

# L.D.S. Newsletter



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# 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 infants between 14 and 19 months of age simple cartoon animation with three characters: Yellow, Blue, and Red (see figure below). Each little scene starts with Yellow and Blue jumping up and babbling different sounds. For instance, Yellow says “roo roo” and is followed by Blue saying “shay shay”. After both have spoken, Red also jumps and babbles. Importantly though, Red copies one of the other two, say Yellow, saying “roo roo” as well. We show infants a number of scenes like this with the characters saying new things each time. This repetition will help babies catch on to what is going on. If they realize that Red is copying Yellow, they should expect this to happen every time and become a little bit more bored at each new instance of the same pattern. But then when they least expect it, the tables turn! Now, Red starts to say the same thing as Blue every once in a while. If the baby has been paying attention, this is the opposite of what they were expecting and they will be surprised. This surprise would be reflected in intently staring into the screen for a long time trying to figure out what happened and what they missed.

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



In this second study, we show 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 whom she will copy. We also ask another question: Which of the other two women does Jenny like best? We ask this question because we are interested in seeing whether children are able to use imitation as a clue to people's feelings towards each other, in this case, thinking that Jenny likes the person she copies more.

Our current findings suggest that children as young as three years can succeed at this task, but that four- and five-year-olds are much better than three-year-olds. Thank you for your participation!



# **Risky choices and probability**

Luisa Andreuccioli and Nancy Soja, Lab Managers

In a previous study conducted in our lab, we investigated children's ability to reason through the disjunctive syllogism. The disjunctive syllogism is a form of logical reasoning which follows this structure: A or B is true, A is *not* true, therefore B must be. In this study, children played a sticker search game with two pairs of cups. One sticker was hidden in each pair. Children were competing against a second experimenter to get stickers and the experimenter went first, picking one of the empty cups, thus leaving the child with a cup that had 50% probability of containing a sticker, and two cups that each had 50% probability of containing a sticker. Children were found to succeed at this task at the age of four years old.

Children were also presented with some "training" trials in which they played individually and there were only three cups – one that had 100% probability of containing a sticker, and two cups that each had 50% probability of containing a sticker. Even though 2.5- to 5-year-old children chose the target cup more often than chance, this was still a difficult task for them.

Overall, we are interested in understanding why both these tasks are so hard for children, especially since we know that by age three years, they master the logical concepts of "no" and "or" – both needed to reason through the disjunctive syllogism.

In the study that we are currently conducting, children first play a game in which they are shown three toys at a time, and asked to give Mr Monkey some of the toys. The requests involve the use of the word "or" (e.g. "Can you give Mr Monkey the apple *or* the shoe?"). The aim of this task is to prime children with the word "or". In other words, we want to make sure that they can successfully represent the concept "or" when playing the cups game. Then, children play a sticker search game with three cups (one target cup and two risky options) and five cups (one target cup and four risky options).

If setting up the task linguistically helps children's performance on this task, it may also help them with the four cups task aimed at testing children's ability to reason through the disjunctive syllogism. We are just starting to collect data for this study, and we look forward to letting you know more about it!

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

Igor Bascandziev, Research Fellow

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

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

## **Understanding “no”**

Nicolo Cesana Arlotti, Postdoctoral Collaborator; and Rebecca Zhu, Lab Manager

“No” is a word with a highly abstract meaning. “No” doesn't refer to any one thing in the world; in fact, when “no” is used, it usually refers to what isn't present and what wasn't said. “no” can be used to assert that something is not present or that a statement is not true. Children often say “no” as a form of rejection, but when do they use the word in a logical sense that can be used to draw inferences about the world?

This study investigates the age at which kids understand that “no” can be used to assert that something is not present. In this study, kids watch a video of objects going into boxes, and hear prompts like “Look at the box with the ball” or “Look at the box with no ball”. Using an eyetracker, we can record where on the screen kids are looking and when, thus figuring out how they're interpreting the sentence.

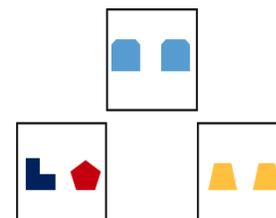
We ran this study with young two-year-olds (24 to 30 months) and found that while they clearly understand affirmative sentences like “Look at the box with the cup”, they do not reliably look at the empty box when hearing negative prompts like “Look at the box with no cup”. So, we are hoping to test slightly older 2-year-olds (31-34 months) in order to find out when kids succeed!

# Exploring relational thinking through matching games

Ivan Kroupin, Graduate Student

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

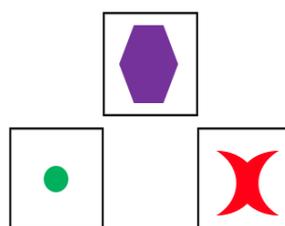
A harder version is thinking about ‘sameness’ and ‘difference’ in terms not of the relations holding between objects. For example, in the pictures at right, the card on top goes with the one on the right and not on the one on the left because the objects in the top one share a relation with the objects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



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

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

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



*(here relatively big shapes go with relatively big shapes and relatively small shapes go with relatively small shapes)*

We have tried several practice games and have found that some of them significantly improve kids’ performance on the first game, often getting them to succeed a whole year earlier than they would normally.

This is preliminary evidence that relational reasoning of the kind needed to play the hard game is difficult not only because you need the right ideas in your head, but because you need to have the right expectations of when and how to apply them.

# How are new concepts formed?

Paul Haward, Graduate Student

Human beings are alone in the animal kingdom in developing an extraordinary repertoire of intricate kind representations during the earliest stages of development—representations for *kinds of things* like dogs, watches, cities, and triangles. A normally developing young child takes as input experience with particular things she encounters, sometimes only one or two particular things, and outputs a representation of an entire category that can then, in principle, apply to indefinitely many novel instances (Carey and Bartlett, 1978; Macnamara, 1986). These representations play a central role in human thought. They underlie the meanings of most count and mass nouns in natural language, and as such, they provide an important interface between non-linguistic conceptual structure and combinatorial, hierarchical, unbounded linguistically expressible thought.

One fundamental question we can ask of kind representations is: what are they like? What information is included in each kind representation, and how is it stored? Previous research has shown that each kind representation contains a deeper formal structure, which means that for each given kind some pieces of information — called *properties*, like being square or having a particular function — have a more privileged status. We call the properties that are part of this deeper formal structure *principled properties*. Principled properties are the properties of kinds that are understood as making a thing what it is (e.g., *telling time* for the kind *watch*, or having *three sides* for the kind *triangle*). They are understood as almost being implicated by that kind of thing. And they are a remarkably stable part of the representation. For example, you can learn all sorts of new facts about watches—e.g., about particular styles of watches. And technology has developed such that new usages of watches are generated—usages that may be even more prevalent than the property of telling time. And yet there remains something special about the property *telling time* for the concept *watch*.

In our most recent line of work, we were interested in how children and adults generate completely *new* kind representations, and how they structure those representations. For any new kind concept, how do they assign some properties as principled, and therefore part of the deeper formal structure? Do they assign certain properties as being principled as soon as the new kind is learned?

To test this, we needed to utilize the fact that principled properties have a number of unique signatures that properties related to the kind in other ways do not have. For example, we can explain the existence of principled properties by simply citing the kind (e.g., “why does that thing tell time?” “*Because* it is a watch”), but we cannot do so for merely highly correlated properties (e.g., consider the unnaturalness of “why does that thing have a round face?” “*Because* it is a watch”). Additionally, if we encounter an object without its principled properties (e.g., a watch that doesn’t tell time), we consider there to be something normatively *wrong* with it, but we do not do so for merely highly correlated properties (e.g., a watch without a round face).

We developed a task with novel objects that the child hadn’t seen before, in which each object had a particular shape, color, and texture. We reasoned that if the capacity to structure kinds via principled properties is primitive, then if participants are introduced to a new property in a new kind using one of the signatures of principled properties (e.g., this blick has fur, *because* it is a blick), then she should assign all of the other signatures of principled properties with no explicit instruction (e.g., when shown a blick without fur, she should judge that there is something *wrong* with it).

This is exactly what we found, both for children as young as four and for adults. Furthermore, we found this effect for both animate kinds and artifact kinds, and it was remarkably stable with age. These findings suggest that though our understanding of a kind may involve many associations and relations to a variety of properties, a subset of those properties are quickly understood as privileged, and that this is true as soon as a new kind concept is formed.

# Baby Newton: Infants' perception of causality and physics

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.



Recently, we've found that adults and babies are sensitive to the Newtonian physics of collisions like these. Most people don't 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. Even though most adults don't know this if you ask them, babies seem to understand it intuitively. 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.

We are trying to figure out when this sensitivity to the physics of collisions develops, and how general it is. First, we're running the same study with 4-month-olds that we ran with older infants. We don't know how they'll respond. They might treat any change as interesting, or they might show a completely different pattern from older babies.

Second, with 7-9-month-olds, we're testing a different law of physics: If B moves off at a 90° angle from A, do babies find that surprising?



Finally, we're just starting to look at what babies think these physics-defying events actually *mean*. Previous work has found that, when babies see events in which A and B move at the same speed (and B moves off at a 0° angle), they expect A to be able to move independently, but they are surprised if B can move independently. However, if B can defy the physics of these collisions, do babies expect it to be able to move on its own? We don't know the answer yet, but we're just getting underway with our new study testing it.

# Number and executive function

Deborah Zaitchik, Research Fellow and Jenny Fielder, Lab Manager

From two to four years old, children develop a rich concept of number. While most older 2-yr olds can recite some part of the count sequence (1,2,3,4), these words have no numerical meaning (they're much like 'a,b,c,d'). It will take another 1½ to 2 years 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 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); *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!

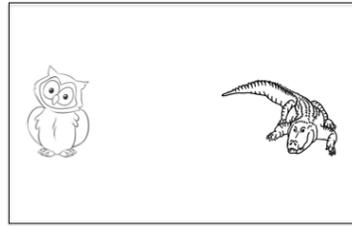
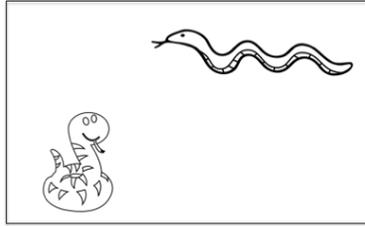
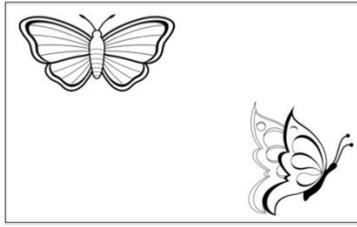
## What's in a name? Nouns help four-year-olds succeed on relational reasoning task

Rebecca Zhu, Lab Manager

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

Why is sorting cards on the basis of abstract relations so hard? One possibility that researchers have suggested is "object focus", namely that kids are paying too much attention to the individual objects to place weight upon the relations between objects. Indeed, when kids who fail the task are asked to explain why two cards match, they will often refer to perceptual properties of individual objects and say, "Because these two things look alike!" In contrast, kids who succeed will say, "Because these cards both contain things that are the same/different".

How can we get kids to notice relations between objects? One way could be through language, as previous research shows that a shared label (i.e. two things both labeled "dax") serves as an invitation to look for commonalities between individuals. In a series of studies, we explored the role of language on children's relational reasoning, specifically about same and different basic-level categories, or kinds, of animals.



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

In Study 1, the experimenter presented children with a training phase in which the experimenter labeled the animals on each card (i.e. “See this card? This card has a snake and a snake! And see this card? This card has an owl and an alligator!”) while teaching them how to play the game. During the crucial test phase, the experimenter stopped labeling the animals and just asked children to match cards. Four-year-olds were significantly above chance at matching *same* cards to *same* cards and *different* cards to *different* cards by themselves after the experimenter had named the animals during the training phase. In another version, we modified the training phase, such that the experimenter taught the child how to play the game without labeling the animals on each card. In this version, four-year-olds failed to match *same* to *same* and *different* to *different*, even though they should have been able to name the animals by themselves.

In Study 2, we changed the cards so that they contained unknown animals (unfamiliar Pokemon). In the training phase, the experimenter labeled the animals with novel names (i.e. “See this card? This card has a dax and a dax! And see this card? This card has a blick and a cheem!”). In the test phase, children still successfully matched cards on the basis of the abstract relations *same* and *different*, despite being unable to name the unknown animals themselves.

In Study 3, we asked if children needed to hear specifically nouns in order to succeed, or if any kind of linguistic repetition helps. The experimenter showed children unknown animals, but labeled the animals with novel adjectives (i.e. “See this card? This card has a daxy one and a daxy one! And see this card? This card has a blickish one and a cheemful one!”). Children trained with novel nouns perform better than children trained with novel adjectives. This result shows not only that language helps, but also that some types of language might help more than others. In this case, nouns specifically highlighted objects’ kind membership, which was the relevant dimension to match on.

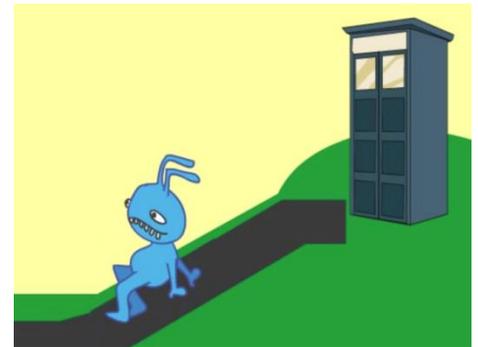
# Learning what verbs might mean

Melissa Kline, Postdoctoral Researcher

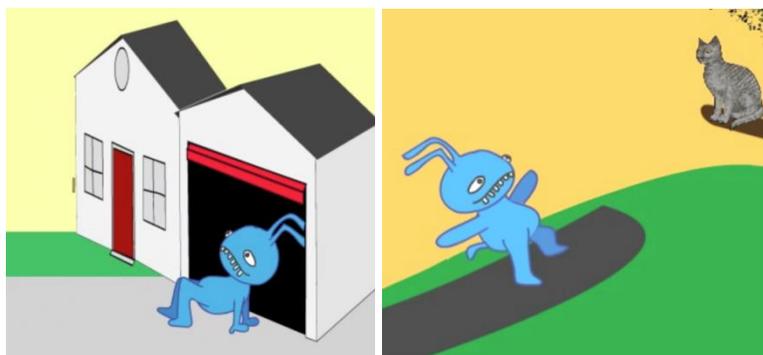
Thank you so much for participating in the “Learning Verbs” study with the Harvard Lab for developmental studies! We are very grateful for your time and participation – this research would truly not be possible without you.

Our four- and five-year-old participants have been playing a game that’s designed to help us understand the guesses that children make when they learn a new word. Oftentimes, just seeing an example might not be enough: If you see a character hop around the tree and you hear “gorping”, does gorpung 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.

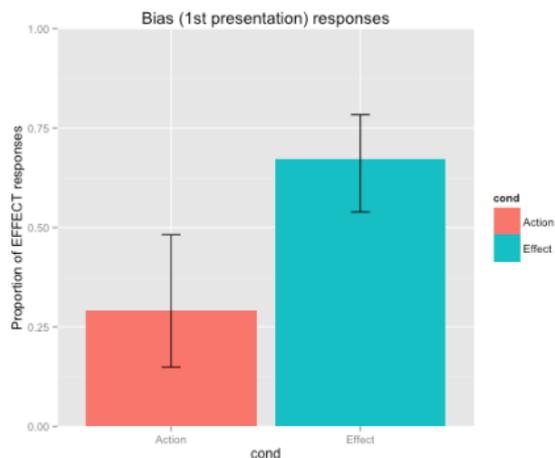
Where do these abilities come from? By age four children’s guesses about manner vs. path verbs already matches the rates in their native language, an even very small infants are sensitive to how manners of acting and goals of acting interact with one another. Do these early systems go on to help children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



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



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 is robust, it would suggest that these effects are based on some deep and very abstract kinds of meaning that children and adults use to put together verb meanings and sentence structures in just the right way. This line of work will help us to establish the development of language and understanding during the preschool years and, to understand all the pieces that fit together to 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 s/he 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!

# 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 hearing 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 the frequency of the word! They show a brain wave response that is smaller to frequent words and larger to infrequent words like those of adults. We are now working to see whether they are also sensitive to how predictable a word is – but look for those results in future newsletters! Thank you to all of the families that participated and to all the kids that got their hair goopy in order for us to see their brain waves!

## Who is Max? Learning how 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 map further the developmental trajectory of these cross-cultural differences by testing children at the earliest point in development where they may appear. We tested a group of four-year-old children in the United States to determine if they had already developed a consistent view of reference. Each child heard a series of three stories involving several characters, each of which has a unique name. At the end of the story, they heard a statement about one of the characters and were asked to judge if it was true or false. Crucially, in two of the stories the judgment depends on which theory of reference people adhere to.

Our results show that 4-year-olds do not show a consistent pattern of responses in line with either theory, answering our prompts at or close to chance level. This pattern of results could have several explanations. It is possible that at age four children have not yet settled on a particular theory of reference and are equally likely to pick either strategy when responding to our prompts. Alternatively, the pattern could be due to the nature of the task used. Although we simplified the stories used in order to make them suitable for the age group, they are still fairly complex and could be challenging for younger children to recall accurately when responding to the prompts. Future research should further modify the task used in order to minimize the working memory load and best enable us to disentangle the underlying cognitive mechanism from the task demands.

## **Role of prior mention in children’s language understanding**

Pooja Paul and Jayden Ziegler, Graduate Students

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

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

# **Thinking about others' mental states: Theory of mind in autism spectrum disorder**

Guiqin Ren, Visiting Fellow and Elizabeth Chalmers, Lab Manager

A key feature of autism spectrum disorders is impairment of social interaction and communication. These deficits are believed to a failure to infer the mental states to others spontaneously and accurately, a skill called theory of mind. While typically developing children succeed at verbally administered theory of mind tasks by around age four, highly verbal children with autism do not succeed until much later – usually around 8 to 10 years of age.

The cause of this delay remains a point of debate among psychologists. Is the success of older children with autism due to late developing, but typical, theory of mind abilities? Or is it the result of a learned cognitive strategy? Some past work suggests that the latter may be the case. Adults on the autism spectrum were able to answer verbally administered measures of theory of mind ability but failed an implicit visual theory of mind task, suggesting that they do not in fact spontaneously represent others' mental states. Our study seeks to further explore these issues with both typically developing children and children with Autism Spectrum Disorder.

Children in our study completed a series of tasks designed to measure their theory of mind abilities both implicitly and explicitly. First, they watched two short videos on an eye tracker of a puppet hiding a ball while an actor watched and subsequently had to retrieve the ball. On some trials, the actor did not see a critical part of the action (e.g., the puppet moving the ball from its hiding spot after the actor turned away). Sometimes this will result in the actor holding a false belief about the ball's location (e.g., because the ball remains in its new location). We then looked at children's looks to the box where the actor had last seen the ball hidden in order to determine if they were accurately representing the actor's knowledge about the ball's location.

Afterwards, the researcher read the children a series of short stories about events similar to the one they saw in the video. For example, one story is about a boy named Jack who hid a chocolate bar in a basket on the kitchen table and left the room. Then, Jack's mother came in and moved the chocolate bar to a kitchen cupboard. Children were then asked where Jack believes the chocolate bar is hidden.

So far we have only run a small number of typically developing children in this study. Our preliminary data appears to show that children consistently do not look to the correct box in the nonverbal theory of mind task despite perfect performance on the verbal tasks. Future work will need to explore if this is due to our experimental materials and design or if this discrepancy in performance is genuine, and if so why it arises.

# Judging, describing, and acting out events

Jayden Ziegler, Graduate Student

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

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

This study has two parts.

**PART 1 - PRODUCTION:** Some children heard and produced dative sentences. Elicited sentences were similar either to (1) or (2) below:

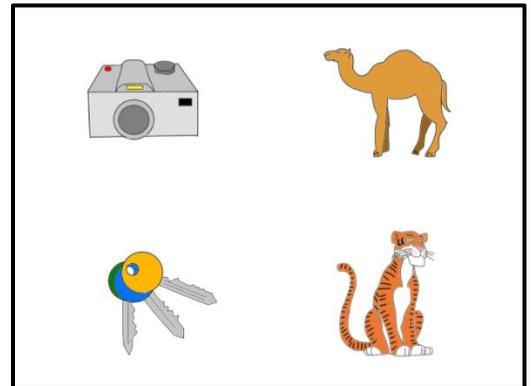
1. The boy brought the camel the keys.
2. The boy brought the keys to the camel.

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

**PART 2 - COMPREHENSION:** Other children only heard dative sentences but didn’t produce them. Instead, they had to act out critical instructions on toy objects. Test sentences were similar either to (1) or (2) below:

1. Now, you can bring the camel the keys.
2. Now, you can bring the camera to the tiger.

As the children in Part 2 heard “bring the cam...,” it was temporarily ambiguous as to whether the entity being referred to was the *camel* or the *camera*. We evaluated children’s real-time interpretation of the sentence by tracking their eye movements to a set of objects on a screen (see example display below). Eye movements have been shown to be closely time-locked with language processing. When the children heard “cam...,” were they looking more at the camel or the camera?



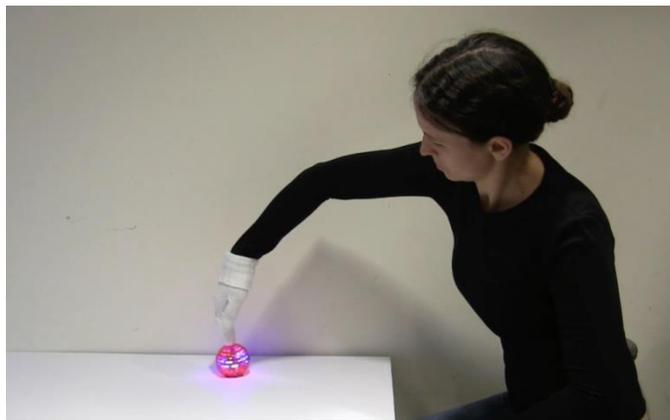
In either case, test sentences were always preceded by two prime sentences. Our main hypothesis was that children’s responses (PRODUCTION) or where they looked (COMPREHENSION) would be influenced by the type of prime sentences they heard. For example, if the children first heard two sentences with the same structure as that in (1), they would be more likely to use (1) to describe the scene (PRODUCTION), or they would expect the first noun in the test sentence to be the animal and therefore look more at the camel (COMPREHENSION), and vice versa.

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

# What do prereaching babies know about reaching?

Shari Liu, Graduate Student

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



In particular, we were interested in whether babies who are still mastering reaching interpret reaching as a goal-directed action. We tested this by asking whether young babies expect a reach to be efficient, a key signature of intentional action. Across a series of experiments, we presented 3-month-old babies with an actress who reached over an obstacle and caused an object to light up on contact (Exp. 1) or picked up the object with her hand (Exp. 2). Then, we removed the barrier. Given that the actress is going to reach again for the object, how will she direct her reach: in a familiar and curved but newly inefficient path of motion, or in a novel but newly efficient path of motion? If 3-month-old babies interpret reaching as a goal-directed action, then they, like older infants, will look longer at an inefficient than an efficient reach. But if they do not interpret reaching as goal-directed, they will either show no looking preference, or will look longer at the efficient action, because it is perceptually unfamiliar. We found that 3-month-old babies expect reaching to be efficient over a change in the obstacles in the actress's way, both when the actress caused the object to light up (Exp. 1) and when she picked up the object (Exp. 2). Results from an additional condition in Exp. 1, where the actress's actions are not constrained by an obstacle, shows that babies did not merely find curved motion more interesting to look at. Further experiments manipulating the surface properties of the hand (Exp. 3; wearing a mitten versus bare), and the cause and effect relationship between the hand and the object (Exp. 4) showed that infants only showed expectations for efficient action when they were familiar with the hand doing the reaching, or when the actions of this hand caused a change in the world.

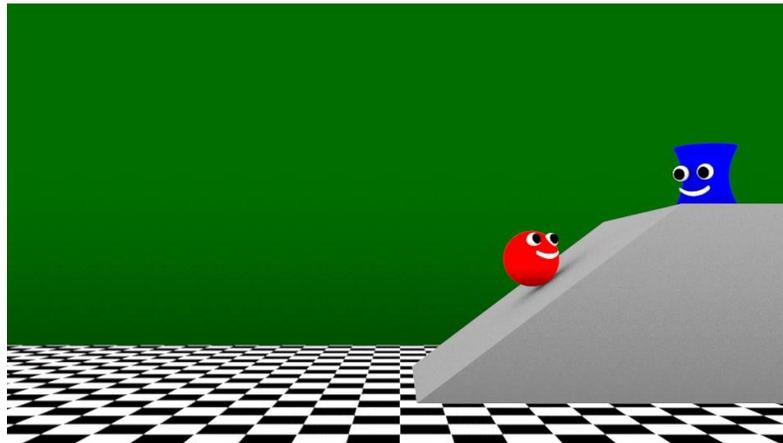
These findings are important for several reasons. First, they show that infants do not need any motor experience reaching around a barrier (which babies do not master on their own until 8-10 months) in order to understand that agents must direct their reaches around obstacles. Second, they show that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

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

Shari Liu, Graduate student

As adults, we understand that one reliable way of inferring someone's subjective valuation of a goal (e.g. apples) is how much of a cost she's willing to pay for them (\$1? \$12? a trip to the store? climbing a tree?). While previous experiments have shown that babies know something about the goals of agents and the effort associated with actions, it's an open question whether they, like adults, understand that effort is informative about value. To ask this question, we ran a series of experiments where we showed 10-month-old infants that an agent is willing to jump a higher barrier, climb a steeper ramp, move a heavier object, jump a wider cliff, or jump a deeper cliff to reach one of his friends over the other. The agent then alternately 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.

While we are still collecting data for several of these experiments, our preliminary findings suggest that infants understand that the amount of effort or risk an agent expends is informative about the value of the goal he's working towards. 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 our species' knowledge about the physical world—objects and their movements—and the social world—agents and their motivations—is integrated early in life!

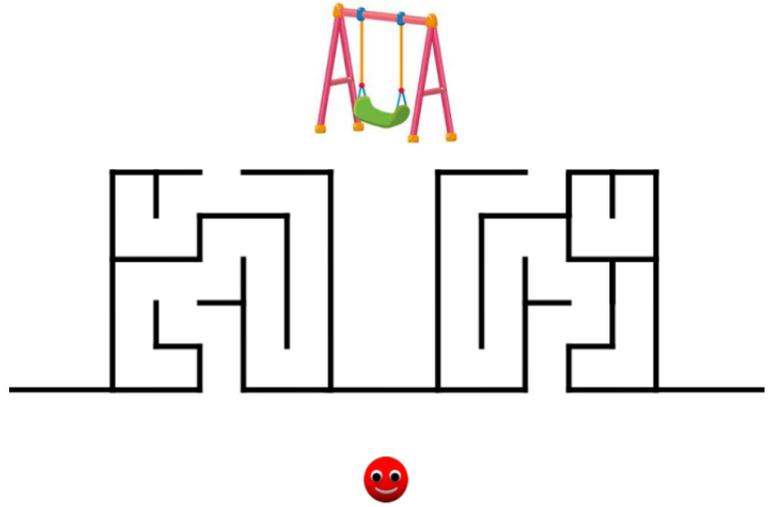


# Lazy agents: Children’s reasoning about habits and the cost of planning

Shari Liu, Graduate Student

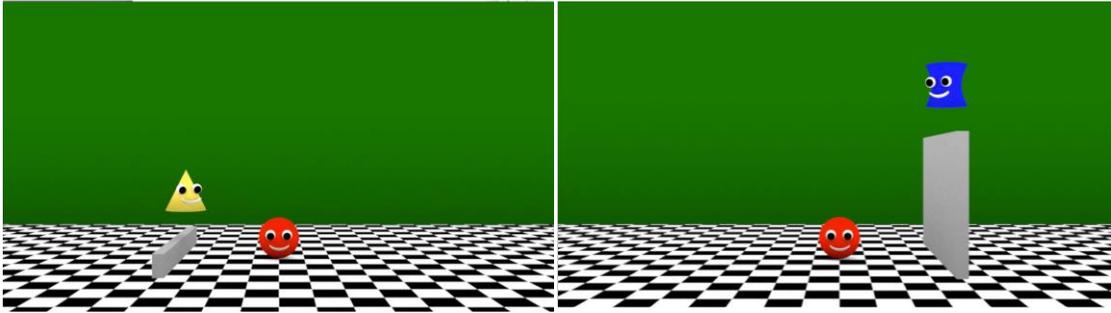
Making decisions is hard! Not only do actions differ in how much effort they require to carry out (e.g. time, energy), but how difficult they are to plan (e.g. complicated versus simple sequences of action, brand new versus habitual actions). While past experiments show that children understand physical 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 that had different habits (Exp. 1) or faced choices that differed in complexity (Exp. 2). In Experiment 1, children were introduced to two agents, and observed one of them traveling down a long road 10 times while the other traveled down this road only once. Then, they saw that a shortcut opened up. They were asked whether each agent would take this shorter, more efficient path, or the longer, more familiar path. Whereas adult participants in a similar experiment were more likely to predict that the agent acting under a stronger habit (i.e. the one who traveled the long road many times) would stick to the same action, while the agent acting under no habit would update its plan given the more efficient option, children responded the same way to both agents. Specifically, they predicted that both agents would take the shorter, more efficient path when it became available. In Experiment 2, we tested whether children understood 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 were 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 mazes, and understood that these were easier to travel through. We are currently planning follow-up experiments that ask whether children understand that making decisions is costly in other contexts. 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



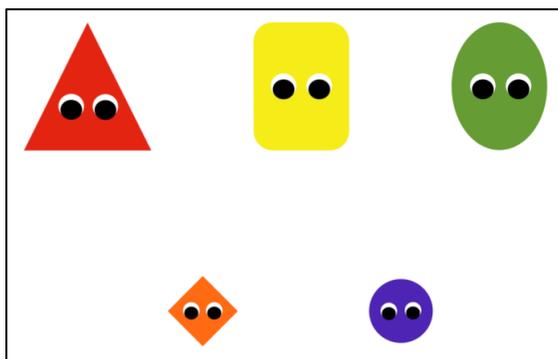
When we think about favors like giving someone a ride to the airport or helping them move apartments, we typically assume that they involve close friends or kin. One reason for this assumption is that we are more willing to expend great effort for people we value highly—people we like or are related 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—Yellow and Blue, pictured above—were willing to take different amounts of effort for a third cartoon shape--Red. For instance, Yellow was only willing to jump a lower wall for Red, whereas Blue was willing to jump over a higher wall. After watching these displays, we asked children (1) which agent Red liked more and (2) whether Red would take different amounts of cost by jumping over walls of different heights to reach Yellow or Blue. 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 running a follow-up experiment 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 question we asked (“Who does he like more?”) is too general.

# Early Understanding of Social Interactions & Relationships

Annie Spokes, Graduate Student

We have been continuing a line of research asking how babies think about and understand the people around them and how people are connected to each other in social interactions and relationships. We show babies animated shapes instead of people in these studies (pictures below).



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

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. These studies had five shapes, or “characters.” In one of the experiments, there were two little shapes (“babies”) and three big shapes (“adults”). In the first videos, babies saw that each baby cried, and one of the adults went to the baby, made a soothing noise, and rocked with the baby. 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. We found that by 15 months, babies did seem to be tracking the social networks and were surprised to see affiliation between adults who soothed different babies.

This set of experiments has been published in a scientific journal, so you can read more about them in the paper. The citation is below, and a link to the paper can be found on our lab website under Dr. Spelke’s publications. A *HUGE* thanks to all the families who participated in these studies!

Spokes, A. C. & Spelke, E. S. (2017). The cradle of social knowledge: Infants’ reasoning about caregiving and affiliation. *Cognition*, 159, 102-116.

We are continuing this line of research by testing when this understanding of affiliation in caregiving networks might emerge in younger babies. We have been exploring these questions with babies around 11- to 12-months-old. Some initial experiments we have run with 11-month-old babies suggest that they can also keep track of social relationships—but it may be more challenging at this age, so we are following up on these results. These studies are still ongoing, so we look forward to sharing more about results in the next newsletter. **Thank you to all babies and parents who helped to make these studies possible!**

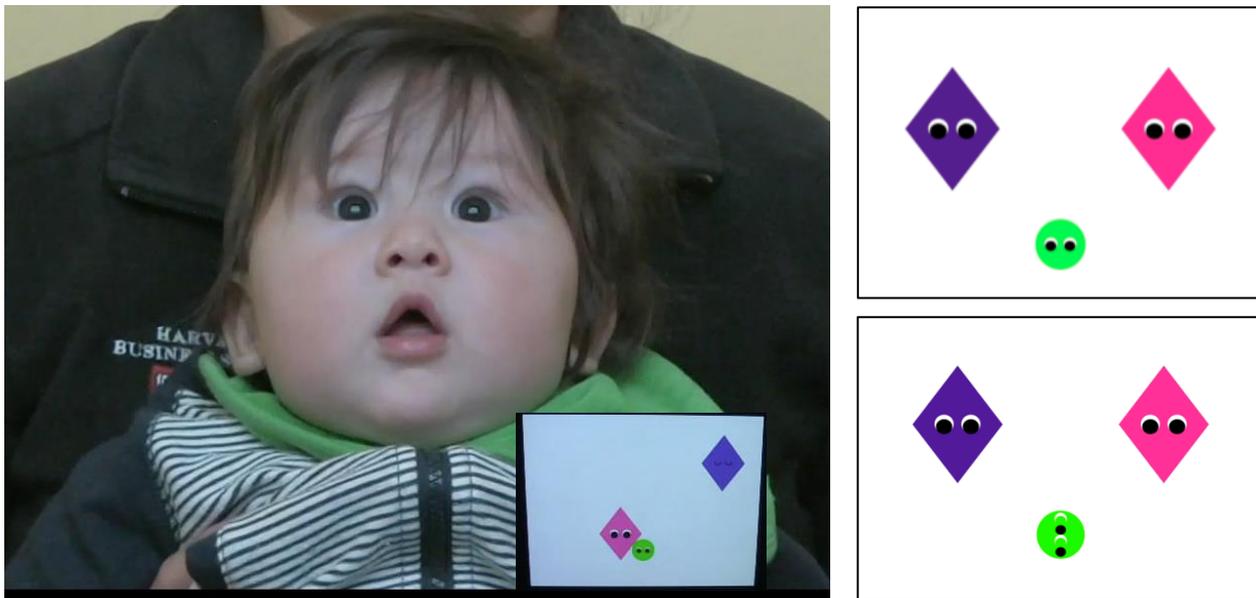
# Five-month-old Babies Attend to Responsive Caregivers

Annie Spokes, Graduate Student and Tara Venkatesan, Yale Undergraduate

In this set of studies, we are interested in learning about how babies think about caregivers and caregiving behaviour. In the first study, infants watched short animations with three coloured shapes. Two of the shapes were "parents," and one was the "baby" (picture 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 only five-months-old, babies indeed preferred to look at the more 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 (picture 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 are continuing this line of research with two different studies. First, we are testing whether five-month-olds show a preference for the responsive caregiver when the baby giggles or fusses (in addition to crying, as in the first study). Second, we are testing whether babies at 7- to 9-months-old show a preference for a responsive caregiver through their looking preferences as they get older. We look forward to sharing about these ongoing studies in the next update. Thanks to all babies and families who have been helping with this research!



*Left: A five-month-old baby watching a video of a "parent" (pink diamond) responding to the baby's cry by moving toward the "baby" (green circle). Right Top: A still image of the animations from the first study, which had two "parents" (red and purple diamonds) and one "baby" (green circle). Right Bottom: 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.*

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

Annie Spokes, Graduate Student and Stephanie Campbell, Harvard Undergraduate

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 animated videos, we have small shapes as “babies” and big shapes as “parents.” First, each adult comes out to introduce themselves by talking, and there will be one male voice and one female voice. Then, a baby shape enters the scene and begins to cry. In alternating videos, each of the adults responds to the baby in turn, and we measure if babies are more surprised by one of these videos by how long they watch 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?

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 cannot wait to find out! This study is ongoing, but some preliminary pilot findings suggested that babies may be surprised to see a male caring for a baby if their primary caregiver is female. **We appreciate all the babies and parents who have helped with this study. Thank you so much!**



*A 14-month-old baby watching a video of a “parent” (orange oval) responding to the baby’s cry by moving toward the “baby” (green square). In the next video, the second “parent” (purple oval) would then respond to the baby too.*

## Magic wands

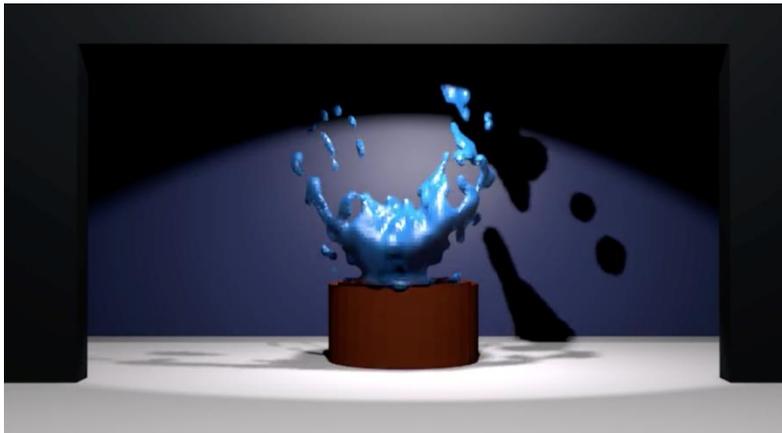
Tomer Ullman, Postdoctoral Fellow



When people push and pull things, we instinctively 'see' the forces of effort and strain in their action. But do kids also perceive these forces? Do they understand that such forces can sum and cancel (if I push you and you push me, we stay in the same spot despite a great deal of effort being used)? We investigate this by showing children video clip of "magic wands" that repel and attract a block sliding down a hill. We then ask the kids to use real-life versions of the wands to try and attract a block towards them.

## Mass: The hidden variable

Tomer Ullman, Postdoctoral Fellow



How do kids understand physical scenes? Do they simply use perceptual cues (such as the shape of an object or its speed), or do they have an understanding of the hidden dynamic variables (friction, force, mass, and so on)? Mass in particular is a variable that controls the interaction of objects across a wide variety of perceptually different scenarios, from splashing to colliding to stability to scattering. In one experiment, we showed young children (3-5 years) videos of objects behaving in different ways across perceptually different scenarios and asked them to identify the heavy or light object. In a second experiment, we gave kids the objects and asked them to predict what would happen next. While kids are not as good as adults at this task, their predictions for most of the scenarios were accurate, suggesting they can productively use the concept of mass.

