby?

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). We are curious to know if babies will look longer at characters that sing lullabies than those that sing other songs and also if they show differences in physiological activity depending on what kind of song they are hearing. Our preliminary findings show that babies' heart rate decrease in response to lullabies, relative to other songs, even though infants are unfamiliar with the cultures in which the songs were recorded.

Thanks to 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

Is ‘more’ Better? Investigating Infants’ Quantity-based Inferences in Third-party Tasks

Pooja Paul, Graduate Student

It is well established that human infants represent numerical as well as non-numeric physical magnitudes (number, loudness, size, brightness) in an analog, ratio-sensitive manner starting right from birth. Recent findings indicate that infants moreover have the capacity to mentally link up correlated physical-perceptual magnitudes (e.g. duration, size), and use such cross-dimensional mappings to guide expectations about their physical environment. Elsewhere, in the domain of early social reasoning, we know that infants make surprisingly sophisticated inferences about other individuals’ goals and preferences on the basis of their observable choice behavior. A standard interpretation of findings in this domain is that infants infer from an agent’s observed choice of a reward A over B, that they have a preference for A over B. In economic theory, it is standard to think of preference in turn as an ordering of reward alternatives based on their relative utility or value. However, it is an open empirical question what infants’ psychological representations of preference and value actually look like.

We explore the possibility that infants employ analog magnitude representations parallel to those used for representing perceptual magnitudes like physical size and numerosity to represent more abstract (i.e., unobservable) variables like an agent’s subjective value assignments for a set of rewards. More specifically, we ask whether infants can employ a contextually-established mapping between the dimensions of quantity and abstract value associated with a set of rewards (where these rewards vary primarily with respect to quantity), in order to (1) predict an agent’s choice among novel reward pairs based on their observable quantity information (experiment 1A: no training; 1B: with training), and (2) infer the relative quantity of a hidden reward A based on the agent’s choice of A over another visible quantity B (experiment 2).

In the first experiment, infants watched videos depicting an animated or human agent choose between pairs of rewards that varied solely with respect to quantity (eg. ‘two cherries’ vs. ‘four cherries’). In one version of this task (Experiment 1A), we test whether infants have a default expectation that other agents operate on the principle that ‘more is better’. Findings from prior infant work involving first-person tasks (where the baby makes the choice between a smaller and larger quantity) suggest that infants might in general associate greater quantity with greater hedonic value. Preliminary findings from our study however indicate that there may be no such default expectation when it comes to third-party ordinal choice tasks. In a second version of this task (Experiment 1B), we ask whether infants can learn from minimal training that increasing quantity is associated with increasing value within a given experimental context.

In a second experiment, also involving training, we ask whether infants expect the chosen one of two rewards to exceed the unchosen one in quantity, crucially when one of the quantities is hidden from the infant’s view (but not the agent’s) using an occluder. If so, infants should look longer at trials in which the chosen (hidden) reward is revealed to be a lower quantity than the unchosen (visible) reward.

Data collection for tasks 1B and 2 are still ongoing, but we look forward to sharing our results in the next newsletter. Thank you!