HARVARD LAB FOR DEVELOPMENTAL STUDIES NEWSLETTER 2025

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Can Children Reason About Sequences of Functions Before They Understand Sequences of Words in Their Native Language?

Lily Zihui Zhu (Graduate Student); Elika Bergelson (Co-Principal Investigator); Jesse Snedeker (Co-Principal Investigator)

This research explores the early conceptual building blocks that may support language development. Language is compositional: we combine smaller units, like words, into phrases and sentences to express complex ideas. For example, when we hear "John loves Mary," we understand that "John" and "Mary" refer to different individuals, and "love" describes their relationship. In this study, we asked whether 9-11-month-old infants can reason about sequences of nonlinguistic functions before they fully understand their native language. Specifically, we tested their ability to track two physical functions: pushing (which changes an object's location) and smashing (which changes its state).

In a 5-minute Zoom session, infants watched videos showing these functions applied in different orders. The outcomes depended on the order. For example, if the object began on the right and smashing occurred first on the left, followed by pushing it to the left, the object remained intact. However, reversing the order—pushing before smashing—resulted in the object being smashed. To succeed, infants needed to represent both functions and reason about how the order of actions affects the final result. If infants could correctly reason about the sequence of functions, they would find the unexpected outcome surprising and look longer at them. This would suggest they are already able to combine simple concepts in a structured way, much like how we combine words in language.

Our preliminary findings suggest that infants do expect different outcomes given different function orders. We are wrapping up the final part of this study now, so please stay tuned for updates in our newsletter next year. Thank you again for participating!

Young Humans' Evaluations of Antisocial Acts of Saliva Exchange

Mia Taylor (Research Assistant); Brandon Woo (Former Postdoctoral Researcher); Ashley Thomas (Principal Investigator)

Adults often socially evaluate others based on their actions, and the same actions can be construed as prosocial or antisocial depending on contextual factors such as consent. In this project, we explore whether consent is salient for children in their social evaluations of actions that involve saliva sharing. We tested this by showing participants (6- to 8-year-olds) videos in which one character interacted with a central protagonist's kazoo in their absence and another character did so in their presence. There were three within-subjects conditions: the Saliva Condition (where both actions involved saliva sharing), the Touch Condition (both actions involved touching the kazoo), and the Prosocial Condition (both actions were prosocial). We then asked whether the action was okay, which character was nicer, and how close each character was with the central protagonist. Absence/presence affected children's evaluations of actions, as well as social closeness ratings. Children thought nonconsensual actions involving saliva sharing and touch were not okay, while absence/presence did not affect children's evaluations of prosocial actions, which they always thought were okay. Children expected those who shared saliva or touched the same kazoo in each other's presence to be closer to one another than those who did not. Closeness ratings for prosocial actions were unaffected.

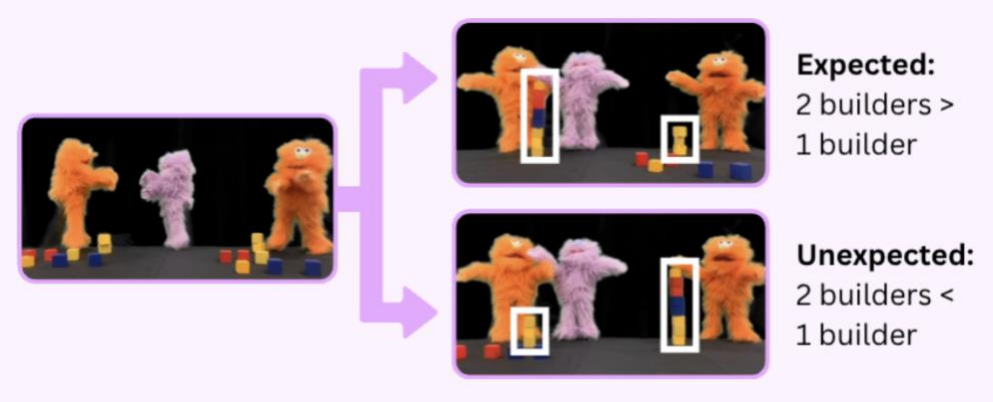
Do Babies Think that Teamwork Yields Better Outcomes?

Hannah Hok (Postdoctoral Researcher); Victoria Chen (Research Assistant); Ashley Thomas (Principal Investigator)

Working together is a fundamental way humans achieve goals. Past research has found that babies notice things like how efficiently someone does an action, whether they're paying attention, and whether they seem connected to others. In this study, we wanted to know if they also expect that two working together can be more successful at building towers than one working alone.

To find out, we showed 16- to 20-month-old babies short videos of puppets building block towers. In each video, two orange puppets started building block towers—one on the left, one on the right. Halfway through, a purple puppet joined in to help one of them. At the end of the video, the towers were either what you'd expect (the two builders had built a taller tower) or surprising (the one builder had built a taller tower). We wanted to test and see whether infants were more surprised when one character built a taller tower versus two. We have also started piloting some similar stories with older children to see if they think people who are close (e.g.,

best friends) will build towers faster together than people who are not (e.g., strangers). Stay tuned for the results!



Unit Tracking and Children's Understanding of Halves and Wholes

Alex Gayle (Summer Intern); Peggy Lee (Research Scientist); Elizabeth Spelke (Principal Investigator)

Children's understanding of units, specifically converting between wholes and halves, is an area of learning that we wanted to explore. Understanding units and how to swap between them is an important skill for children to develop, essential for everyday tasks such as handling coins, cooking food, and sharing fairly. Previous research in our lab has shown that many children around 4 years of age struggle to distinguish between wholes and halves during tracking tasks, behaving as if half objects were just a different kind of their respective whole object. When two whole cups were placed into a box, cut, and 2 half cups were taken out, nearly a third of the children studied said that the box was empty. Given this, it is important to figure out what exactly is driving this behavior and what interventions lead to a more mature understanding. It is possible that some children just do not yet have enough experience with half objects at this stage in life. It is also possible that children are familiar with halves yet do not appreciate the properties that differentiate them from whole objects.

In this study, children 42-60 months old were given a tracking and identification task using cups that could be horizontally split in half, a red box, and panels of half and whole cups. They were all shown two cups placed inside a box and then taken out. They were then asked whether the box was empty or if something was inside. If they responded that something was inside the box, they chose from 3 possible panel options of what remained (a half cup, a whole cup, or a half and whole cup). This procedure was repeated for 16 trials and lasted roughly 20 minutes per participant. Each child was assigned to one of 3 conditions that affected what they were shown before the task. The first condition showed water being poured into a whole cup, the cup being cut in half in front of them, and then water being poured into the half cup, going everywhere. This condition was designed to isolate the impact of emphasizing the functional difference between wholes and halves. The second condition showed two cups being cut in half in front of them, which was designed to isolate the impact of merely observing the cutting process in detail. The final condition showed nothing, attempting to be a control reference and replication of prior experiments.

This study just concluded its pilot phase, helping assess the viability of its methods and materials. Having run 8 children through its procedures and conditions, the researchers hope to fully run the study this fall.

Children's Early Understanding of Groups

Christina Steele (Graduate Student) and Ashley Thomas (Principal Investigator)

We're studying how children think about sharing, specifically when it comes to sharing saliva—like when they share food or drinks—with other kids. To do so, we ask children if they expect others to be willing to engage in this type of sharing with children of a different social group. By looking at how kids approach this behavior, we hope to learn more about how

children's ideas about groups might influence their decisions in everyday social interactions. This will give us insights into how early social behaviors and attitudes about groups develop.

Title: How "Fine-Tuned" is a Baby's Word Knowledge?

Lilliana Righter (Lab Manager); Sophie Schoenbohm (Lab Manager); Michika Ito (Lab Manager); Elika Bergelson (Principal Investigator)

In this study, we use eyetracking to ask whether babies start out with very specific or very vague ideas of what words sound like and what they mean– and how those change over their second year of life! For example, to learn the word "dog" in English, you have to learn that it's not pronounced "tog" or "dug," even though those words sound pretty similar. You also have to learn what's a dog and what's not: it's probably pretty easy to rule out a banana, but what about other furry four-legged friends? It might be harder to know right away that a cat isn't a good example of a dog! Second, we wonder if you have to be really good at identifying the way a word sounds before you can narrow down what it means, or the other way around.

We put two pictures on the screen during each trial of the study, and we play a recording that says something like, "Find the dog!" During some rounds, the two pictures might be a dog and a cat, or a dog and a banana. During other rounds, we might show a dog and a banana, but we will mispronounce dog as "doog." Based on how long a baby spends looking at each picture, we can infer what they think that word refers to. Babies do both types of trials in the same study session, so we can look at their sound skills and meaning skills at the exact same age!

We're a little more than halfway done with this study: 125 out of our goal of 160 babies have participated in this study! So far, it looks like kids get better at identifying a word's meaning as they get older, no matter what the distractor image is. It's more or less just as easy to find a dog when there's also a cat on screen as when there's a banana on screen. This tells us their categories for what a word refers to might be pretty clear cut from an early age! Second, we find that their idea of what a word sounds like gets more specific as they get older: they start out treating "dog" and "doog" pretty equally but have more of a preference for the correct pronunciation as they get older. We'll see if these patterns are significant with a full sample of babies!

How Children Reason About Group Dynamics

Mack Briscoe (Graduate Student) and Ashley Thomas (Principal Investigator)

This project looks at how children think about disagreement within groups. Across three studies, children were told stories about novel groups (called the "Wugs" and the "Flurps") who were either building a garden or a well together. One of the groups was hierarchical, where one person was the "boss" and made all the decisions on the behalf of their group. The other group was egalitarian, where everyone talked about and agreed on every decision. In the story, someone in each group eventually disliked a decision being made, and we asked kids what they thought that person would do: would they go along with the decision they didn't like, speak up about their disagreement, or leave their group to join another? We found that 6- to 8-year-olds held a strong initial expectation that disagreers would speak up, despite believing that the kind of group they were in determined how effective it was to do so. These expectations were also dynamic: when given evidence that speaking up did not work, children deferred to other strategies. These results suggest that children update their expectations based on both what has worked in the past and on group dynamics.

Picture Matching with Polly the Parrot: Investigating Whether Linguistic Prediction is Flexible Based on Context

Margaret Kandel (Graduate Student); Danielle Novak (Former Thesis Student); Jesse Snedeker (Principal Investigator)

We know from prior research that adult listeners can use contextual cues to predict upcoming words before they hear them. Recent evidence from our lab suggests that this ability is already in place by early childhood. This study investigates the flexibility of this process and whether children and adults can modulate their linguistic prediction based on the reliability of contextual cues.

We are currently conducting this study with adults and 4–6-year-old children who speak American or Canadian English. In each trial of the study, participants hear two words and see a picture; their job is to respond yes or no whether the picture matched one of the two words. In some trials, the words are related to each other (e.g., mattress – bed). In others, the words are unrelated (e.g., celebration – bed). We manipulated the proportion of related word pairs in the experiment (80% vs. 20%). When the word pairs in the experiment are typically related (80% of the time), then the first word provides a reliable cue to the second word. When the word pairs are not often related (20% of the time), the first word does not serve as a reliable cue to the second word. We are investigating whether participants predict more when contextual cues are reliable (in the 80% condition) than when they are not (the 20% condition).

To assess prediction, this study uses electroencephalography (EEG). Participants wear a sensory cap that measures the electrical activity on their scalp as they complete the study. We are particularly interested in an electrical response called the N400. When participants have correctly predicted an upcoming word, they produce a smaller N400 response after hearing that word than when they hear an unexpected or otherwise non-predicted word. Thus, by comparing the N400 response to the second word in a pair when it was related vs. unrelated to the first word, we can determine whether participants predicted the second word based on the first. If participants predict the second word, then the N400 response should be smaller when the second word is related to the first (and thus matches the prediction) than when it is unrelated; otherwise, if participants are not predicting the second word, there should be no difference in the N400 response depending on whether it was related or unrelated to the first word. We are planning to compare N400 responses to related vs. unrelated second words across the 80% condition and the 20% condition to see whether participants predict more (resulting in a larger N400 difference between related and unrelated words) in the 80% condition, when the first words are more reliable cues to the second words. We will also assess how this differs between adults and children.

Data collection is currently underway. So far, it appears that adult participants predict more in the 80% condition than the 20% condition, suggesting that they perform more linguistic prediction when the available contextual cues are reliable. Comparing the data from the first half of the experiment to the second half, we see that adults start out predicting in both conditions in the first half but then reduce the amount of prediction in the second half of the experiment in the 20% condition when contextual cues are unreliable. This suggests that adults can flexibly modulate linguistic prediction based on the context. We still need more child participants before we can determine whether young children do the same. Stay tuned!

Do Babies Use Accent to Predict Who Will Respond to Distress?

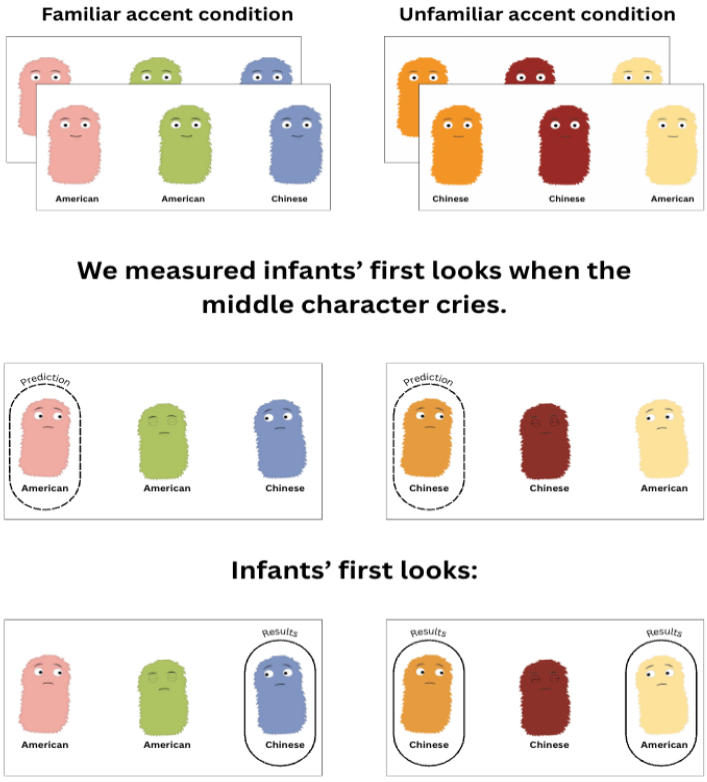
Denisse López Flores (Lab Manager); Christina Steele (Graduate Student); Dhanishtha Upadhyay (Research Assistant); Paola Lee-Vega (Thesis Student); Ashley Thomas (Principal Investigator)

Previous research suggests that babies expect same-language speakers to affiliate and imitators to approach one another. However, it is unclear whether infants use more subtle speech differences, like accents, to make social predictions. In this study, we explored whether 13-to-18-month-olds anticipate speakers with the same accent to comfort each other when one of them is upset.

To explore this question, we showed monolingual English-learning toddlers from the U.S. two groups of animated characters. In each group, two characters shared the same accent and one did

not. For one group, the shared accent was American English; for the other group, it was Chinese-accented English.

After we familiarized infants with each group, we showed them a scene where one of the same-accent characters looked sad and started crying. Followed by this, we measured which side character infants look at first and for longer — thinking this might show which character they expected to comfort the one who was upset.



Our early results suggest that toddlers at this age may not use accent to guess who is likely to respond to someone else's distress, as we did not find a consistent pattern for which character they looked at first or looked at longer. We are currently testing more babies to see if we replicate these findings — stay tuned!

Abstraction for Babies

Elena Luchkina (Research Scientist); Elizabeth Spelke (Principal Investigator)

Children begin comprehending relational terms like same and different around 2.5–3 years, even though they can represent and generalize relational structures before their first birthday and map

words to abstract or unseen referents by 15 months. We hypothesized that this delay arises because natural input provides few clear opportunities to infer the meanings of relational terms, which are often ambiguous and seldom explicitly labeled by caregivers. To test whether structured input facilitates learning, seventy-four infants (average age 16.11 months) were assigned to one of three conditions: no familiarization, simple familiarization with alternating labeled sets of identical or distinct images, or complex familiarization with varying set sizes. In test trials with novel image pairs, only infants in the simple familiarization condition looked reliably to the correct pair, while those in the other conditions preferred the more salient "different" pairs. These results suggest that infants as young as 15–18 months can learn and generalize relational terms when input is structured, contrastive, and highlights only the relevant dimension.

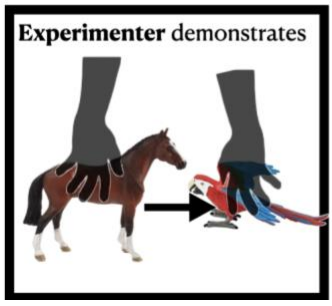
Fun on the Farm! Infants Understanding of Event Participants

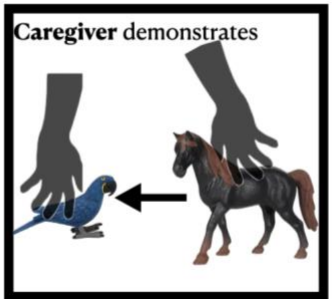
Irene Canudas Grabolosa (Postdoctoral Researcher); Britney Balseca (Research Assistant); Cathlyn Boyle (Research Assistant); Jesse Snedeker (Principal Investigator)

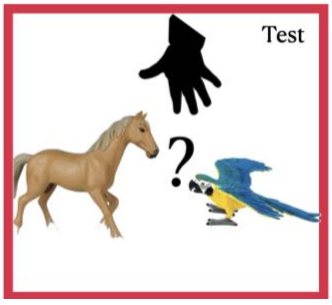
In this study, we are exploring how infants understand events and how broadly they think about the participants in these events. When encountering different scenarios, such as various horses pushing different dogs, do infants form the general idea that "horses push dogs," or do they perceive each instance of a horse pushing a dog as a separate, unrelated event?

Past research suggests that forming such general concepts requires substantial language experience. Without it, one might only see each scenario as isolated events. To investigate this hypothesis, we tested 30 18- to 21-month-olds using an imitation task. In this task, we showed them an example of one animal acting on another species (e.g. a horse pushing a parrot), then we asked their caregiver to copy the action with two different exemplars (i.e. a different horse and a different parrot), and then we presented infants with a third exemplar of each species (a new horse and a new parrot) and invite them to imitate what they saw.

We're finalizing data collection this summer, so we will soon be able to tell you how infants conceptualize these events. Stay tuned for results!







Do People Value Plants Over Non-Living Objects?

Lizette Pizza (Postdoctoral Researcher) and Ashley Thomas (Principal Investigator)

In this current moment of environmental crisis, many plants are at risk of extinction, and although we need to develop ways to promote their conservation, little is known about the development of our moral consideration for plants. However, we know that early in development, humans do not ascribe life to plants and might see them as objects because they do not move. This raises the question: do we value them more than objects or tools? Do we observe how others treat plants and take that information into account before choosing to be friends with them?

In this study, we showed children videos of puppets interacting with plants and objects. One puppet harmed the plant but protected the object, while the other puppet harmed the object and protected the plant. We asked children which puppet they wanted to be friends with more and which one was the bad guy. We also inquired whether participants knew that plants can grow and die (i.e., biology knowledge). We are also in the process of piloting a similar version of the study with babies.

We found that children do not prefer to be friends with one puppet over the other, but most of them say that the puppet who harmed the plant was the bad guy. This tendency was even stronger among those who knew that plants can grow and die, which suggests that our knowledge of biology might play a crucial role in how we consider whether plants are more valuable than objects. We are now in the process of replicating these findings as they have important implications for our understanding of the key information humans consider when caring for non-human entities.

Is Knowing the Sound Structure of Words the Secret Key to the Word Comprehension Boost?

Jasenia Hartman (Postdoctoral Researcher); Lilliana Righter (Lab Manager); Michika Ito (Lab Manager); Elika Bergelson (Principal Investigator)

Babies start recognizing words as early as 6 months old, but between 12 and 14 months, their word learning suddenly takes off — a period researchers call the “comprehension boost.” We’re curious about what drives this change. Is there a key skill that helps babies rapidly improve at understanding and learning words? One skill we’re especially interested in is the ability to tell real words (like diaper, ball, shoe) from non-words that sound English-like (like depper, bool, or

showe). In this study, we tested whether recognizing familiar word forms is linked to the comprehension boost.

What did babies do? Babies completed two short video tasks. In one, they heard lists of real and made-up words while we tracked how long they listened. In the other, we used eyetracking to see how quickly they recognized familiar objects when named.

Until recently, this study focused mostly on monolingual English-learning babies. But over the past year, we expanded the project to include bilingual and multilingual babies learning English — thanks to a special senior thesis project led by Harvard graduate Nicole Calderon! This project let us ask: Do bilingual babies recognize familiar words in English the same way monolingual babies do?

So far, the results show that both bilingual and monolingual babies listen to real and made-up word lists for similar amounts of time. In fact, bilingual babies don't show a strong preference for real words and while monolingual babies prefer real words slightly more than bilingual babies, the difference between the groups isn't dramatic. We're now in the final stretch of collecting data: 60 out of 66 bilingual/multilingual babies have already participated. Thank you to everyone who's helped us get this far!

What Babies Learn from Their Parents

Brandon Woo (Former Postdoctoral Researcher); Haowei Peng (Research Assistant); Emma Yu (Lab Manager); Ashley Thomas (Principal Investigator)

Past research has examined what babies understand of other people's actions but has mostly presented babies with people who are strangers. Yet, the people whose minds may be most relevant for learning, cooperation, and social life are the people within a child's social network: especially the child's own parent. The present study investigates 8- and 9-month-old babies' sensitivity to the gaze of their parents and of strangers. We found that babies readily track animate beings whom their parents look at, but they don't readily track animate beings whom strangers look at, nor objects whom their caregivers or strangers look at.

What Do Children Know About Number Words They Do Not Yet Know?

Adelaide Kelsey (Research Assistant); Yiqiao Wang (Graduate Student); Elizabeth Spelke (Principal Investigator)

Children go through distinct stages as they acquire cardinal meanings of number words. Around the age of two, children learn to count up to ten or so. At this point, children don't have a cardinal understanding of these numbers, meaning that they don't understand what each number word in their list actually represents. Over the next few years, children learn the meaning of small number words, between one and four, in sequence. At this stage, it is still unclear how much children know about larger number words that they are able to count to but not yet able to generate a set for.

In this study, we examined what children know about these larger number words. We tested three-year-old participants over Zoom. Each participant played several short number games. In the primary game, they were given a short storyline about two hungry bears. Children were presented with three visual sets of berries and told how many berries each bear wanted to eat; they were then asked to pick which set represented each of the number words. This task was designed to test whether children have a partial understanding of number words that they don't already know.

We found that children didn't demonstrate any understanding of number words just outside of the ones that they knew, such as "five" or "six," but they did appear to have some partial knowledge of the magnitude of larger number words, such as "nine" or "ten." Thank you to every family who participated!

Children's Early Understanding of Family Networks

Christina Steele (Graduate Student) and Ashley Thomas (Principal Investigator)

We're exploring how young children understand family relationships and social networks. From a young age, kids are surrounded by people who form their social world—like parents, grandparents, and other caregivers. This study aims to see how well 4- to 5-year-olds grasp these family connections. Do they understand who's who and how they're related, even before they can explain it?

Past studies show that young kids tend to struggle with definitions of family words like "grandmother". However, while kids may not always know these specific definitions, our study aims to see whether kids may have some early knowledge of family social networks. To find out, we ask kids who they think their parents would turn to for comfort as well as the common definitions of family words. We compare their answers with who their parents say they are close to in order to see how children's understanding of family reflects these social ties.

Ultimately, this research will help us understand how kids build their early ideas about family, which is a key part of learning about social relationships.

Which Cup do You Want to Pick?

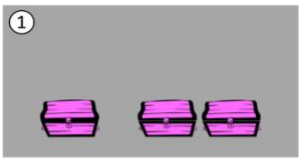
Irene Canudas Grabolosa (Postdoctoral Researcher); Kerrie Zhu (Research Assistant); Susan Carey (Principal Investigator)

In this study, we investigated children's understanding of multiple possibilities using the 3-cup task. In this task a coin is hidden in one occluded cup and another in an occluded pair. Choosing the single cup is the safer bet, but previous studies show that 3 to 4-year-olds choose from the pair almost half the time.

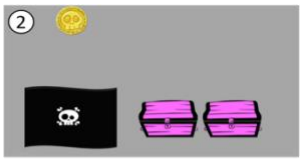
Why should younger children make an unsafe bet? Some previous research suggests that even infants have some awareness of possibilities, but that process is implicit (i.e. measured with pupil dilation, showing different reactions of infants' pupils to situations involving different possibilities). So, a possible explanation of 3-year-olds failure would be that the task of tracking and retrieving coins masks 3-year-old understanding of possibilities. Another line of studies, some coming from our lab suggests however, that children systematically cannot think of possibilities until they are around the age of four.

To help disentangle between these two competing explanations, in our study we measured pupil dilation in the standard 3-cups task, in addition to verbal responses. We compare the pupil dilations of situations where they find a coin to situations where they do not find a coin. If children have some awareness of possibility, their pupil should dilate (indicating greater surprise) when they find the single chest empty (because there's nowhere else the coin could have gone!) than when they find a chest in the pair side empty. This is the pattern we found in a group of adult controls.

We have been testing a group of 40 3- to 4-year-olds, and we're almost finished with data collection. Tentative results show that the pupil profile of adults running this task and of children seem to be very different even if they behaviorally act as adults. We are currently analyzing the data to understand what these trends tell us about their understanding of possibility!

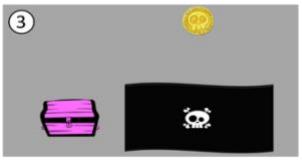


"Here, we have three new chests."
"Watch closely, here come the coins..."



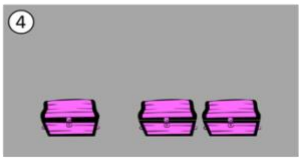
"Here comes the first coin..."

Coin falls into a chest behind the flag.



"... And here comes the second coin..."

Coin falls into a chest behind the flag.



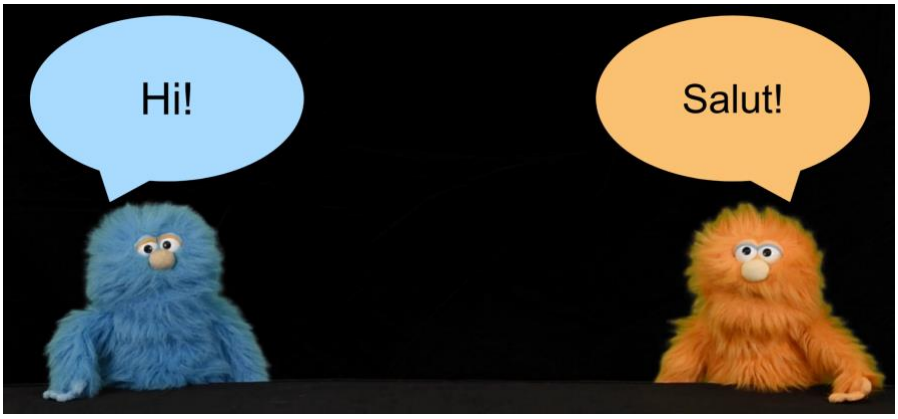
"Which chest are you really, really sure has a coin inside it?"

Do Children Prefer Speakers of the Same Language as Them?

Dhanishtha Upadhyay (Research Assistant); Christina Steele (Graduate Student); Denisse Lopéz Flores (Lab Manager); Ashley Thomas (Principal Investigator)

In this study, we are curious whether children prefer to make friends with people who speak the same language as them, and whether this is driven by wanting to have a shared language or not wanting to have different languages.

We ran this study with 4- and 5-year-olds who are primarily exposed to English (90-100% of the time). We first showed children two puppets: one who speaks in English, and one who speaks in either French or Hindi. Then we asked them which one they would like to have as their friend. After this, we told them that the puppet who speaks in a different language can also speak English (bilingual puppet) while the puppet that speaks English only speaks English (monolingual). Since both puppets speak English but one also speaks a different language, this was to determine whether children care more that their friend speaks their same language, or does not speak a different language.



We are close to completing data collection for this study. So far, we find that children tend to prefer the English-speaking puppet as their friend over the French- or Hindi-speaking ones. This is in line with previous research that children prefer to befriend speakers of their same language. When they are told that both puppets speak English but one also speaks a different language, they do not show a strong preference for either puppet. This indicates that, when using language to inform their social preferences, children favor having a shared language, but do not avoid making friends with people who also speak other languages.

Can Compositional Language Help 2.5 - 4 Year Old Children Learn New Number Words?

Lucia Vilches (Graduate Student); Cassie Liu (Research Fellow); Akshita Srinivasan (Former Graduate Student); Elizabeth Spelke (Principal Investigator)

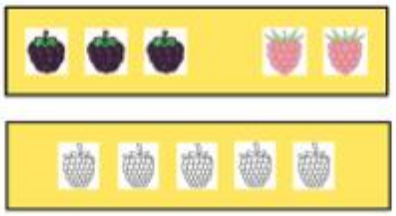
Even before school, children have capacities for mentally representing small numbers exactly (e.g., the difference between "two" and "three"), and large numbers approximately (e.g., the difference between "twenty" and "forty"). However, the question of how we create exact representations of large numbers (e.g., the difference between "twenty" and "twenty-one") remains open. In this study, we aim to test one possible answer: that compositional language (language that shows how large numbers are made up of smaller numbers) is what allows children to create exact representations of large numbers.

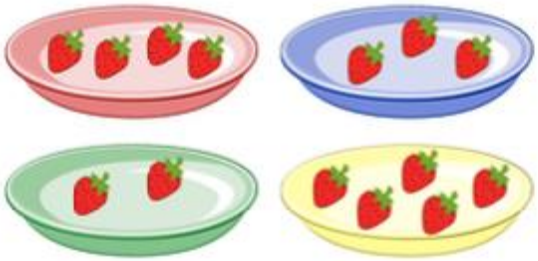
For this study, we are recruiting children ages 2.5-4.5 who speak only English at home. Each child completes a short (15-30 minute) series of activities over Zoom. First, they demonstrate their number-knowledge by picking out sets of a variety of sizes (e.g., "which of these plates has exactly five pieces of candy?") Then, they watch and interact with a demonstration in which they will be exposed to sets of either "five" or "six" objects. In this demonstration, children in the compositional group will be shown how the set of "five" or "six" can be broken down into smaller subsets (e.g., a set of "five" can be broken down into a set of "three" and a set of "two). The other half of children will be shown how the sets are made up of individual objects (control

group). After the demonstration, children will interact with sets of objects of varying sizes, to show what they have learned from the demonstration.

The first iteration of this study is complete, and we found that the children in our sample who demonstrated knowledge of numbers up to, but not beyond, “three” at the beginning of the study benefited significantly from being in the compositional group compared to the control group. However, children who only knew numbers up to one or two, and children who already knew numbers beyond three at the beginning of our study did not show such a difference: children in the compositional and control group performed equally well. This is likely because children who knew fewer numbers before training did not understand the numbers used to label subsets in our activity, and children who already knew more numbers already had a strong understanding of “five” and “six”. Therefore, the version of the activity we ran was best suited for children who know the numbers up to, but not beyond three. In a new iteration of this study, we are testing out activities that are specifically designed for children at different stages of their number-learning, such as activities that aim to teach children who know numbers up to, but not beyond, two how a set of four is made up of two groups of two.

Data collection for this project is ongoing. We are grateful to the families who have participated so far, and we look forward to sharing what we find in a future newsletter!



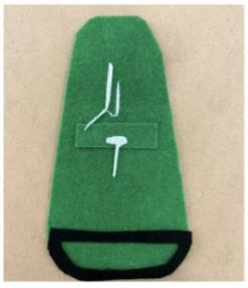


What Does it Take to Learn a Few New Words?

Kristen Gilyard (Graduate Student) and Elika Bergelson (Principal Investigator)

With this study, we are curious what helps toddlers learn new words. We know that toddlers already know a lot of common words. However, it is hard to know exactly how many times they need to experience the word before they can learn it. For example, how many times does a toddler have to experience an apple before they learn the word “apple?" 5? 50? 100? We also know that during the 2nd year of life, toddlers are improving in their word learning every day. That means 14-month-olds might need more experiences with new words to learn them than 22-month-olds, who have gained more overall word knowledge and other developmental skills, even though they are relatively close to each other in age. We also know that caregivers are a big part of toddlers’ life, and we are curious what are the differences in how caregivers interact with their toddlers.

To find out more about all of these things, in this study, we introduce 3 new words into the toddlers' environments with a picture book! We hope to better understand the differences in comprehension across 14-,18-, and 22-month-olds. Caregivers read the picture book twice a day for 2 weeks and record these shared book-reading sessions. In the recordings, caregivers of older toddlers (the 22-month-olds) tend to read for longer and go beyond the text of the book to add extra words or sentences. These extensions beyond the book included comments bringing attention to the new object's color ("This one is yellow") or connections to the toddlers' experiences ("That looks like your PJs"). From our results so far, it seems like the more extensions a parent includes during reading, the more likely their toddler is to produce these new words. After 2 weeks, caregivers and toddlers return to the lab for an eyetracking study and a short activity! These tasks both allow us to measure how well the toddlers comprehend the new words. In the eyetracking study, we show 2 images to the toddlers and play a voiceover that prompts them to look at one of the images. We then look to see where the toddlers look the most. With the activity, we have brought the objects from the book into the real world! We present a set of felt objects to the toddlers on a tray and ask them "Where is the ___?" The toddlers then help us place the object in a bucket. We have just started this new activity and are excited to see where it goes. There are a lot of competing factors that influence toddlers' choices, such as a side preference or a color preference.



This year, we have focused more on 18- and 22-month-olds. With twenty 18-month-olds and twenty 20-month-olds, we see that (1) caregivers read differently by age of their toddlers even if it's the same book, (2) some overall word comprehension of the new words such that the picture book introduced them enough times, and (3) some age differences where the 22-month-olds are looking faster and more at the prompted object than the younger toddlers. Overall, we are still seeing similar results as previous years of the study!

Additionally, we have included a survey asking caregivers of toddlers how they typically read with their children! With this survey, we found that caregivers use a lot of different strategies during shared book-reading, from labeling to counting to pointing. We look forward to learning

more about the different ways that caregivers read to toddlers. Our target is 144 toddlers in total, so we still have a way to go!

Can You Choose Who I Choose? Children's Understanding of Event Participants

Irene Canudas Grabolosa (Postdoctoral Researcher); Hanna-Sophia Shine (Lab Manager); Jesse Snedecker (Principal Investigator)

In this study, we explored how children understand events and the roles of the people involved in them. Specifically, we were interested in how abstractly children represent these events and how easily they can use those representations. For example, if they see a ballerina tapping a fireman and a skater pushing a princess, can they group the ballerina and the skater together as the "doers" of the actions?

We showed children short videos featuring two characters. In each video, one character acted upon the other—for instance, a princess poking a prince. An experimenter then systematically selected one character from each pair, either always the one performing the action (the doer) or always the one receiving the action (the receiver). After a few examples, the children were asked to make the selections themselves. We wanted to see whether they could infer the rule—"choose the doer" or "choose the receiver"—and apply it on their own.

We tested 20 children aged 4 to 5, and the results showed that they performed very well. They consistently inferred the underlying rule and generalized it to new actions and unfamiliar characters. This suggests that the concepts of doers and receivers (agents and patients) are readily accessible to children—even without language.

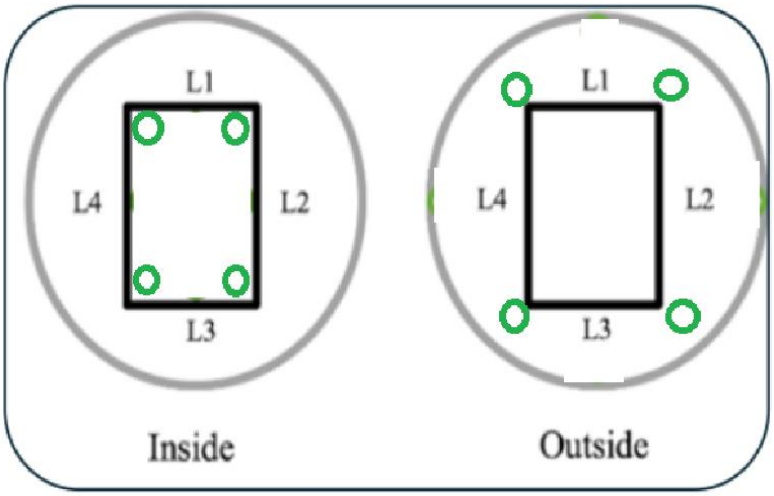
In the current phase of the project, we are investigating the origins of these abilities. To do this, we have adapted the task for a unique population: Homesigners—deaf adults who never had access to formal linguistic input, as they were not taught a sign language while growing up. This allows us to test whether language is necessary for categorizing event participants as agents and patients. We are also working on extending the task to prelinguistic infants to further explore the developmental roots of these abilities. Stay tuned for the results!

Children's Cognitive Representations of Spatial Geometries

Georgios Dougalis (Lab Manager); Ganzhen Feng (Visiting Graduate Student); Elizabeth Spelke (Principal Investigator)

A rich experimental literature has shown that when disoriented, children and non-human vertebrates can rely on the environmental geometry of their surroundings to reorient themselves. Past experiments have leveraged target locations (in relation to which reorientation could occur) that were contained by the geometric shapes in the layout (i.e., objects within the boundary of shapes), but naturalistic navigation often occurs relative to objects that are outside the available surface layout (i.e., walking to a mailbox outside a house fence). Whether children can leverage environmental geometry as a reorientation cue when their target is not contained by the layout remains unclear.

To address this gap in the literature, our experiment investigated how children retrieve a hidden object after disorientation in an environment with nested surface borders, where only the inner border is geometrically informative. We set up two experimental conditions to explore this. As shown in Figure 1, both conditions took place in a large circular room. In the inside condition, the goal was hidden in one of four containers (L1-L4) placed in the corners within a rectangular enclosure. In the outside condition, the goal was hidden in one of four containers (L1-L4) placed outside the rectangular enclosure, against the circular room's wall. Pilot data from 103 children suggest that children could successfully leverage geometric cues to reorient in the inside condition (a finding consistent with previous literature), however, they performed at chance in the outside condition, suggesting an inability to leverage geometric cues when the target object is not contained by the layout. Formal data collection is still ongoing, with 53 children tested out of our target sample size of 72.



Do Children Believe There Is a Limit to the Number of Best Friends We Can Have?

Melanie Luximon (Research Assistant); Mack Briscoe (Graduate Student); Ashley Thomas (Principal Investigator)

Imagine your best friend told you that they also had ten other best friends - how would you feel? You might be jealous or even a little sad! We know from previous work that children and adults experience friendship jealousy, and that we generally do not have unlimited numbers of best friends. However, we do not yet know how children reason about these together, especially for other people's relationships. Therefore, in this research we told 6- to 8-year-old children about characters who have different numbers of best friends, and we asked whether they thought this was possible, if it was okay, and whether the children would want to be best friends with these characters.

So far in Study 1, we have found that children think larger numbers of best friends are less possible. However, they do not indicate that having larger numbers of best friends is less okay or seem to distinguish whether they would want to be best friends with someone based on how many other best friends they have. This is in contrast with adults, who suggest a character having larger numbers of best friends is not okay and that they would not want to be best friends with them. In Study 2, we will compare how children think about best friends and friends in reference to these questions, and how children use the information about how many relationships someone has to inform their preferences. We hope this work can add to how we understand children think about and make judgements in their close relationships.

Children's Understanding of How the Word 'Not' Works

Kimi Costello (Research Assistant); Victor Gomes (Postdoctoral Researcher); Briony Waite (Graduate Student); Jesse Snedeker (Principal Investigator)

In this study, children hear parts of sentences and guess the next word. We are interested in what children predict when the word 'not' (a type of negation) appears in a sentence.

When you are understanding language, you make predictions about what is coming next. The word 'not' changes these predictions. For example, imagine on a sunny day, someone points outside and says "Look, outside it's…" The next word you predict could be *sunny* or maybe *nice.* But, if they then say "not", your prediction suddenly has to change to *rainy* or *cloudy* or *snowy*. Previous research shows that in some contexts, negation (like the word 'not' in the above

example) makes a sentence more difficult to understand. In this project, we are interested in what children predict when they hear the word ‘not.’

To test this, we are using a sentence completion task with children aged 4.5 to 6.5. Children hear the first part of sentences, spoken by Rilo the alien! Some sentences use the word ‘not’ and some don’t. We are looking at whether they can guess a correct word when ‘not’ appears in a sentence.

So far, we have collected data from a handful of kids, and we found that children are really good at guessing the last word of the sentences! They can finish sentences both with and without the word ‘not.’ Data collection has just begun, so please check back next year - we’re excited to share the final results!

Unpacking Toddlers’ Early Understandings of Groups

Mack Briscoe (Graduate Researcher); Christina Steele (Graduate Researcher); Charlston Stovall (Research Assistant); Ashley Thomas (Principal Investigator)

From a young age, we all notice and react to the groups people belong to. Whether it’s at school, work, or in our communities, we’re constantly picking up on who’s part of our “in-group” and who isn’t. Even kids are quick to notice these group dynamics. For example, research shows that children as young as 3.5 years old already expect people from their own group to support them, and they might even think it’s normal for people from other groups to be less friendly.

Interestingly, babies are also tuned into these group differences, even before they can talk. They tend to prefer people who speak the same language as their caregivers and expect people who spend time together to help each other out. For example, if three characters are playing together, babies are more likely to think that those characters will support each other during conflicts.

However, scientists are still trying to figure out exactly what babies and young children understand about groups. Are they really thinking about "groups" like adults do, or are they more focused on individual relationships? And how do they learn about new groups, especially since group memberships can be different depending on where they live?

We are currently running a study to explore whether and how babies recognize group members, specifically testing whether they expect members of the same group of shapes to act similarly

and be 'surprised' when they don't. We hope this study will show us whether babies may have early abilities just like we do as adults to recognize social groups in their world!

Can Preschoolers Track Exactly Five Objects?

Yiqiao Wang (Graduate Student); Susan Carey (Co-Principal Investigator); Elizabeth Spelke (Co-Principal Investigator)

This project aims to study the development of children's integer concepts. As adults, we know some key properties of integers. For instance, we have an exact representation of each integer so that we can distinguish each one from the others. Previous research has shown that two preverbal systems can support our exact representations of small numbers (i.e., numbers up to three or four). However, it's still an open question where the capacity to represent large, exact numbers comes from. We hope to find an answer through a case study investigating young children's representation of the number five. We chose the number five because it's where the two preverbal systems reach their limitations.

In two baseline studies, we recruited children aged from 36 to 54 months who speak English as their primary language. Each child played two games with an experimenter in a Zoom session. The first game was to measure whether children could track and represent exact numbers of objects. In this game, children saw certain numbers of stars hidden in an empty box. On half of the trials, they saw all the stars come out of the box; on the other half, they saw all but one star come out. At the end of each trial, children were asked whether all the stars had come out. The second game was to measure children's number word knowledge. Children were asked to put a certain number of objects on a plate upon hearing the number words. This game sorted children into two groups: Children who have understood how counting works and what the number word "five" means (i.e., CP-knowers) and those who haven't (i.e., Subset-knowers). We expected that CP-knowers could rely on the counting procedure to successfully track five stars, but not the subset-knowers. We found that only 30% of the CP-knowers succeeded at tracking exactly five stars and subset-knowers could not track five stars.

We think one possible reason that CP-knowers did not perform well is that they might not spontaneously deploy their resources, such as counting to track the stars. In a follow-up study, we prompted children to count the stars before they went into the box. If counting is one of the resources available to children, CP-knowers, but not subset-knowers, should perform better than those in the baseline studies. Our results so far confirmed that CP-knowers, but not subset-knowers, benefited from the counting prompt.

We also explored whether compositional capacity supports children's exact representation of five. In two follow-up studies, we chunked a set of five stars into a set of two stars and a set of three stars using spatiotemporal, linguistic, and/or color cues. If tracking a set of five by tracking a set of two and a set of three is within children's compositional capacity, we expected all children to perform better than those in the baseline studies. So far, we have failed to find evidence supporting this hypothesis. Further exploration showed that composing sets of uneven numbers may be difficult for children at this age.

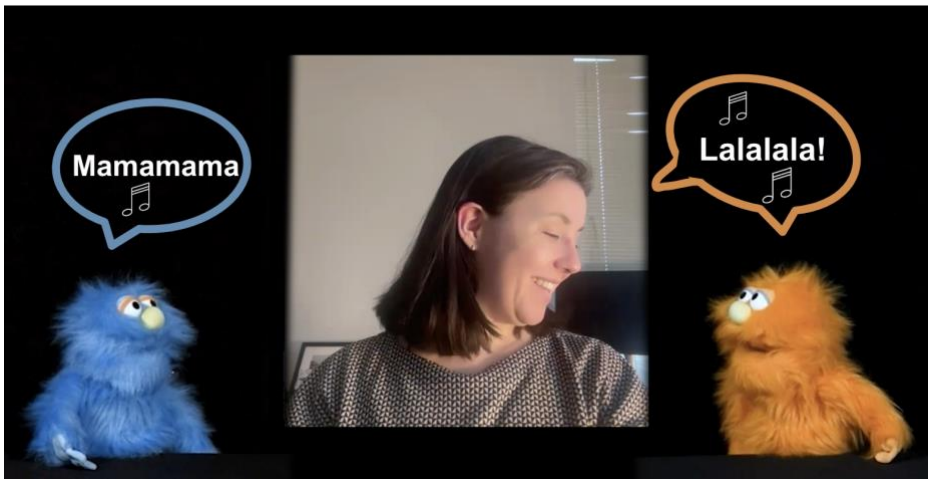
In another two follow-up studies, we explored whether understanding the tally system serves as one of the resources available to children. We provided children with fingers that are in one-to-one correspondence with stars and found that children from both groups benefited from the one-to-one correspondence cues and outperformed those in the baseline studies. However, when we provided finger tallies without one-to-one correspondence cues, children in both groups performed no better than those in the baseline studies.

How do Children use Language and Their Caregivers' Interactions to Inform Social Preferences?

Dhanishtha Upadhyay (Research Assistant); Christina M. Steele (Graduate Student); Denisse Lopéz Flores (Lab Manager); Ashley Thomas (Principal Investigator)

From previous studies, we know that children prefer to befriend people who speak the same language as them. However, language is not the only thing children use to guide their social preferences. Previous research also shows that infants tend to prefer strangers that their caregiver interacted with positively over strangers their caregiver did not interact with. In this study, we are curious whether children will prefer to befriend someone that speaks the same language as them, or whether they prefer someone their caregiver shows a preference for.

We ran this study with 4- and 5-year-olds who are primarily exposed to English (90-100% of the time). We started by showing children two puppets: one that speaks in English and one that speaks in either French or Hindi. Next, we showed them a video of their own caregiver (which we requested parents to send us before their appointment) edited to look like they are interacting with the two puppets. We tell a story about how their caregiver is "super close best friends" with the puppet that speaks a different language, while they do not know the English-speaking puppet too well. The video shows both puppets singing a tune to the caregiver, and the caregiver imitates the tune of their "friend" but not of the stranger. This is because imitation is seen by children as an indication of social closeness. After showing this, we asked children which puppet they would like as their friend; the one that speaks their language, or the one that speaks a different language but that their parents prefer.



This study is still collecting data, so please check for results next year! Thank you for your support with our research, and we hope to see you again soon!

Form-Based Prediction Among Bilingual Kids During Code-Switching

Yuhui Huang (Graduate Student); Chris Miyai (Research Assistant); Jesse Snedeker (Principal Investigator)

While research with adult monolinguals has demonstrated robust form-based prediction—such as anticipating specific English words during language comprehension—there is still limited understanding of how bilinguals engage in similar predictive processes. In particular, very little is known about young bilinguals' ability to predict specific upcoming words, whether in their dominant language or across both languages, especially during naturalistic interactions like story time. To address these gaps, our project examines the developmental changes in form-based prediction among bilinguals, with special attention to comprehension in code-switching contexts involving typologically distant language pairs.

To test this, we are using electroencephalography (EEG). This tool allows us to measure changes in the electrical activity on someone's scalp in real-time! We are currently at the piloting stage for this study, but we look forward to telling you more about our findings next year!

Infant's Sensitivity to Others' Perspectives on Objects the Words for Which They Do Not Know

Georgios Dougalis (Lab Manager) and Elizabeth Spelke (Principal Investigator)

Previous studies have shown that preverbal infants as young as 6 months may understand the meanings of various nouns used by others in their communicative environment, even though they themselves do not use them to communicate. Contrastingly, previous studies have shown that though infants are exposed to adjectives at similar rates, they show no evidence of understanding them until after 18 months of age.

Leveraging this disparity, our experiment aims to investigate a potential mechanism that enables infants to learn the meaning of novel words: taking the perspective of others in their communicative environment. Infants are shown 4 counterbalanced pre-recorded videos in which an actor sits between two sets of objects, either a book and a shoe or a dog (plushie) and a ball. The actor identifies each object by facing it and saying, "this is a [insert identifier]", using either corresponding color adjectives or object nouns. Our outcome measure is looking time at either of the two objects, with preferential looking at the actor's desired object being taken as evidence for the infant attending to said object by virtue of accommodating the actor's perspective on the world.

Pilot data from 7 infants revealed that babies would accommodate the actor's perspective when that was articulated in reference to object nouns, but not when it was articulated in reference to color adjectives. We have collected formal data from 108 infants, but further testing is necessary to power the requisite analyses.

Do Children Infer Closer Relationships from Rarer Actions?

Mack Briscoe (Graduate Student); Min Feldman (Research Assistant); Ashley Thomas (Principal Investigator)

We reserve certain actions for the people we are closest to: for example, we are willing to shake hands with many but only hold hands with a few. We can also expect that two people who are holding hands are likely to be in a closer relationship. In this research, we are interested in whether children use the rarity of a social action (like hand holding) to infer who is in a close relationship.

To test this, we introduced children 4-8 years old to novel characters in a park. A central character encounters and greets others in the community, each time performing a novel greeting action (e.g., toe tapping and hip bumping). In most interactions, the characters greet each other in

the same way (e.g., they tap toes). In one interaction, the characters greet each other in a different way (e.g., they bump hips). We then ask children 1) which action is done with best friends, and 2) whether they would prefer to befriend somebody who performs the common action with most others or the rare action with most others.

This study is currently collecting data on Children Helping Science/Lookit and we plan to conduct a follow-up study shortly investigating sound-based greetings rather than touch-based greetings. Our preliminary data suggests children do tend to use the rare action to identify best friendships and are not yet showing a clear preference for either type of friend. We look forward to sharing results as they come in!

Does Understanding Other People's Pointing Unlock Word Learning for Young Babies?

Lilliana Righter (Lab Manager); Sophie Schoenbohm (Lab Manager); Elika Bergelson (Principal Investigator)

We see that children undergo a "word comprehension boost" around 12 to 14 months old, on average. We want to know what other skills kids might need to develop to hit this word boost. Past research has found that there is a relationship between young babies' ability to understand adults' pointing and their later vocabulary. We are investigating how strong that relationship is and if learning what someone's trying to tell you when they point at something is also the main skill that helps you figure out words faster.

In this study, we play three games and do an eyetracking study. In one super quick game, we point towards fun stuffed animals around our room and just see if the baby will look towards the animal we're pointing at. Almost all babies in this age range do this, easy peasy! Then it gets a little harder: we play a game where we need babies to guess something about what we're trying to tell them with a point. We have two boxes, covered with curtains. We show the baby a really cool toy we want to play with, and then, putting our hands under the table, we hide the toy in one of the boxes! We ask the baby to find the toy, and we point to the box where it is hidden. If a baby is able to understand points, they will pull the curtain off the box we're pointing towards and find the hidden toy, and get to play with it.

The last game and our eyetracking study are two ways that we measure if a child has reached the word comprehension boost. In our game, we're trying to fill up a gift bag for our friends. We have a set of soft felt objects that look like common things: a bottle of milk, a car, a sock, a stroller, a banana, and a baby. We put two objects at a time on a tray and ask the baby, "Pick up

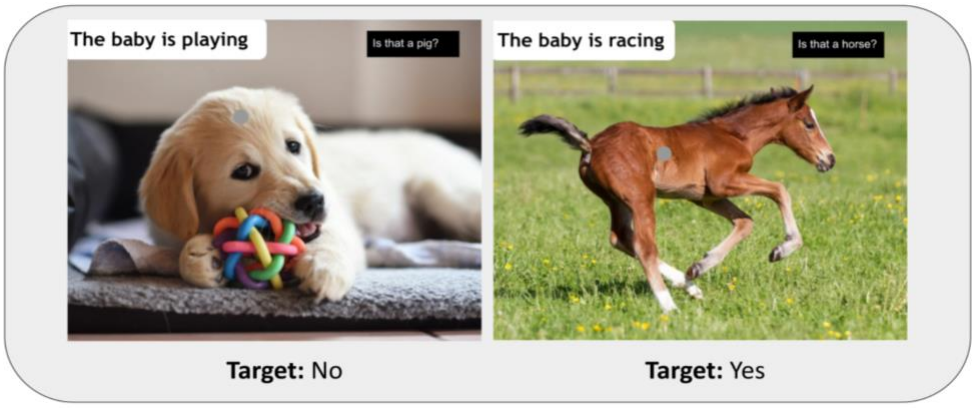
the banana!" We have them put whatever shape they pick up into the bag. The eyetracking study is very similar, but instead of felt shapes they have to pick up, we put two pictures on the screen and see where they spend the most time looking. The felt game is a new method that we are trying out as a new way to assess word learning. We aren't sure if it clearly tells us about babies' word knowledge– we think we are seeing some effects of kids being right- or left-handed, and being more drawn to play with some objects than others, even if they know all the words. Our pilot sample showed that kids who know more words tend to be better at point comprehension and that kids get better at point comprehension right around 12 months old, which is promising! We started data collection for this study this year and, once complete, we can investigate whether point comprehension independently contributes to the word boost!

Additionally, when we play these games with babies in the lab, it gives us an idea of their language knowledge at one very specific point in time. This year, we wanted to test how these skills evolve in the same baby over a longer period. To do this, instead of just playing these games with babies one time, we play these games in the lab together every two weeks for about six months! We've just started data collection in full for both of these studies - so look out for new results next year!

When do Children Start to Use "No" Logically?

Hsi-Er Liu (Research Assistant); Victor Gomes (Postdoctoral Researcher); Jesse Snedeker (Principal Investigator)

The development from simple "no" to logical "not" reveals fascinating insights into early childhood logical reasoning. Children typically start saying "no" in simple ways, like rejecting something they don't want ("no veggies!") or describing something that no longer exists ("no more juice"). Eventually, "no" takes on a more complex meaning that requires determining whether a statement is true or false, similar to "not". For example, saying "no" when someone calls a pig a dog has an equivalent meaning to "it is not a dog". In this study, we are investigating when children begin to use "no" in a logical way. In particular, we examine how 16- to 28-month-olds respond to accurate ("Is that a horse?") and inaccurate yes/no questions ("Is that a dog?" while pointing to a pig) embedded in storybooks read aloud by their caregivers. This age range is especially interesting because children can understand questions but have not started saying "no" or "not" yet. By examining their verbal responses, nonverbal behaviors, and how caregivers ask the questions, we hope to understand how children come to say "no". We just finished piloting this study and will begin full data collection soon!



Do Children Expect Emotional Consolation to Occur in Close Relationships?

Emma Yu (Lab Manager); Audrey King (Research Assistant); Kana Tsuruta (Research Assistant); Ashley Thomas (Principal Investigator)

In this experiment, we are interested in whether 6- to 8-year-old children expect emotional consolation to occur in close social relationships.

In Study 1, we showed kids four stories about a protagonist (Riley) feeling sad or okay after experiencing a hardship. One character (Sam) hugs Riley when she is sad and ignores Riley when she is okay. The other character (Alex) hugs Riley when she is okay but ignores Riley when she is sad. We asked kids who is better friends with Riley, how likely Riley is to share a secret with each character, and who Riley would hug first if the roles were reversed. We found that 6-8 year olds see emotional consolation during distress as a cue for social closeness (they believed Sam was closer to Riley than Alex).

In Study 2, we are interested in whether children think best friends and friends are more obligated to help than strangers. We are also interested in whether children differentiate emotional consolation (giving a hug) from instrumental help (fixing the fallen block tower). Data collection is in progress, and we are excited to share more findings in the future!

Prediction in Children with and Without Autism

Tanya Levari (Postdoctoral Researcher); Briony Waite (Graduate Student); Hanna-Sophia Shine (Lab Manager); Jesse Snedeker (Principal Investigator)

In this study, your child played many games, both in-person and on Zoom. For example, we asked your child to find smiley faces among pictures of real faces, tap along to a beat, and listen to a story! For some of the games, they were set up for an electroencephalogram (EEG) recording, and we recorded their brain responses while they completed different tasks.

These games might not have seemed connected, but we think they will help us understand different aspects of prediction; how do our brains find patterns in the world and how do we use those patterns to anticipate what we might experience next! In this study we are interested in seeing if there are differences in how children with and without autism make predictions.

For example, in one game, your child was asked to first listen and then tap along to sequences of sounds. This sequence of sounds had a predictable pattern but occasionally a sound was either omitted or delayed - breaking the pattern. By seeing your child's brain responses to these different errors, we can get an understanding of the kind of information being used to make predictions and how such predictions are updated when something new happens.

Your child also listened to a story while we recorded their brain activity. We are looking at the brain's response to each word in the story to see whether children's brain waves, like those of adults, are sensitive to various word features, such as frequency and predictability. This helps us understand linguistic prediction. 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 was "kite", but you would be very surprised if 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".

Our data so far has shown both similarities and differences in the way that children with and without autism predict information. Preliminary results suggest that children with autism rely less on discourse information when predicting upcoming words during naturalistic listening. Although data collection is ongoing, follow-up analyses thus far suggest that this is unlikely to be due to differences in language ability. Instead, children with autism may rely less on the preceding context (so the information conveyed in the prior sentence or sentences) or make different linguistic predictions than their neurotypical peers. Stay tuned for more results next year! We loved seeing families in person for this study. Thank you so much for participating!

How Children Think About 'Grandmothers'

Paola Lee-Vega (Thesis Student); Christina Steele (Graduate Student); Ashley Thomas (Principal Investigator)

Despite the importance of family during early life, family words are challenging for children. In this project, we tested whether children were better able to understand the term “grandmother” with supporting information.

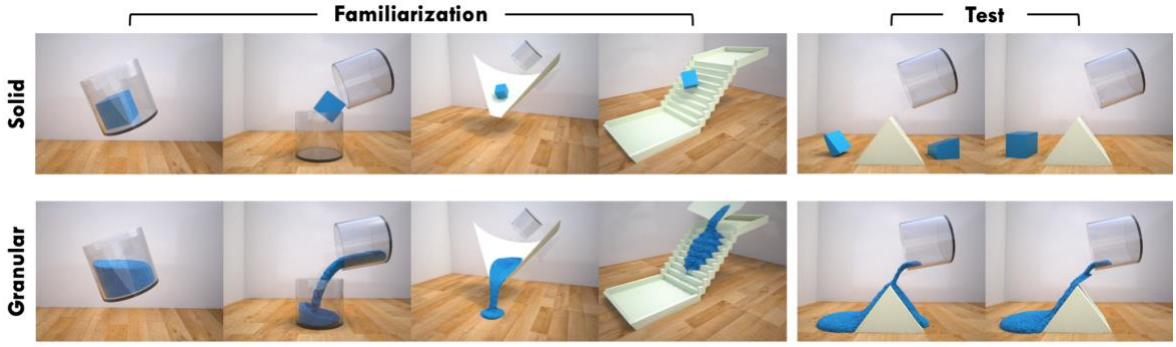
Children were presented with the 2 sets of images seen below, each image representing a family, and told what the definition of a grandmother was. For the first set of images, they were told the relative ages of the characters (who is older than who, or whether they were the same age). For the second set of images, they were told about the relationships between the individuals (who is the mom of who, or whether the two ladies are sisters). For each individual image, children were asked whether they believed there was a grandmother present. We asked a total of 50, 4–5-year-olds and found that children seem to be relying mostly on old age, rather than on information about who is the mom of who, when making determinations about who is a grandma.

Set 1 *Set 2*

We are currently in the process of designing a follow-up study, which will follow a similar structure, but test the understanding of the concept “grandparent” more broadly. This time, we will show children how different members of the family are connected and how those connections make a particular member of the family a grandparent. We are curious about whether learning this information will affect their answers. We look forward to sharing the results of this follow-up study next year!

Exploring How Babies Understand Solids and Non-Solids

Sanghee Song (Visiting Postgraduate Research Fellow); Vivian Paulun (Postdoctoral Researcher); Elizabeth Spelke (Principal Investigator)



These are still images from videos showing solid objects (top row) and soft, grainy stuff (bottom row). The videos include four familiarization events and two test events. Babies watched these videos and also versions where the objects moved the other way (left to right).

From past research, we know babies tend to look longer at things that surprise them. For instance, in our pilot studies, when shown a solid object that splits in an unexpected way, babies often stare longer, as if they're thinking, "That's not supposed to happen!" This tells us that very young babies have expectations about solid objects to stay whole.

But what about things that aren't solid, like sand or jelly? Do babies expect these to behave like solids? If they do, they'll be surprised when these substances split apart. If they understand that non-solid materials behave differently, they might not be surprised—and might even find it strange if these materials don't split.

We're investigating this by studying two age groups of babies. Our big question is this: *Do babies expect solids and non-solids to act differently?* If they do, this will open up new insights into how babies make sense of the physical world early in life.

We're halfway through data collection, with around 100 participants so far. Each condition will have 24 babies, divided evenly across age and substance groups, using four different scripts to keep the study balanced.

We're excited to continue gathering data and can't wait to share what we learn about how babies perceive the world around them.

Social Engagement Leads Babies to Represent People as Individuals

Brandon Woo (Former Postdoctoral Researcher); Haowei Peng (Research Assistant): Christina Steele (Graduate Student); Ashley Thomas, (Principal Investigator)

Past research has found that young babies don't readily represent different kinds of objects (e.g., a duck vs. a ball). Here, we find evidence that young babies nevertheless readily represent the different identities of people, so long as those people are socially engaging: smiling, making eye contact, and speaking in an enthusiastic tone. We've posted a conference proceedings paper here: https://osf.io/preprints/psyarxiv/en52x_v1

How do Children Order Temporally Ambiguous Events and States?

Elena Marx (Visiting Graduate Student); Hanna-Sophia Shine (Lab Manager); Yasmine Frojmovic (Research Assistant); Maxine Bailey (Research Assistant); Eva Wittenberg (Co-Principal Investigator); Jesse Snedeker (Co-Principal Investigator)

In a sentence like "*The girl **fed** the rabbit that **hopped** to the fence",* what happened first? Did the girl feed the rabbit before or after it hopped to the fence? Given that linguistic descriptions often lack explicit information about the sequential order between situations, the question is: what factors determine how complex temporal structures are mapped onto linguistic form?

This study examines how children comprehend the temporal order of ambiguous events. While prior work has focused on the influence of pragmatics (i.e., the influence of context on the interpretation/understanding of language) and syntax (i.e., the influence of sentence structure on the interpretation/understanding of language) on the comprehension of temporal order, the current study is exploring the influence of event cognition. Specifically, how do perceptions of temporal order shift when presented with events and states?

(1) eventive MC – stative RC
*Tiger **danced** next to the wagon that Sheep **sat** on*

(2) stative MC – eventive RC
*Tiger **sat** next to the wagon that Sheep **danced** on*

Previous research on language comprehension has shown that adults have a strong tendency to temporally order states before events. In this experiment, we ask how this tendency takes shape during development. While data collection is ongoing, we have some preliminary results to share! So far, it looks like children also have a tendency to temporally order states before events. Specifically, when a sentence introduced a state and then an event children preferred to enact it using that linear order (see sentence 2). But when a sentence started with an event and then had a state, they reversed the order and enacted the state first (even though it came second in the sentence, see sentence 1). We are wrapping up data collection this summer; we look forward to giving a final update about this next year!

Early Understanding of Parent-Child and Other Caregiving Relationships

Christina Steele (Graduate Student); Denis Tatone (Postdoctoral Researcher); Ashley Thomas (Principal Investigator)

Every day, we recognize social relationships and use knowledge about social relationships to inform our behavior. We act to maintain our existing relationships, create new ones, and change the ones we have. For example, we recognize that it is acceptable to eat off our spouse's plate, but unacceptable to eat off our employer's plate. We may laugh at our boss's joke to maintain our deferential relationship or do a favor for a coworker to maintain a cooperative one. We might bring a rose to a friend to create a new intimate relationship or advocate to incorporate voting to change our book club into a democracy. While scholars in Anthropology, Sociology, and related fields have long studied the structure and nature of social relationships, relatively little is known about how these behaviors arise from cognitive processes in individual minds, especially in babies and young children. Babies are born into complex social networks made up of many relationships.

The most relevant and common relationships in a baby's social network are caregiving relationships. These can be with parents, older siblings, teachers, grandparents, babysitters, nannies, etc. Even when a baby's social network expands, caregiving relationships dominate the social experience of young humans throughout early childhood. Compared to most other species, human babies are more dependent and interact with a greater number of caregivers. Accordingly, the ability to recognize caregiving relationships may be particularly useful for humans. We are currently running a study to investigate how and whether babies and young children represent caregiving relationships, specifically testing whether they use physical (e.g., size) and social cues (e.g., touch) to make predictions about response to distress and food requests.
So far, we have found that babies and kids appear to expect characters who are bigger and have a close relationship with a smaller character to comfort the smaller character when it is in distress. This tells us that babies and young children may have early abilities to recognize social relationships (e.g., caregiving) important for their survival.

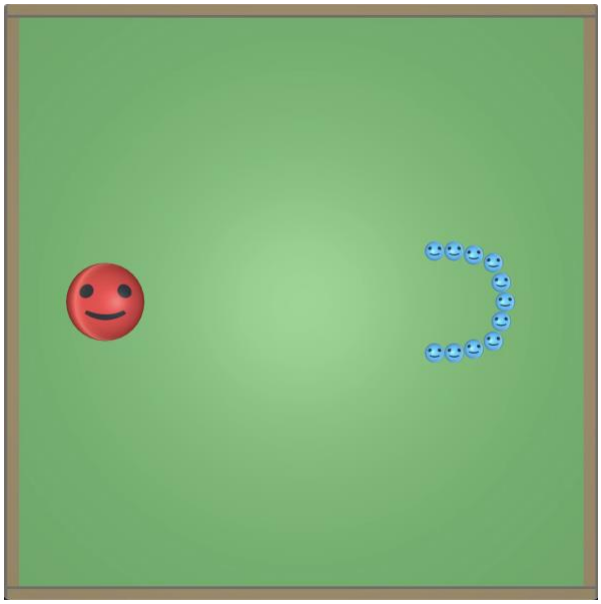
“Some” and “All” in Infancy

Irene Canudas Grabolosa (Postdoctoral Researcher); Maxine Bailey (Research Assistant); Gennaro Chierchia (Co-Principal Investigator); Susan Carey (Co-Principal Investigator)

The aim of our study was to investigate whether young children can understand logical concepts before they can verbally express them. Specifically, we sought to determine if they could differentiate between the concepts of "some" and "all."

To achieve this goal, we recruited 20 participants aged 11-13 months. Using an eye-tracking machine to record where and for how long they looked, we showed them a series of videos where a large ball collided with a group of small balls, causing all of the small balls to explode. We continued to show these videos until the children lost interest. Then, we presented a new video where only *some of* the small balls exploded, instead of all of them. If the child could differentiate between "some" and "all," they would find the new video more interesting and show renewed attention.

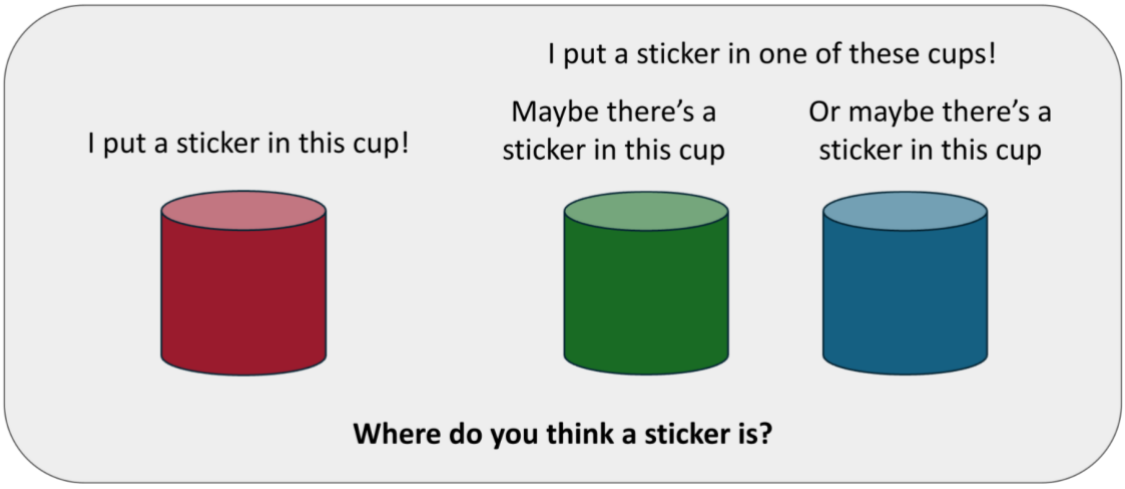
Our results indicate that children didn't look longer at the "some" videos, and their pupils did also not react to the difference in the videos, which suggests they did not track the difference between these concepts.



Can Children Think About Possibilities?

Victor Gomes (Postdoctoral Researcher); Hsi-Er Liu (Research Assistant); Jesse Snedeker (Principal Investigator)

The cookie could be in the jar or in the box! Where could the cookie be? Past research shows that children around the age of 3 don't think both places are possible at the same time. Instead, they seem to think the cookie can only be in one place, such as the jar, and only consider other locations after checking the jar and finding it empty. Similarly, in experiments where participants see a toy is placed into one cup (cup A) and another toy placed behind a screen into one of two cups (cup B or C), adult participants always pick cup A because we know for sure there is a toy there, but 3- and 4-year old participants pick cup A only half the time. How come? One explanation is that children struggle to separate possibility from certainty. Instead of thinking both cup B and C are possible, they think either cup is just as certain to contain the toy as cup A. However, it is also possible that their inability to consider possibility is specific to this task, where visually tracking objects makes it hard to consider both cup B and C as possible. In this study, we are interested in whether children can think about possibilities when we remove the challenge of tracking objects and focus on language alone, such as by saying "maybe it's in this cup!" At this age, children also begin using words that refer to possibility, like "maybe", but do they understand them the way adults do?



To find out, we play a fun sticker-finding game, where children have to listen carefully to what the researcher says to find animal stickers. For our test trials, the researcher will introduce a single cup ("I put a sticker in this cup") and a pair of cups ("I put a sticker in one of these cups"). If children can think about possibilities (like us!), they will choose the single cup because the single cup is certain and the other two are uncertain. If children cannot think about possibilities, they will choose either the single cup or one from the pair because both options are certain to them. We are currently piloting this study, and we look forward to sharing our results soon!

What Should Change? How Children Think Groups Should Redistribute Power

Mack Briscoe (Graduate Student) and Ashley Thomas (Principal Investigator)

In this project, we are interested in how children think about addressing power imbalances between groups. In the study, we told 6–8-year-old children short stories about two different groups of people living on an island, sharing a limited amount of food. Children were also told that one of these groups was in charge. There were two different versions of the study. In one version, the group that was in charge of splitting up the food did so unfairly, giving more to themselves and less to others. In the other version, the group that was in charge split up the food equally between themselves and the other group. At the end of the story, we told children that the people on the island could change the way they decided who got what. We asked them how they thought things should change: should they make it so that the same group, the other group or both groups were in charge? We found that children initially preferred to make both groups in charge, regardless of whether the previous group split the food up equally or unequally. However, as children gained additional experience with new groups, they preferred to have only

one group in charge rather than both. Currently, we are running new studies to try to understand why children switched their preferences.

How Do Babies Understand Language So Quickly?

Jasenia Hartman (Postdoctoral Researcher) and Elika Bergelson (Principal Investigator)

Humans are great at predicting what others will say. We often finish each other's sentences! This is possible because we use the structure and rhythm of language to anticipate upcoming words, which helps us understand speech more quickly. For example, when someone says, "I'm going to the ___," we expect the next word to be a noun, like "store" or "park." We also listen for changes in pitch to know which words are most important.

Research shows that even babies as young as 18 months can pick up on these patterns. In fact, they even use them to process language faster! Our study explores how early this ability begins and how it develops over time.

To investigate, we are working with babies between 10 and 16 months old. During the study, babies see two familiar objects on a screen while hearing a sentence that names one of them. Sometimes the sentence follows the typical English rules, like "Look at the dog", where the determiner precedes the noun. Other times, we changed the sentence — using a made-up word instead of "the" or muffling the sentence, so only the rhythm remained.

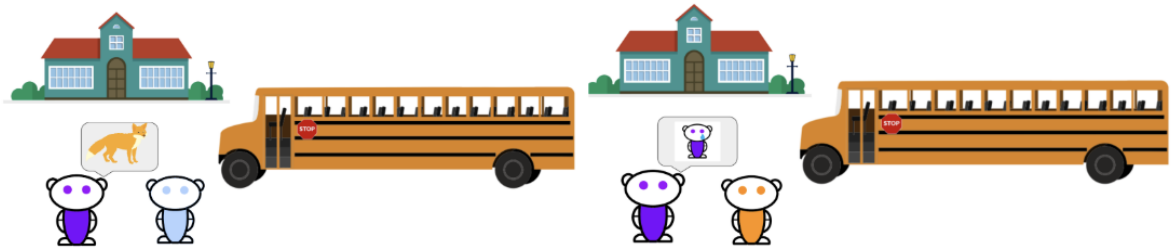
By comparing how babies respond to these different sentence types, we can better understand what cues they use — like grammar or rhythm — to recognize words faster. Thank you for helping us learn more about how language learning begins!

Children's Expectations about Telling Emotions to People Who Are Close

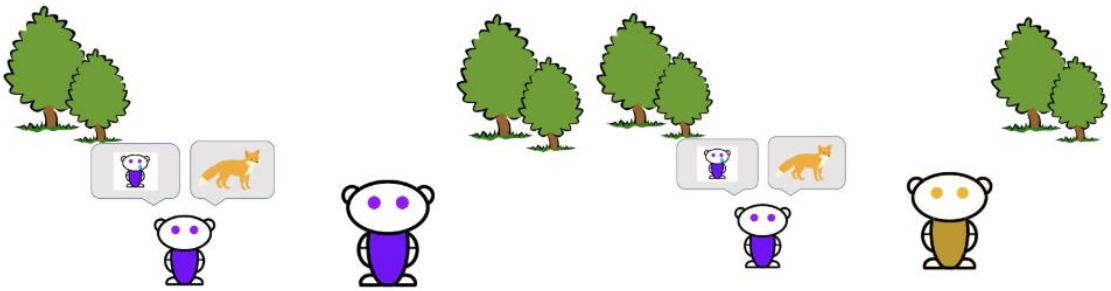
Megan Richardson (Research Assistant) and Ashley Thomas (Principal Investigator)

If you are feeling sad, would you tell your best friend or an acquaintance? Most adults would prefer to tell their emotions to someone who is close over someone who is not. In this study, we wanted to see if 6-9-year-old children had similar thoughts about disclosing emotions in close relationships.

We told children a story about a character who learns a fact in school and also feels happy. In a separate story, we talked about a different character who also learns a fact in school, but this child is feeling sad. In each story, the character encounters two classmates and tells one about the fact and the other about how they are feeling. We asked children which classmate they thought was a better friend, and which classmate they thought the main character would be most likely to share a single ice cream cone (which requires an action that signals social closeness) and candy (which does not require close social action). Children chose the classmate who was told the sad emotion over the classmate who was told the fact to be a better friend and most likely to share a single ice cream cone but did not think the same when the main character was feeling happy. Children did not have expectations about who the main character would share candy with.



Next, we told children that the main character sees their mother and a friend's mother. We asked children if the main character would tell each person about the fact or how they are feeling. Children expected that the main character would tell sad emotions to their mother and not their friend's mother, but did not expect happy emotions to be told to their mother or the friend's mother. Finally, we told children that the main character met someone new who they wanted to become friends with and asked children if the main character would tell the new character the fact or how they are feeling in order to achieve this goal. Children did not think that telling emotions, regardless of whether they were happy or sad, was a good way to create a new relationship. In sum, children expect sad but not happy emotions to be told in close relationships.



We conducted a follow-up study that had the same story structure as the previous study. In a new story, we told children that the main character sees their friend and their best friend. Then we asked children if the main character would tell each of them the fact that they learned or how

they are feeling. Children showed the trend of expecting sad and happy emotions to be told to a best friend over a friend, but the evidence is not strong. Next, we told children that the main character saw their mother and a friend's mother who were feeling the same emotion as the main character, and learned a fact at work. We asked children if the mother or the friend's mother would tell the fact or how they are feeling to the main character. Children did not expect the main character's mother or the friend's mother to disclose happy or sad emotions over the fact to the main character. Finally, we told children that the main character saw a friend at the playground with whom they wanted to become best friends. We asked children if the main character would tell the fact or how they are feeling in order to become closer to this friend. Children did not think that disclosing happy or sad emotions would achieve this goal. Conclusively, these studies helped us to further understand how children think about disclosing emotions in different relationships.

Funny Moves in Funny Paths. Children's Understanding of Event Dimensions

Irene Canudas Grabolosa (Postdoctoral Researcher); Maxine Bailey (Research Assistant); Vandita Gupta (Summer Intern); Jesse Snedeker (Principal Investigator)

In this study, we aim to explore how children comprehend different aspects of motion events. Specifically, we're focusing on two key dimensions: **manner** (the way in which something moves) and **path** (the trajectory it follows).

To investigate how abstractly children think about these dimensions, we designed a game for 5.5- to 7.5-year-olds. In this game, children watched a series of videos featuring figurines that either move in different ways while following the same path (keeping the path constant but varying the manner) or move in the same way while following different paths (keeping the manner constant but varying the path). After these videos, children were presented new two videos, one keeping manner and the other path stable, and were asked to pick the correct one.

The goal of this game is to determine if children can abstractly differentiate between manner and path. If they can, we expect them to recognize patterns—such as always keeping the path constant while varying the manner—and therefore show a preference for choosing one video versus the other.

So far, we've tested 20 children in this game, and interim results seem to show that children are quite good at being able to pick on the rule (either keeping manner stable or path stable) and use it to infer the right videos to pick throughout the task. Stay tuned for more exciting results!

How Long Should We Talk It Out? How Children Think About Consensus

Mack Briscoe (Graduate Student) and Ashley Thomas (Principal Investigator)

In this project, we are interested in whether children are more optimistic than adults on the ability of groups to reach consensus. In the study, we told 6-8-year-old children about a group of people deciding on where to have their big yearly party. We tell kids that the people in the group all disagree on where to have it, and that they can either talk about it or just do what they did last year. Here, we are interested in how many times children say that the group should continue to talk things through, despite their lack of agreement. This study is still in its earliest stages, so we don't have the full picture yet. However, we currently expect that children will say that the group should continue to talk it out more often than adults.

Find Sound: A Game-Based Intervention to Improve Children's Reading Skills

Gianna Zades (Research Assistant); Akshita Srinivasan (Former Graduate Student); Cristina Sarmiento (Former Lab Manager), Ayana Lomas (Former Research Assistant); Isminur Yilar (Former Research Assistant); Elizabeth Spelke (Principal Investigator)

Reading is an essential skill that helps children grow intellectually and better understand the world around them as they learn to decipher both sound and meaning in written language from a young age. Reading broadens a child's horizons, as readers of both fiction and factual texts discover and explore physical, cultural, and social worlds beyond their immediate experience. Learning to read is a process that formally starts in kindergarten and continues through early elementary school. Previous research has shown that early reading skill is a predictor of children's success in the rest of their education. In order to help support children's reading acquisition at home, we developed a fun game that focuses on teaching the different sound properties of words including rhyme, alliteration, and syllables. We ran our study initially in 2022-2023 and have revised it to a slightly modified version where we tested children in kindergarten, not just the age in kindergarten.

Our study tested the effectiveness of this reading game by comparing it to a similar game in the domain of geometry. We evaluated the extent to which these games improved kindergarten (5-6.5 years) children's school-relevant reading and geometry skills in the short term. The geometry game, "Find Shape," and the reading game, "Find Sound," are played as a game of war, where children are asked to find which shape or word belongs in a group based on its geometric or sound properties. Each participant was sent one of the games to their home. The study involved two remote zoom sessions that were about 45-60 minutes long and at-home gameplay for about 2-3 weeks in between the two sessions. In the first session, we asked children questions on the computer about reading and geometry and then another researcher taught the child and parent how to play the game. Then, parents were asked to engage in at-home gameplay with their child on 8 separate occasions. Finally, in the second zoom session the child and parent played one more round of the game and then a researcher asked the child more questions related to geometry and reading. Previous preliminary results indicated that children who played Find Sound did not show significant improvements in their reading scores compared to children who played Find Shape, though the results were trending in the direction that favored children who played Find Sound. The previous preliminary data also indicated that, in comparison to those who played Find Sound, children who played Find Shape showed significant improvements in one set of geometry skills that were directly trained in the game and tested in the assessments. We are still in the process of analyzing the data from this last round of testing. We also received qualitative data from participating children and their families regarding the duration and difficulty of the games in addition to their feedback on how the games might be adapted and improved based on their experiences playing them at home. This research evaluated the effectiveness of two home-based educational interventions with the aim of improving children's school relevant skills in the short term and the hope of fostering their subsequent learning in school.

The outcomes of this work are extremely useful as we continue to develop and test educational interventions that can support the success of young children. Figure 1: Find Sound is played with two players. Each player has their own deck. For each card, the child must find the answer on the

bottom (blue, red, or green) that matches the symbol or word represented by an image on top. Once the players have determined the correct answer, the player whose card has borders that are the same color of the correct answer gets to keep both player's cards in their 'winning pile.' After repeating for each card in a deck, the player with the most cards in their winning pile wins.