



Lab for Developmental Studies



at Harvard University

NEWSLETTER 2010



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SYSTEMS of GEOMETRIC KNOWLEDGE

Sang-Ah Lee, Post-doc

Geometry was thought by the ancient philosophers to be one of the purest forms of human knowledge. However, research in cognitive development has shown that abstract Euclidean geometric concepts may be constructed in childhood, partly from cognitive systems specialized for navigation and partly from cognitive systems specialized for object shape recognition. Several ongoing experiments in our lab are exploring this question of young children's use of geometry in various types of tasks.



In one line of studies, we are using a small table-top apparatus to determine what geometric properties children can use to remember spatial locations on a small table-top apparatus. So far we have found that in this non-navigational task, while 3-year-old children are adept at using angles, distances between points, and lengths of surfaces, they do not use directional relationships to distinguish mirror-images from one another.

A second line of studies investigated children's use of geometry navigating in large-scale geometric environments. In one of these navigational tasks, we found that while children can consistently reorient using distances, and sense relations within the 3D environmental terrain, they do not use angle (i.e., the measure of the corners at which two surfaces meet) to remember locations and reorient themselves.

In another navigational task, we are investigating whether we can induce an illusion of distance using relative size differences of 2D patterns on the wall. Using a small, slightly rectangular room with two opposite walls covered in large dots and two walls covered in small dots, we are testing whether children's searches are guided by the perceived shape of the room by either cancelling out or amplifying its rectangularity using the arrangement of dots. We are testing this geometric hypothesis against an alternative – the use of image-matching (i.e., remembering the correct corner by taking a mental snapshot of the location with the smaller dots on the left and the larger dots on the right, for example). Data collection is still on-going, but we look forward to sharing the results with you in the next newsletter!



HIDDEN CAUSES and CONSEQUENTS in VERBS

Josh Hartschorne, Graduate Student

Consider the following sentences:

Dora frightens D.W. because she is silly.

Dora fears D.W. because she is silly.

The pronoun “she” is ambiguous in both sentences. Nonetheless, most people have the intuition that “she is silly” refers to Dora in the first sentence and D.W. in the second sentence. Swap out the verbs “frighten” and “fear” for other verbs, and similar effects are noticed: sometimes the ambiguous pronoun “she” seems to refer to the subject of the verb, and sometimes to the object. This was discovered by Alfonso Caramazza (now a professor at Harvard) and Catherine Garvey over 35 years ago. However, it is a strange phenomenon still not completely understood.

More recently, several researchers discovered that a slight change in those sentences completely changes the effect:

Because Dora frightens D.W., she is gonna have trouble being friends.

Because Dora fears D.W., she is gonna have trouble being friends.

Here, and in contrast to the first pair of sentences, most people think that “she” is more likely to refer to Dora in the second sentence than in the first. Careful experimentation has shown that this difference is due to moving the word “because,” and not due to the different endings of the first and second pair of sentences.

Over the last three years, we have found that 5-year-

old children behave very much like adults in how they interpret pronouns in such sentences. We tested 5-year-olds because they are the youngest children who fully understand the meanings of the verbs that seem to drive this effect. The experiment involved hearing sentences

D.W. likes Dora very much, because she is such a nice girl. Can you point to her?



like “Dora frightens Susan because she is silly. Can you point to her?” while looking at a picture of Dora and Susan. We measured both who the children pointed to and also who they looked at when they heard the word “she” (people tend to look at whatever is being talked about). This gave us both an explicit measure of what the child thought the sentence meant (the pointing) and an implicit measure (eye-gaze). The latter is important because some children are shy.

Some researchers have suggested that it would take a very long time for children to learn the patterns of pronoun use described above. That 5-year-old children already behave like adults suggests that learning must be relatively rapid.

SPATIAL AND TEMPORAL RELATIONSHIPS

Maheśh Srinivasan, Graduate Student

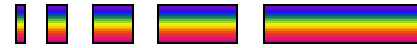
SPACE AND TIME STUDY

When we talk about time, we often use the language of space. We will say that the meeting is on Friday, the deadline is approaching, and that final examinations are behind us. We do not often, however, use the language of time to talk about space. This pattern has led psychologists and linguists to suggest that we may think about time metaphorically in terms of space, but not the reverse. In this line of research, we are interested in whether the relationship between space and time is asymmetric, with time relying on space, or symmetric, with time and space relying on something they have in common. We are especially interested in studying infants, who have not yet learned to talk about time in terms of space.

These experiments have two phases. In the first ‘familiarization’ phase, we might show children a sequence of rainbow colored lines that get progressively longer in length. Once they have been bored with this, we move onto the second phase. In this phase, we might show children the rainbow colored lines again, but this time, their length does not change, but the duration that they are on screen does change, such that lines are shown for progressively longer times on some trials, or progressively shorter times on other trials. If children get ‘bored’ by watching an increasing spatial sequence in the first phase, will they ‘carry over’ their boredom to an increasing temporal sequence, and thus be more interested in a decreasing temporal sequence? And what if we reversed the study, such that we initially bore children with an increasing temporal sequence in the first phase. Would the children also carry over their boredom to the increasing spatial sequence in the second phase?

Thus, of interest to us is whether information transfers equally from the spatial domain to the temporal domain, and vice versa. This work is currently in progress, but other similar work from other universities suggests that the relationship between space and time is actually a symmetric one. Thus, although we might talk about time in terms of space, they appear to be on an equal footing early in infancy.

LENGTH AND DURATION STUDY



In this line of research, we are interested in whether infants can perceive commonalities among spatial and temporal entities. In cultures all over the world, such commonalities are noted in language with words serving a dual purpose of describing spatial as well as temporal entities. For example, we can describe a table as long and use the same word in describing a three-hour film. Our purpose in this research is to determine whether this type of metaphorical use of language has its basis in an underlying similarity that we perceive between these things, even before we have learned language.

In these experiments, we show children something spatially (a rainbow-colored line) paired with a temporal entity (a tone), such that the two appear (or begin playing) and disappear at the same time (see below). By varying the length of the line with the length of the tone, we present your child either a “congruent” pairing of spatial and temporal entities (longer lines with longer tones), or an “incongruent” pairing (longer lines with shorter tones).

We show this to children over and over until they get bored, and we then present them new line-tone pairings that are either new in being congruent, or new in being incongruent (depending on which version the child initially saw). We record looking time to these new pairings, and compare them to looking time to the old pairings. The hypothesis is that children who initially saw congruent pairings will be able to distinguish these from the incongruent pairings, but children who initially saw incongruent pairings will not be able to distinguish these from the congruent pairings.

Data collection is not yet complete, but other similar studies suggest that children who see the congruent pairings will be better able to distinguish these pairings from the incongruent pairings.

FACE PREFERENCE STUDY

Talee Ziv, Graduate Student

This series of studies has been exploring three-month-olds' preferences for faces of different races. In our initial experiment babies were presented with 8 pairs of faces, each pair consisting of an African and a Caucasian face of the same gender. Observation of participants' looking patterns revealed an overall preference for faces of their own race, however we noticed an interesting difference between the male and female pairs. When babies saw two females on the screen they



looked equally long at both faces, but when two males appeared they spent much more time looking at the own-race face. Previous research has shown that babies who have a female primary caregiver (as did the majority of our participants) prefer to look at female over male faces. Therefore, we think that the results of our study reflect a generalization of the female preference to other races.

Next we were curious to understand what drives the own-race preference in the male pairs. It is possible that the different level of contact infants have with own- and other-race individuals plays some role. Perhaps since infants engage more with people of their own race they become experts at telling own-race faces

apart, while at the same time they have trouble differentiating other-race faces. If that's the case, then every time a new pair of faces is shown (as in our experiment), babies are sure they are seeing a new own-race person, but they may be less certain that they are seeing a new other-race individual. It is known that babies are highly interested in novel stimuli, so this potential difference in face differentiation could lead to the observed pattern of results.



In order to assess the above interpretation, we decided to present babies with the same two people over and over again, 8 times. If novelty were necessary for the own-race preference to emerge, then we would expect no preference in this version of the study. However, our results so far are indicating that babies still prefer to look at the face of the familiar race when the same two males are presented consecutively, while showing no preference when presented with the same female pair.

We'd like to send a special THANK YOU to all the parents who allowed us to conduct these studies in their homes!

PATERNALISTIC ALTRUISM

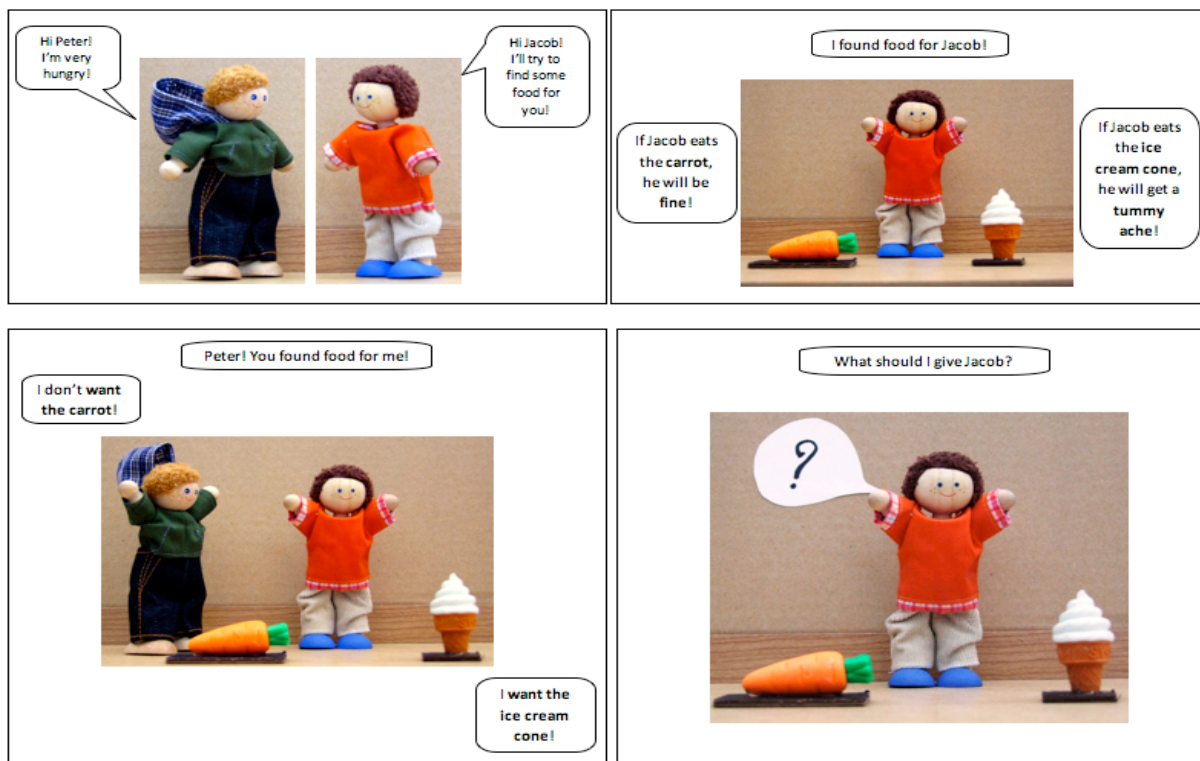
Lauren Kleutsch, Lab Manager
Elsa Loïssel, Researcher

Paternalism refers to the act of making a decision on someone else's behalf that may go against the current desires of that person. For example, parents may make paternalistic decisions on their children's behalf by making them go to bed earlier than the child wants; the parent feels that it is better for the child to be well rested, even if the child does not want to go to bed. In this study, we are exploring when children begin to understand that decisions to help others sometimes involve this conflict between giving others what they have asked for and giving them what you is good for them in the long term.

In the Paternalistic Altruism study, we tell children short stories, which we act out with puppets or dolls. The stories involve characters facing a "paternalistic" conflict. For example, in one story, a hungry character asks for something to eat and a helper has to decide what item of food to give (for example, a vegetable or a cupcake which the hungry character had asked for). The item desired by the hungry character will make his tummy hurt, but he doesn't want the item that would

make him feel fine. The helper character in the story doesn't know what to do and asks the child who is listening for advice as to what item to give. We are interested in knowing whether most children will advise the character to give the desired item (which will make his tummy hurt) or the undesired item (which would have no negative consequences).

We are running this study with children aged four to nine years old, and are interested to know whether children's preferences change over development. At this point, most children have responded paternalistically (advising the helper to give the character the undesired item that would make him feel okay), although some younger children have advised the helper to give the desired item. We are now using a new version of the story involving clothing, to ensure that the trend we have observed is not specific to decision-making about food. With this study, we will gain deeper insight into children's ability to think about the relationship between helping and other people's needs.





LEARNING ABOUT PEOPLE

Katie Pilbeam, Undergraduate Researcher



Previous research has found that children and adults pay a good deal of attention to another person's gender. In this particular study, we were interested in looking at when infants begin to notice and care about the gender of others in the context of social interactions.

In this particular study, we tested whether 5-month-olds respond differently to the social behaviors of men and women. Infants see four short video clips of: a smiling woman speaking in a friendly tone, a smiling male speaking in a friendly tone, a scowling woman speaking in a stern voice, and a scowling man speaking in a stern voice. We videotaped infant reactions to these clips in order to study each child's body language reaction towards the different videos (e.g., number of smiles, frowns, fidgeting, etc.). A research assistant (who is unaware of what each infant saw) used this body language information to rate how happy each infant looked during the study as well as the number of

smiles each infant showed throughout the video presentation.

We found that infants seemed happier and smiled more while watching both the friendly video clips than the unfriendly ones, and they preferred the video clip featuring a female instead of a video clip featuring a male. Additionally, infants seemed equally happy and showed roughly the same number of smiles when seeing the clips of the unfriendly female and the friendly male. This is interesting to us since adult participants rated the men and women shown in the clips as being equally friendly (in the smiling clips) and equally unfriendly (in the scowling clips).

We are about to begin a second phase of the study that examines if infants use, notice, and care about the race of others in the context of social interactions. Check out next year's newsletter to find out how it goes!



BELIEFS

Larisa Heiphetz, Graduate Student



Previous work has found that infants and young children understand that other people do not always share their beliefs. However, this work doesn't address the question of how children reason about different kinds of beliefs, especially beliefs that they may not be able to verify for themselves.

To address this question, we conducted a study examining factual beliefs, opinions, and religious beliefs. We conducted this study with children between the ages of 5 and 10 years. Children heard about two characters that disagreed; for example, on one trial, the experimenter told children that one character thought that germs were very big while another thought that germs were very small. The experimenter then asked children whether both of the characters could be right or if only one could be right.

Children of all ages were most likely to say that only one character could be right when they disagreed about facts and least likely to say that only one could be right when they disagreed about opinions, such as which color is the prettiest. Religious beliefs fell between these two extremes. We also found age differences such that 5-6 year olds were more likely than 7-10 year olds to say that only one character could be right when the characters disagreed about either opinions or religious beliefs. However, when the characters disagreed about facts, we did not find age differences; children of all ages said that only one character could be right almost all of the time.

We are planning follow-up studies that will help us learn more about why children gave the answers that they did. We will also be studying adults to see how they reason about different kinds of beliefs.

EVENT STUDY

Kate Hobbs, Graduate Student

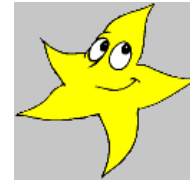
There are some concepts that infants possess innately but there are many, many more complex ones that infants acquire through experience and maturation. Language development is often studied in conjunction with conceptual development, asking whether language reflects the child's conceptual knowledge or whether it might in fact advance conceptual knowledge.

We are interested in such questions about language and conceptual development when it comes to action and event understanding. Before children are able to combine words to express an event like "mommy kissing baby," do they have an abstract concept of such an event, or do they only entertain the singular occurrence of such an event? Could it be growth in language that allows children to represent general event concepts?

To address these questions, we sought to find out whether language would benefit children in generalizing event concepts. 2- to 5-year-old children watched us demonstrate transitive events with toy animals and people as participants, acting on one another in differ-

ent scenes. For half of the children we simply enacted the scenes and then let them try it, and for the other half we narrated the event as we demonstrated it ("look, a boy is pushing a tiger"). After each scene children were asked to demonstrate the same event with a new set of toys, to see whether they had abstractly represented the event. We wanted to know whether providing a linguistic description would help children create an abstract representation of the event.

It appears that at least in this task, language is helpful in understanding events. But we don't know yet whether this is because language helps kids represent these events or recall these events. In the future we hope to test infants on a modified version of this to see whether they understand transitive event concepts pre-linguistically.



CHILDREN'S GRAMMAR

Manizheh Khan, Graduate Student

Four-year-olds are remarkably sophisticated language users. They rarely make grammatical errors, and can use syntax to figure out that "The cat's chasing the dog" and "The dog's chasing the cat" mean two different things. In an ongoing series of studies, we are interested in finding out exactly how adult-like these young children are when it comes to language.

By looking at how they understand sentences as they're hearing them, moment-by-moment, we can see if they're using similar processes to adults or if they're arriving at the same end but using different means. We use a technique called priming to look at the nature of children's grammar. Children in these studies listen to short stories, interspersed with instructions to interact with toys that are on a stage in front of the child. A small video camera records which toys the child looks at as he or she hears the instructions. This gives us a

hint as to what he or she expects the instruction to say before it has finished unfolding. With these expectations, we can look for effects from the types of sentences they had heard during the story phase of the game – do children expect the same types of sentences to be used again? That is, does the story prime children's sentence comprehension during the instruction phase?

Using this technique, we can see when priming does occur, and when it does not, to gauge the types of knowledge children are using when processing language. So far we can see that children at this age do indeed show implicit knowledge of language categories such as nouns and verbs, and implicitly appreciate the grammatical similarity between the sentences "Elmo gave an apple to Ernie" and "The lion passed a tie to the whale," even though the two sentences have very few words in common.

WHITE LIES

Emily Orlins, Undergraduate Researcher



Which drawings belong in the good and bad piles? Would your answer change if an experimenter told you that the drawing on the right was hers?

In this study, we are interested in when children begin to recognize that white lies can make someone feel better. For example, when adults receive a gift that they do not really like, they would probably still say that they liked it. Previous research shows that children are capable of telling white lies in such contexts. However, it is unclear why exactly they do this. Is it because they have learned a politeness norm and just follow this norm? Or do they actually understand that telling the truth might make the other person sad and telling a white lie will make the other feel better?

In the White Lies study, children sort “good” drawings and “bad” drawings. Later, the children learn that some of the drawings were done by one of our experimenters. In some cases, the experimenter has expressed that they are sad about being a bad drawer; in other cases, they say it doesn’t matter to them that they are bad at drawing. The experimenter asks whether her drawing belongs in the good or the bad pile. We are interested to see if children will say that the experimenter’s (obviously bad) drawing belongs in the “good” pile in order

to make the experimenter feel better, and whether they are more likely to do so if the experimenter has expressed frustration about being bad at drawing.

We recently added a “training session” that shows how telling a white lie is an option for making someone feel better. We will see how children respond after the training session, compared to how the children respond to the spontaneous trials. Once we have data that compares children’s responses after the training session to children’s responses when they are tested spontaneously, we will see whether children consider telling a white lie an option to make someone feel better. If they do tell white lies after the training session, it would show that children are capable of learning and understanding how to tell a white lie. Otherwise, it would show that children at this age do not have the capacity to understand and tell a prosocial lie in this situation. Ultimately, the results of this study will give insight into how children view social interactions and to what extent they understand the effect of their actions on others.



HELPING IN ABSENCE

*Nicole Grifka, Researcher, Tony Huang, Undergraduate Researcher
Lauren Kleutsch, Lab Manager*

In the Helping in Absence study, we are interested in learning whether children's helping behaviors are affected by the presence or absence of other people. During the study, the child watches the experimenter as they try to accomplish a task. The experimenter leaves the room briefly to get more materials, and a problem arises that would prevent them from continuing with their task. (For example, imagine that you see someone's pen roll off the table when they are out of the

room. An adult would probably put it back on the table). We are interested to know whether children will help out even when there is no one observing their helping act, and if so, at what age they begin to do that. The study is conducted with children aged two to three and a half. Although the study is just beginning, ultimately, we hope the findings will help us understand how children's helping behaviors are related to social cues.



BIOLOGY and EXECUTIVE FUNCTION

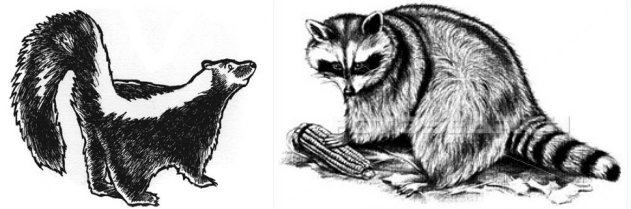
*Deborah Zaitchik-Samet, Research Fellow
Yeshim Iqbal, Researcher*

We are interested in discovering how young children learn about the world around them and how their understanding changes over time to arrive, eventually, at an adult-like state. Previous research has shown that children's understanding of fundamental biological concepts (such as alive or grow or breathe), goes through an interesting transformation around the age of 5. In this study, we investigate the mental skills children require to build this new understanding. In particular, we think a set of skills called 'executive function' are important when children are trying to change and improve their theories about how the biological world works. Executive function refers to mental operations that allow us to think and act flexibly, and includes working memory, inhibitory control, and planning abilities.

To see if there is a relation between the development of children's biological knowledge and their executive functioning, we have our participants (5-7 year olds) come into the lab for two separate sessions. In the first session, we assess their understanding of biological concepts – we bring up examples of different categories (e.g. animals, plants, tools, etc.) and describe dif-

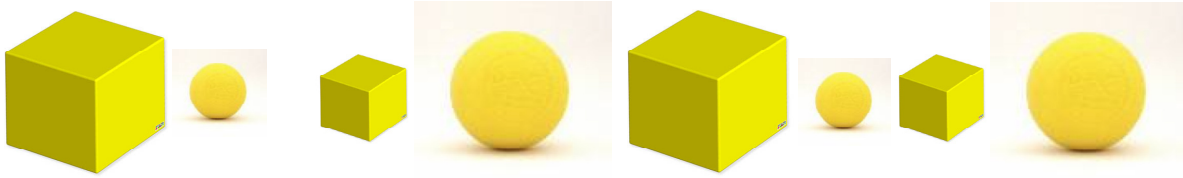
ferent scenarios (e.g. what if a raccoon was painted to look like a skunk?) We ask a variety of questions about these items and events to get an idea of how they sort things into living and non-living categories and what they think about living things. In the second session, we assess their executive functioning by playing two computer games, called 'Hearts and Flowers' and 'Flanker Fish', where they have to respond quickly by pressing buttons according to certain sets of rules. We also play a memory game where we give the child a short list of colors to repeat in backward order.

We're still running the study, but preliminary results show that there is a significant relationship between biological knowledge and executive function skill. We hope to be able to describe the nature of this relationship in more detail soon, so stay tuned!



BUCKET SETS TASK

Arin Tuerk, Graduate Student



We are constantly bombarded by new gimmicks promising to “improve our memory,” and human interest stories about individuals with either incredibly long or devastatingly short memory spans. People have long been intrigued by the parameters of short-term, or “working” memory, and the ways in which we can expand our mnemonic capacity beyond these limits.

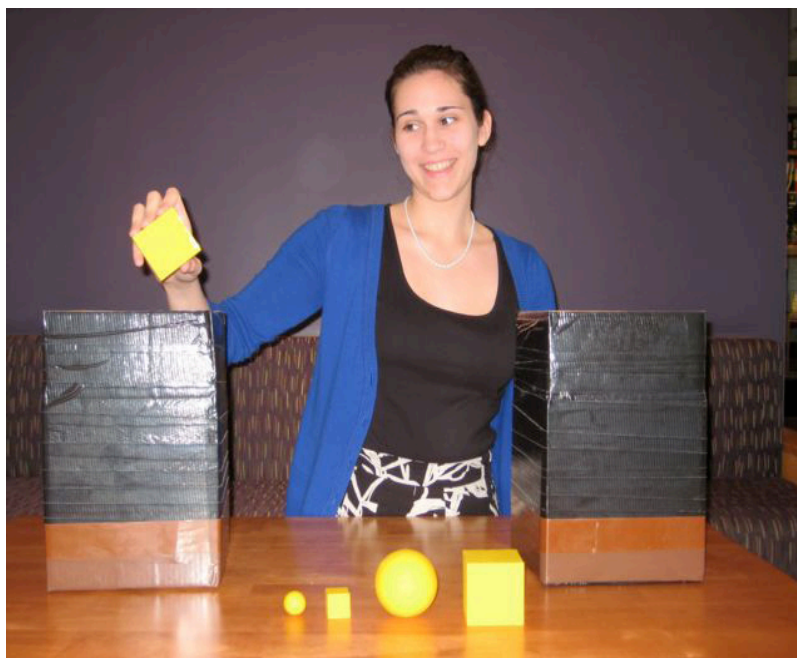
We know that adults can hold only 3-4 “units” in working memory at once, and that these units can be individual items, or “chunks” of 3-4 associated individuals. We also know that for adults, large sets of similar items can also function as units in memory, but that we can only store about 3 such sets in working memory at any given time. We have been exploring this capacity limitation and found that although adults can only remember about 3 independent sets (such as a set of cotton balls, a set of poker chips and a set of starburst candies) their memory capacity for sets of items that overlap in features (such as 4 sets of blue and red circles and triangles) is much less limited. In fact, adults can remember information about 16 sets, when they share features along color, shape, size and topology dimensions!

The goal of this set of studies is to see how whether children can also advantageously organize the contents of working memory, and thereby increase the total amount of informa-

tion they can remember. In our first study, we replicated some adult findings with 3, 4 and 5 year olds and found that just like adults, children can only keep track of up to 3 sets of non-overlapping items. We then created 4 overlapping sets out of large and small blocks and balls to see whether, like adults, children could remember information about more than 3 sets by capitalizing on the shared features across these sets. Is this ability to reorganize and encode information effectively a uniquely adult trait? Or is this advantageous mnemonic process available throughout the lifespan?

Our results show that indeed by 7 years of age, children can simultaneously hold in mind 4 sets of items when they overlap in features. However, this same task seems much more difficult for 3 and 4 year olds. While even the 3 year olds could recognize and attend to both the shape and the size of an object, only the older children in this study were able form overlapping categories based on these features. This suggests that the abil-

ity to flexibly organize and reorganize groups of objects in working term memory develops with age. At what age does this ability become robust? What is the underlying cognitive change that supports this ability? Future studies will ask just these questions, so stay tuned!



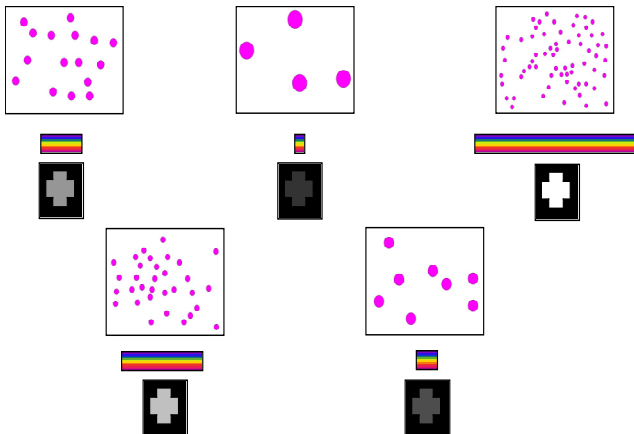
SPACE AND NUMBER

Lola De Hevia, Post doc

8-MONTH OLDS

As adults, when we think about numbers and quantities, we tend to generate spatial images. In fact, some experiments have shown that we unconsciously order numbers in our mind from left to right, the so-called 'mental number line.' Along the same line, when we see a small number we tend to think of a small space, and the reverse happens for large numbers. Since infants can discriminate quantities from as early as 6 months of age, we are investigating whether these associations are learned in school, for instance when we learn mathematics, or whether they reflect an intrinsic knowledge of magnitude information.

In this study, we present babies with movies showing a series of quantities that are accompanied by lines of different lengths. During the first part of the study, one group of babies is shown a congruent rule: small numbers are paired with short lines and large numbers are paired with long lines. The second group of babies is shown an incongruent rule: small numbers are paired with long lines and large numbers are paired with short lines. Once babies become bored of looking at either of these movies, we test them by showing both groups new numbers and new lines that are paired either congruently or incongruently. We discovered that only the group of babies that was first shown a congruent rule was able to generalize the rule to the new information presented in the test, thus preferring to look to the numbers and lines that followed the congruent rule.



Another version of this experiment has been developed in order to test whether infants can learn a rule that relates number to other dimensions, such as brightness. In the same way as described before, one group of babies is shown a congruent rule: small numbers are paired with a dark object (against a black background, so there is little contrast between the object and background), and large numbers are paired with a bright object (again, against a black background so there is a stark contrast). The second group of babies is shown an incongruent rule: small numbers are paired with a bright object, and large numbers are paired with a dark object. We have found that only the group of babies that was shown a congruent rule was surprised (looked longer) when we violated the rule, while the other group did not look longer when we changed the rule. This suggests that the babies in the group that was trained on the congruent rule were in fact able to learn the rule, although they were unable generalize it to the new information.

These results strengthen previous results obtained in our lab with similar stimuli: We've shown that the relationship between number and space is somehow unique and differs from the capacity to form associations between number and different dimensions like brightness.

SMALL NUMBER AND SPACE: 11-MONTH OLDS

When we see small numbers of objects (one, two, or three), we can either think of their quantity, track the properties of each of the objects like the shape, the color, the position, or we can compute all of these properties together with number.

Extensive research in our and other labs has shown that infants can compute number using two systems that are triggered depending on the number of objects. One of the systems is devoted to compute large numbers of object, from approximately four upwards, while another system is recruited when there is a small number, usually one to three objects. One crucial difference

between these two systems is that the first one, the large number system, is used to approximate the numerosity of the array, while the second one, the small number system, precisely computes exact numerosities. In the previous experiments with 8-month olds, we have observed that infants are able to generalize an increasing or decreasing order in large numerosities (for example, 4, 8, 16, 32, 64 or the reverse) to increasing or decreasing lengths (for example, very small, small, medium, large, very large or the reverse). Infants can even learn a rule that relates number and length in a congruent way, but they fail to learn the rule if it is incongruent.

With the present experiment, Small Number Space, we were asking whether the small number system would behave similarly to the large number system; specifically, if small numbers of objects can also be associated to different spatial lengths. We have found that infants can in fact relate the order in small numbers of objects (one, two and three) to the order in line lengths (small, medium, long). This result suggests that the two systems available to compute number show the same property of a natural relationship with spatial representations.

SPATIAL-NUMERICAL ASSOCIATIONS: 3 to 9 year olds

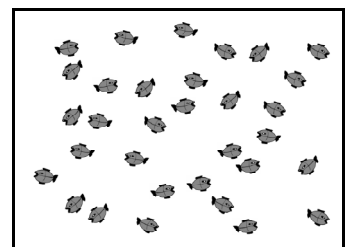
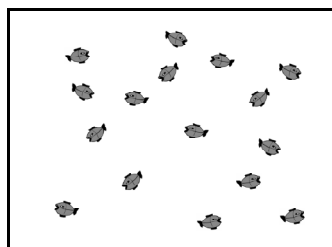
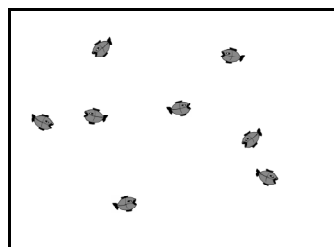
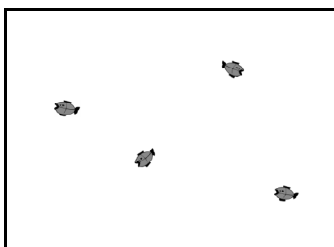
When we think of ordinal information, like numbers, we tend to generate a mental image of it with spatial properties: in western cultures, we tend to think that the beginning of a sequence is on the left side of the space (for example, small numbers) and that the end of the sequence is on the right side of the space (for example, large numbers). That is, we think of numbers as if pictured in a number line. In other cultures, where the writing system follows a right to left direction, the beginning is associated to the right and the end to the left. In fact, when adults think about numbers, even though it is generally unconscious, we tend to display such a picture of numbers in our minds. With this study we are trying to understand when and how this mental image

takes place in our numerical thinking. We want to ask whether it is only related to writing and reading skills, or whether it is something that appears before children master those skills. Also, we want to investigate the impact that those skills have in a more fundamental visualization of numbers. Finally, we ask whether the horizontal line is the only mental image that is usually generated, or whether also a vertical one is a natural way of 'seeing' numbers.

In this study your child was asked to play a short computer game showing a series of pictures with different quantities of animals. The animals appeared in different colors, and the game consisted of matching the color of the animals with the color of the keys in a response box. These keys are in different positions, left, right, bottom and top, so we can observe how fast children are when each of them is used for each quantity (small and large numbers).

So far, we are observing that even the youngest children, from 3 years of age, display spatial-numerical associations, in the form of linking bottom to small and high to large. These initial findings suggest that the associations between number and space are more fundamental than previously thought, and they do not depend solely on the writing and reading skills. On the other hand, when children start mastering those skills, they show an association of left and small and right and large.

We have also traveled to Israel to play the same game with kids. Our preliminary findings show that when children master the reading and writing skills in this country, they associate left with large and right with small, just the reverse than American children. However, they similarly associate bottom with small and high with large. These initial findings suggest that the reading and writing skills do have an impact in the spatial-numerical associations, and as a result we can observe differences among different cultures, while other spatial-numerical associations remain the same for both cultures.



UNDERSTANDING “NOT”

Roman Feiman, Graduate Student

This study investigated what 7-month-olds understand about the concept “Not”, as in, “I am not going to the store.” We tested their understanding by showing them two objects on a stage. One object would always be present on the stage, while the other would be switched at intervals off-stage by an experimenter. The objects that kept changing would appear, rise up into the air on an invisible string, dangle and come back down. The object that stayed constant in all the trials never did that.

We wanted to see if infants could notice that the pattern that the ever-present object did not get up in the air and dangle. Although our results are not completely

conclusive yet, it looks like infants are able to entertain that particular thought. When they finally saw the ever-present object dangle at the end of the study, on average they looked longer at it than they had at the other objects right before, which they had gotten used to seeing dangle. This tells us that they had some expectation about the ever-present object not dangling, and that this expectation led to something like surprise when it finally did.

Although it is too early to tell for sure, we think there is some chance that babies as young as 7 months really can understand a very abstract concept like “not”, and we think that’s pretty amazing!!

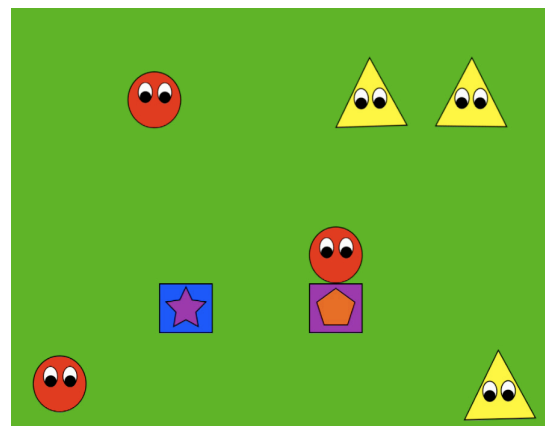
DO INFANTS EXPECT CONFORMITY?

Lindsey Powell, Graduate Student

Recent research from our lab and other labs has shown that infants are remarkably savvy when it comes to the social world. They can interpret the goals of others’ actions. They notice who’s helpful and who’s not and prefer the helpful individuals. They even prefer people who speak the native language of their family to those who speak a foreign language. This last finding raises the possibility that infants might already have an understanding that people form different social groups and that those groups tend to behave differently in some ways, including speaking different languages.

Our study tests this hypothesis that infants both perceive different social groups and notice the ways in which groups’ behavior differs by showing 4-, 8-, and 15-month-old infants animations of two groups of shapes. At the start of the animation, there are three circles on one side of the screen and three triangles on the other. The groups do little dances in alternation – first the circles, then the triangles, etc. – to introduce the idea that the groups are separate and do things together but not with the other group. The next phase of the animation involves two boxes at the bottom of the screen. The infants see two of the three circles fly

down and jump on one of the boxes and two of the three triangles fly down and jump on the other box. We then ask whether the infants expect the last circle and the last triangle to do jump on the same boxes their group members jumped on by measuring how long the infants look when the last circle and the last triangle do and do not conform to their groups. This study has just started, but so far our results suggest that starting at 8 months the infants do, in fact, expect the last circle and triangle to conform to their groups. The 4-month-olds, however, do not look differently at the conforming and nonconforming events.



LANGUAGE and IMITATION STUDY

Lindsey Powell, Graduate Student

Although there are many things toddlers and preschoolers have yet to master, there is something they already seem to be quite good at – mimicry. Though we use the verb “to ape” as a synonym for imitation, it turns out that it’s actually humans who are the most prolific imitators, and that tendency appears early in childhood. In fact, young children are so prone to copying others that they do something psychologists call “overimitation” – when reproducing someone else’s actions they often copy not just the parts of the action necessary to complete its goal but any unnecessary things or mannerisms that they witnessed the other person doing along the way. For example, if you were to tap three times on top of a box before opening it up to retrieve a toy, then when your 3- or 4-year-old got a chance to open the box herself, chances are she would tap three times on the box before opening it as well even though it’s obviously not a necessary step for retrieving the toy.

There are different theories about why kids overimitate, and they fall into two main camps. One theory is that children overimitate in order to learn how the world works. Often, it’s not obvious how the tools, toys, and other artifacts that people make actually work, so maybe the safest thing for children to do is just to copy exactly what they see others do. The other theories appeal more to the social nature of human beings. Different cultures have different conventions – different ways of cooking the same food, different ways of greeting one another, different ways of dressing, for example – and people often prefer those who share their conventions, and thus their culture. Overimitation may be one way that children learn the conventions of their group.

If this second theory is true, then we might expect that a child would only overimitate people who belong to the child’s own cultural groups. The first theory, however, would predict that children would overimitate any individual who seems successful in her actions. Our research set up a situation where English-speak-



ing toddlers between the ages of 18 and 24 months were introduced to someone who either spoke English or French. After the introduction phase, the toddlers watched the English or French speaker play with three toys, performing both relevant and irrelevant actions. The toddlers were given a chance to play with the toys themselves, and we measure the degree to which they mimicked the adult’s actions. We found no difference in how much the toddlers imitated when the model was speaking English versus when she was speaking French, which supports the idea that children simply learning about the way the world works from any capable person they see. Overall, because the rates of imitation were low, additional research may be necessary to reach a firm conclusion.



UNDERSTANDING PLURALS

Manizeh Khan, Graduate Student

What's the difference between "dogs" and "a dog"? Intuitively, we can all see that "dogs" means more than one dog, and "a dog" only refers to one. In a new series of studies, we're trying to figure out if this is really true, or if the story might be more complicated. In particular, we're looking at the idea that maybe plurals don't always mean more than one. We can see examples of this in instructions like "If you dropped toys on the floor, you should tidy up", which clearly holds even if just a single toy was dropped even though the plural "toys" was used. The challenge, then, is to figure out when plurals do mean more than one, when they don't, and how a child is ever supposed to figure out the difference!

We have started looking at three year olds intuitions about plurals by playing a card game with them. In this

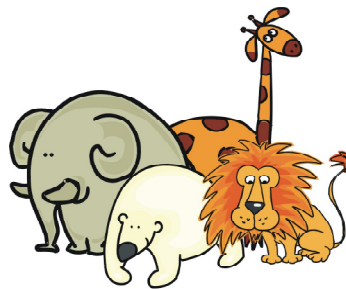
game, children are shown three cards, each showing Big Bird with some possessions. Two of the cards are face-up, so the child can see what Big Bird has, and one is face-down, so that it remains a mystery. The game is to find the card that matches the description that's given. We are interested to see what children do when they hear a description that uses a plural, for example "the card where Big Bird has kites", but only see Big Bird with a single kite – do they accept that "kites" might refer to the single kite, or do they reject this possibility and choose the mystery card instead? Results so far indicate that children are willing to accept the single kite when they hear "kites," even though they know that saying "a kite" would have been a better description.

INFERENCES ABOUT SOCIAL RELATIONS

Miriam Sofronia, Visiting Student

We live in a highly social environment and understanding social relations is essential if we want to behave properly in each situation. It is important to understand the relationships between other people, but also to understand where one would stand in the social network.

In this series of studies we wanted to see how children understand social relationships and what kind of inferences they make when they see some characters interact. In our first study, we presented children with five pictures of other children and told them a story about how they interact when they go to the zoo. In all these interactions, one of the characters in a pair appeared as dominant. The five characters were ranked in a dominance hierarchy, and we only showed interactions between characters that were next to each other in the hierarchy (Abigail-Brittany, or Brittany-Charlotte if the hierarchy is Abigail>Brittany>Charlotte). Then we asked children how they thought characters they



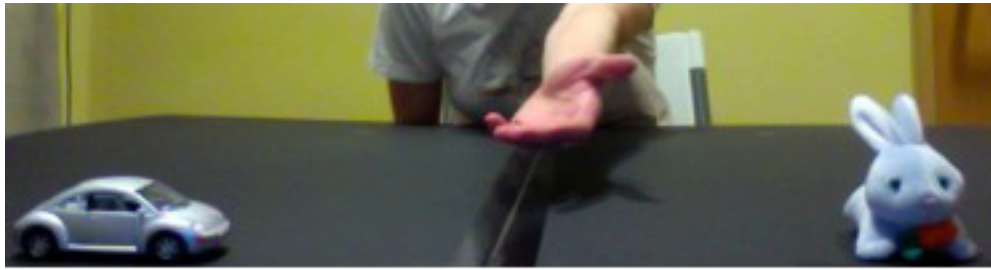
The ZOO

have never seen paired together would interact (Abigail-Charlotte).

This task is quite demanding, but we found that children behave just like adult subjects: they are very good at detecting who is first and who is last in the hierarchy, but they don't infer anything about the relationship between the 3 middle characters! In order to understand these results, we built a second study in which we wanted to see if children use the number of times a character has been in a dominant position to understand the hierarchy. Adults seem to count the number of times a character gets what he wants to understand what his rank will be! In this new study, some of the characters appear as dominant two times, others once, others appear as submissive two times or once. We are still waiting to have all the results for this study and see what children do in this case, but we're excited to find out!

INFANTS' UNDERSTANDING OF OTHER PEOPLE'S DESIRES

Kate Hobbs, Graduate Student



Though there may be days when you wonder whether your toddler will ever be helpful again, studies have shown that infants are quite willing to help others by as early as one year of age. Infants point to objects to inform others of their whereabouts, open doors for others, hand out-of-reach objects to others, and show them new ways of attaining their goals. So it would seem that even one-year-olds infants can be very eager helpers.

Babies also know quite a bit about the goals of other people. This knowledge is vital for understanding when another needs help and how to best provide help. As measured by their looking behaviors, 6-month-old babies expect people to have the goal of attaining an object rather than just performing an action like reaching towards the same place. They can calculate what someone can and can't see when reasoning about that person's goal. And by 9 months, infants appear to know that individuals have goals that can differ from other people's goals.

So given that infants are both knowledgeable about others' goals and willing helpers, we predicted that infants would be able to infer another person's preference for an object and use that information in figuring out which object to give to that person. We sought to test this idea by giving infants information about an actor's goals, and then seeing whether the infant would

be more likely to give the person their preferred object rather than an object they had previously shown no interest in.

In two different conditions, infants were shown that the actor preferred one object over another. In subsequent trials, the actor then asked the child to help her, extending her hand palm up as a request. In one condition, the actor gave no indication about her goal during this test trial, so infants had to rely on previously-demonstrated information about her preference. In the other condition, the actor again reached towards her preferred object in the test trial, so infants only needed to notice this gesture to figure out which object she wanted.

So far, it appears that while infants are pretty successful in giving an actor her goal object when that goal information is immediately available, when forced to rely on previous evidence, infants are equally likely to give either object to the actor. We don't yet know whether this is hard for infants because of the memory demands of the task or because infants have a fundamentally different concept of appropriate helping than do adults. Future research will address these questions and investigate why some kinds of helping prove so difficult for infants. Perhaps this work will even shed some light on the "terrible twos," when infants often seem to give up on helping altogether!



MUSIC and SOCIAL PREFERENCES

Gaye Soley, Graduate Student

MUSIC AND EARLY SOCIAL PREFERENCES

Previous research has shown that infants show a striking preference for the structures of their native culture, such as their native language, faces of their own race, and even the music of their own culture. The fact that a preference for familiar things emerges very early in life raises the possibility that it serves important social functions such as directing attention towards the caregiver or identifying members of one's own social group.

A previous study in our lab (Kinzler, Dupoux & Spelke, 2007) showed that the preference for native language is generalized to a social preference early in life. For instance, 5-month-old babies prefer to look at a person who previously spoke in their native language rather than a person who previously spoke in a foreign language. Based on this result, we asked whether familiar music would also guide social preferences of infants.



In order to answer this question, we tested five-month-old babies on their parents' lap in a dimly lit testing room with a screen located in front of the infant. Parents listened to classical music through noise-canceling headphones so that they wouldn't influence their babies' responses. We presented babies with alternating films of two women singing or clapping to familiar or unfamiliar music. Before and after showing these videos, the two women appeared side by side on the screen, silently smiling at the infant, and we coded how long the baby looked to each person during these silent trials in order to infer their preference for one person or the other.

Our results showed that familiar music only guided social preferences in the singing conditions, but not in the clapping conditions, suggesting that producing the sound might be crucial in order for young infants to associate the music with the person.

MUSIC AND TOY CHOICE

In order to investigate these questions with slightly older infants and using a slightly altered method, we presented 10-month-old infants with videos of two women clapping to familiar or unfamiliar music. Afterwards the women in the videos presented two different toys to the infant. The real versions of these toys were placed on a table in front of the infant, but they were too far to reach. Then the parent was asked to push the infant's high chair toward the table to allow the infant to grab the toys. Each infant had 4 trials with four different pairs of toys. We coded infants' first reach for each trial.

So far, our results have shown that the infants prefer to take the toy that was presented by the person who previously clapped to the familiar music rather than the other toy. This result suggests that familiarity in music might play a role in 10-month-old infants' subsequent interactions with people. We are also exploring this hypothesis by testing younger babies and also children by using different methods.

MUSIC AND FRIENDSHIP PREFERENCES

Music is a potential cue to social group membership, since it is a universal activity with culture-specific features. Previous research has shown that familiar music guides children's friendship preferences. For instance, 5-year-old children choose their friends among children whose favorite songs are familiar to them.

Right now, we are exploring the nature of these social preferences: Whether they depend on shared preferences or shared knowledge about music.

To address these questions, we are testing 4 and 5-year-old children. First, children are introduced to two other children on a computer screen. Then they are presented with a song that is either a popular children's song or an unfamiliar 18th century American folk song that the children are presumably unfamiliar with. Next, children are told that this song was previously played

for the children in the pictures on the computer. They are also told that one of those children knows the song very well but doesn't like it at all, whereas the other child didn't know the song before, but after hearing it she liked it very much. Children are asked which of these two children they would rather have as their friend. Children receive six trials, 3 of which are with familiar songs and 3 of which are with unfamiliar songs. On each of the trials, they are introduced to a different pair of children.

We're still in the process of analyzing our data, but we do have some interesting results to share! When the songs are familiar, children are equally likely to prefer the child who knows the song yet doesn't like it and the child who doesn't know it but likes it very much.

On the other hand, when the songs are unfamiliar, children tend to choose the one who doesn't know the song but likes it, suggesting that they might be avoiding someone who knows a song that they don't know of. Right now, we are exploring these questions in greater depth by doing follow up studies in which we only give children information about knowing or liking to see if we get differential patterns of preferences with familiar and unfamiliar songs in both cases.

These studies contribute to our general knowledge about how children learn about music, and how their responses to music change as they become increasingly familiar with the music of their culture. The success of this research depends on generous parents like you!!

INFANT SOCIAL CATEGORIZATION

Andrew Baron, Graduate Student

In this study, we wanted to know whether 10-month-old infants could perceive categories of people. In particular, we wanted to know whether infants categorize people based on race and/or skin color. Additionally, we wanted to understand how language might help infants to form categories.

For this study, infants watched a large screen as faces of individual people appeared one at a time. Infants saw 9 of these faces, all belonging to the same race (either European-American or African-American). The faces were of college-aged adults and were headshots only. During 6 of the 9 presentations, infants heard a spoken utterance when a face was presented on the screen: "Look at the Blicket." Here, this sentence encourages children to pay attention to the screen and to figure out what a "blicket" refers to across the different trials. Past research has shown that infants expect nouns, even nonsense ones like "blicket," to refer to a category. We thought that if infants were motivated to find the category, they might be able to observe that all of the faces being presented were either White or Black (depending on the condition).

To test whether infants actually formed the category White or Black we presented them with two "test" tri-

als after the 9 familiarization trials. During these two trials, infants saw two faces side-by-side. One was of a European-American individual and the other of an African-American individual. Both were unfamiliar faces to the child.

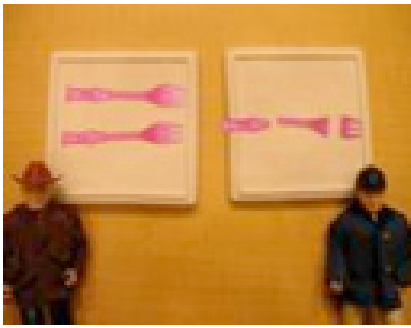
If infants had formed a category over the previous familiarization trials, then they should be more interested in looking at the face from a novel category (e.g., if they saw all White faces first, they should be more interested in looking at the Black face). We expected this result because previous research has demonstrated that infants prefer to look at unfamiliar or novel images at this age.

This study is still ongoing, but thus far we are finding what we expected - infants look longer at the unfamiliar race face during those two test trials at the end of the study. Since previous research has failed to demonstrate that infants can categorize based on race, we believe our study is different because of the use of language. We believe that by labeling the faces in the beginning of the study, children are motivated to figure out what is held in common and what is different across the trials. Thanks to all those who have participated!

LEARNING ABOUT UNITS OF QUANTIFICATION

Peggy Li, Post-doc

In many past research projects in our laboratory, we have asked how children come to understand the meanings of number words – how they come to understand that applying the numbers of the count list to the number of objects in a set via one-to-one correspondence determines the total number of objects. In the present study, we are interested in what exactly they have learned about the units of counting. Curiously, it seems that children under six or seven would count a fork broken into three pieces as “three forks” not “three pieces of fork.”



In our present study, we are looking at when children come to understand the language that contrasts pieces from wholes. When do they learn that a broken piece of a fork is not “one fork”, but “one piece of a fork”? How does children’s understanding of such language relate to how they count and make quantity judgments, or how they represent and track pieces and parts of objects? We are exploring how 3-5 year-olds talk and reason about quantities of objects with three tasks.

First, in a “quantity judgment” task, the child is introduced to two characters that each has a set of objects. For example, one set might consist of a single object broken into pieces, while the other might consist

of whole objects. They are then asked who has more (e.g., “Who has more forks?”). In the second task, a “quantity tracking” task, the child observes cups being taken in and out of a box. More specifically, the child is first shown an empty box. Then, with the inside not visible to the child, the child might see three cups being lowered into the box, and then two or three cups being taken out of the box. The child then has to guess whether the box is empty or still has something inside. In some trials, the cups are cut in half while inside the box, and so when the child sees the cups, they are in halves. The child has to infer from the halves whether the box is empty or still has something inside. Finally, in the last task, a “measure words” task, the child helps the researcher select photographs to be put into a picture book: the child is asked to select photographs of either whole objects, pieces of objects, or boxes of objects on the basis of the description that the researcher provides (e.g., “a fork”; “a piece of a fork”; “a box of forks”).

We have just begun our research, but have found that many four- and five-year-old children have difficulty with the “quantity tracking” task when the objects undergo cutting. They also often do not know the language that contrasts whole and parts (i.e., a piece of a fork cannot be called “a fork” or that a fork cannot be called “a piece of a fork”). These same children also consider that three pieces of a whole object is more than two whole objects of that kind (i.e., three pieces of a fork is “more forks” than two whole forks). We find this pretty interesting, and look forward to further exploration of this topic!



NUMBER WORDS and THEIR MEANINGS

Heena Lakhani, Researcher

STUDY 1: ESTIMATING MARBLES

All humans have an innate number sense. Both adults and children are capable of perceiving and discriminating based on number, and interestingly enough, they end up applying number words to their corresponding numerical representations. However, if 15 dots were quickly flashed on a computer screen, an adult could estimate that there were approximately 15 dots there, whereas a 4-year old child may not be able to do so. We are interested in understanding how children apply number words like '15' to their corresponding numerical representations – a process that we call 'mapping'.

We are specifically interested in whether children use a generative process when mapping. A generative process is one in which they use a few mappings that they do have (e.g., 7) along with their knowledge of the number line to make their mappings. For example, if I know approximately what 7 looks like, and I see about 14 dots, then the number word that I use to describe 14 must be greater than the one I use to describe 7. This constitutes the use of a rule-based process that says that later on in the count list means more.

In our study, we designed a dot estimation task for 4-year old children to study their numerical estimates for dots ranging in cardinal size from 11-34. In our task, SpongeBob would reach inside of his hat and throw out marbles and the children would have to guess the number of marbles he threw out. The children were put in one of 2 groups: one group saw small sets of dots such as 2, 4, and 7, whereas the other group did not. We call the former group the "anchored" group because they received dots of small set sizes – ones that they may have mappings for already. Would they be able to use the anchor to help them in assigning numerical estimates for dots ranging in size from 11-34?

Our results show that the anchored group was better able to assign larger numbers as the number of dots increased, whereas the group without the anchor did not. When we gave the non-anchored group a calibration of 10 (e.g., this is what 10 dots looks like), they, too, became better at assigning large numbers as the number of dots increased. These results indicate that 4-year old children are capable of using a generative process when assigning numerical estimates to large arrays of items when they have a stable mapping to begin with.

STUDY 2: TEACHING TEN

We have recently started a new study looking at how 3-year old children perform in a task in which we teach them a meaning of a number word like 10. In other words, we would like to know if we can teach them to map the number word 10 to its corresponding numerical representation.

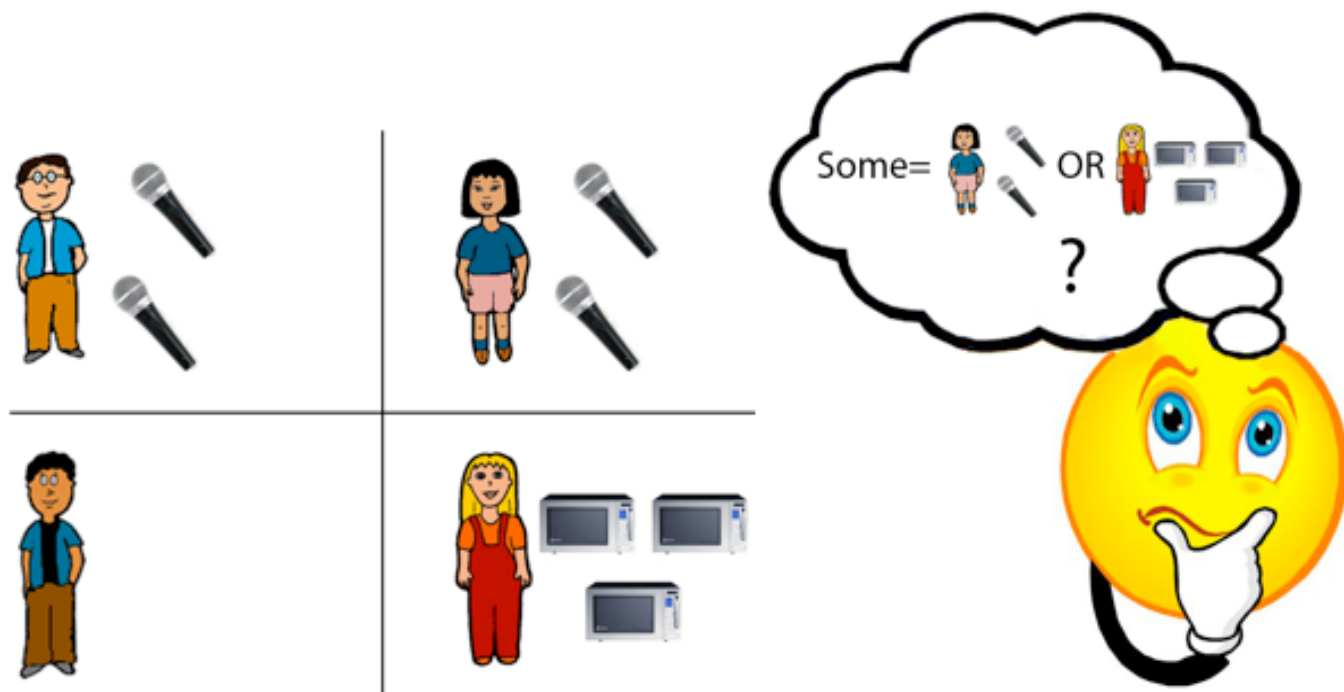
In the study, the children go through a training phase. In the training phase, the experimenter presents the child with two cards. One is the target card (e.g., 10) and the other card is a distracter card (e.g., 20). During the training, the experimenter makes the contrast explicit between the two cards. For example, the experimenter will say: "this card (while pointing to the target card) over here has 10 birds. This card (while pointing to the distracter card) over here also has some birds, but it doesn't have 10 birds." We are currently contrasting 10 with the following numbers: 3, 5, 7, 15, 20, and 30.

Are 3-year old children capable of mapping 10? Will they be more likely to succeed in trials in which the numerical distance between the target card and the distracter card increases (e.g., doing better when 10 is contrasted with 20 rather than 15)? We are still in the process of collecting data and we look forward to sharing our results with you in the next newsletter.



SOME CHILDREN LIKE THIS

Noemí Hahn, Researcher
Yi Ting Huang, Post-doc



Every day communication involves both understanding the literal meaning of what is said (semantics) as well as generating inferences about what is meant (pragmatics). Our experiments aim at exploring how these interpretations are generated, by focusing on how people process words that refer to quantities like some, all, two, and three. In particular, we focus on sentences like “A girl has some of the microphones” which is logically consistent with a situation where she has all of the microphones (the total set) but is often interpreted with an inference that implies that she doesn’t have all of them (a proper subset). This is because, as listeners we assume that if the speaker wanted to refer to a girl with a total set of the microphones, he/she could have said all instead.

We examined the relationship between these interpretations by recording children’s eye-movements to a display. In the display there was a girl with 2 of 4 microphones and a girl with 3 of 3 microwaves. We were particularly interested in where they looked when they heard the sentence: “There is a girl who has some of the microphones.” Before the final por-

tion of the compound word (...phone) is spoken, the logical meaning of some is compatible with both characters. However, during this period, children should be able to predict the correct character (and look in that direction) if they generate an inference and restrict their interpretation of some to the subset (e.g., the girl with 2 of 4 microphones).

Earlier studies in our lab found that adults are able to generate an inference to predict the correct referent during the ambiguous window (...some of the micro-). However, the current study found that children at the age of 6-9 years looked at both of the girls equally during this ambiguous region, suggesting that they favor the logical meaning of “some” and did not generate an inference.



FINGER PUPPETS

Véronique Izard, Post-doc

In this study, we are looking at how young children, between the ages of 2 ½ and 3 years, understand the notion of quantity. At this age, most children interpret large number words as if representing approximate quantities (meaning something like “a lot”), and have not discovered yet what counting means. They can recite numbers in order, sometimes up to a very high number, but do not use counting spontaneously in novel situations. For them, counting is a sort of game that people do when they face sets of objects, but this game does not mean much more than other children songs. For example, when asked to give “three fish”, these children do not count to give the fish: instead, they just grab a handful of fish (usually more than three), and hand them to the experimenter. And they do the same thing when asked for four, five, etc.

In sum, it takes children almost one year between the moment they start to understand what the first number words mean (one, two), and the moment they use all number words correctly. At that point, they also start to understand that counting is a strategy for assessing quantities. Why do numbers take so long to learn? The difficulty children experience with numbers is all the more puzzling because we know that around age 2, children can learn up to 10 new words a day!

In the Finger Puppet study, we look at the children’s competence with quantities, in a setting where we are not using the words for numbers. In this study, we ask whether children are able to track a certain quantity of objects, and make sure that all the objects are present at all times.

The children played a game with the experimenter, which involved finger puppets. At the beginning, a

family of puppets were placed on the branches of a tree, such that each puppet had its own branch on the tree. Then, the puppets disappeared in a box (they “went to sleep”), and then we “woke them up”, and took the puppets back onto the branches. By looking at how the children searched in the box, we could infer when they thought we had all the puppets back on the tree.

The results show that 2-year-old children are able to use the branches to track the number of puppets present in the box, but only in some conditions. Indeed, sometimes we made the task more challenging, by having different types of events occurring while the puppets are sleeping in the box. For example, one puppet would leave the box temporarily to go to the bathroom, or one additional puppet would come out of the sleeve of the experimenter, or there was a storm that broke one of the

branches of the tree ... Altogether, we find that children are able to use the correspondence between branches and puppets when the group of puppets stays identical to the original group (such as, for example, when one puppet went to have a snack and then came back to sleep), but they are not using the correspondence when the group of puppets has changed (for example, if an extra puppet has joined the group). This shows at this age, children have some understanding of exact quantities, but this understanding is very fragile. Perhaps, the difficulty of the children to use one-to-one correspondence cues and track large quantities can explain why number words are so difficult to learn for them.

After more than three years of activity, this study has about been completed. More than 300 children participated! We very much thank all the families that came in for this study and made this research possible.



IMPLICIT ASSOCIATION TEST

Larisa Heiphetz, Graduate Student

Previous work in our lab has shown that children between the ages of 5 and 10 do not show explicit preferences for fictional characters based on their religion. For example, children don't show a strong preference for either a Christian or a Jewish character when we ask them whom they would rather be friends with.

To explore this finding further, we conducted a study where we included a reaction-time measure of preference as well as asking children direct questions. In this study, children heard about fictional Jewish or Christian characters and then answered questions about their social preferences. After completing this task, children played a short computer game where they were asked to categorize words and pictures as quickly as they could. This task is a modified version of the Implicit Association Test (IAT). In this game, we asked children to pair pictures representing particular categories (e.g., Jewish, Christian) with positive and negative words. We were interested in whether children responded more quickly when asked to pair one of the categories with positive words and the other with negative words, or if both types of pairings were equally quick. If participants are faster when using the same key to respond to Christian

+ good and Jewish + bad, this suggests that they may have an implicit preference for Christian over Jewish. If participants are faster when using the same key to respond to Christian + bad and Jewish + good, this suggests that they may have an implicit preference for Jewish over Christian. If participants are equally fast to respond in both conditions, this suggests that they may not have a bias towards either Jewish or Christian. We included this task to see whether the results of the IAT matched participants' self-reported responses.

Our results suggest that children from Christian backgrounds do not show an explicit preference for either of the characters. However, participants in this group tended to respond more quickly when pairing Christian + good and Jewish + bad rather than making the opposite pairing. Because most of our participants came from Christian families, we are unable to draw conclusions about participants from other types of backgrounds.

To learn more about the IAT, please visit the Project Implicit website:

<https://implicit.harvard.edu/implicit/>

STORIES

Larisa Heiphetz, Graduate Student

In this study, we were interested in how children respond to members of different religions. In particular, we were interested in how children reason about religions with which they are more familiar as compared with less familiar religions. To examine this question, we read children a story about a Christian and a Hindu character. During the story, we asked children questions about the characters as well as about their own preferences. After finishing the story and answering these questions, children played a computer game called the IAT (please see a description of this task in the description of the study above "Implicit Association Test").

We found that children from Christian backgrounds tended to ascribe bad behaviors, like stealing a toy, to Hindu rather than to Christian children. They were also

more likely to exhibit an explicit social preference for the Christian over the Hindu character. For example, when we asked children which of the characters they wanted to be friends with or invite to a party, they tended to select the Christian character. In addition, children from Christian backgrounds responded more quickly when we asked them to pair Christian + good and Hindu + bad in the computer game than when we asked them to make the opposite pairing. Because most of our participants came from Christian families, we are unable to draw conclusions about participants from other types of backgrounds.

We are interested in learning more about how children reason about different types of beliefs. Thank you to all the families who participated in our research!

WORDS WITH MULTIPLE MEANINGS

Maresh Srinivasan, Graduate Student

This set of studies looked at how children understand words with multiple related meanings. Many words that we use have more than one meaning, and often, different words have patterns of meanings that are like one another. For example, the word book can refer to either an object (as in a red book) or to the content that that object contains (as in an interesting book), while other words like video, and magazine can have similar kinds of meanings. And there are many other examples. Words like chicken and corn, for example, can refer to animals or plants, but also to the food derived from them. These words are different than words like bat, which have multiple meanings that are unrelated. In this set of experiments we were interested in whether children conceive of the different related uses of words like book and chicken as uses of the same word, or as two different words.

Your child watched puppet shows in which Sesame Street interacted with each other and with objects. Another puppet, Elmo, watched the stories along with your child. When the story was over, Elmo would say what had happened in the story, and your child would decide if Elmo was right or wrong. Before the stories began, our method was to teach your child a novel word to refer to just one meaning of a word with multiple related meanings. We would then observe whether your child thought the novel word could be used with the other meaning of that word. For instance, Elmo might have taught your child that the word devo means corn, referring to a plant. Then we would tell a story, for instance,



in which Cookie Monster was at a farm and dug out a corn plant and put it in a box, and then later went home for dinner and put kernels of corn on a plate. At the end of this story, Elmo would say “I know what happened, Cookie Monster put the devo on the plate.” Of interest to us was whether children would think that the word devo could refer to the kernels of corn, or whether they thought it could only refer to corn plants. We reasoned that if your child thinks that the different uses of these words are uses of the same word, they should be willing to accept the extended use of devo, but if they think that the different uses are separate words, they should not.

The results are in, and they suggest that while children think that the uses of words like book, chicken, and corn, are uses of the same word, they think that the uses of words like bat are in fact different words. Thus, even young children have a sophisticated understanding of the flexible ways in which words can be used.

Thank you for your participation!



OBJECT MOTION AND GRAVITY

In-Kyeong Kim, Visiting Scholar

INFANTS' KNOWLEDGE OF GRAVITY

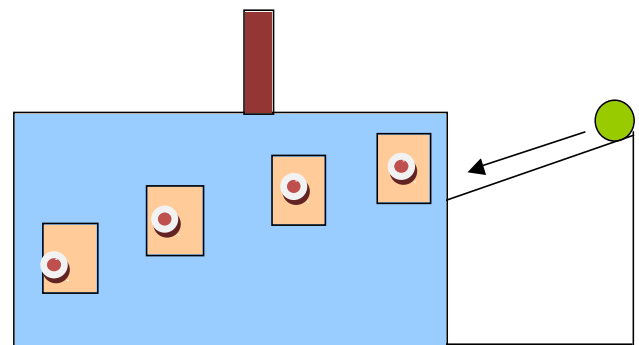
Do young infants know that objects fall until they hit the ground if they are dropped in midair? Do they know that objects do not stay in midair with no support? Previous research has shown that young infants are sensitive to the effect of certain physical laws on object motions. For example, we know that 2 ½-month-old infants understand that one solid object cannot pass through another solid object, and the same object cannot be in two different places at the same time. Past research has also shown that infants are sensitive to the effects of gravity on object motion. In one study, six-month-old infants were presented with a ball that was dropped behind an occluder. In one condition, when the occluder was lifted, the ball was placed on top of a solid surface. In the other condition, the ball was placed in midair when the occluder was lifted. Infants were surprised by the midair event that violated the gravity effect, and they looked longer at that unnatural event than at the natural event.

There has also been research on what children know about gravity and how their knowledge changes over the course of development, starting in early childhood. The current study explored these changes in an earlier stage of infancy. Four-month-old infants were presented with a fully visible version of the aforementioned infant study of gravity. First, infants were shown events of a ball and a solid surface directly beneath the ball. Then they watched computer-animated stimuli of the ball being dropped, falling, and landing on the solid surface (natural) or the ball being dropped and stopping in midair (unnatural). This is still an ongoing study, and it is too early to draw conclusions. So far, there is no significant difference in how long infants look at the two types of events.

YOUNG CHILDREN'S UNDERSTANDING OF SOLIDITY

In this study, young children's understanding of the concept of "solidity" was explored. Previous studies have shown that young infants are sensitive to the effects of solidity. For instance, in one study, infants were sur-

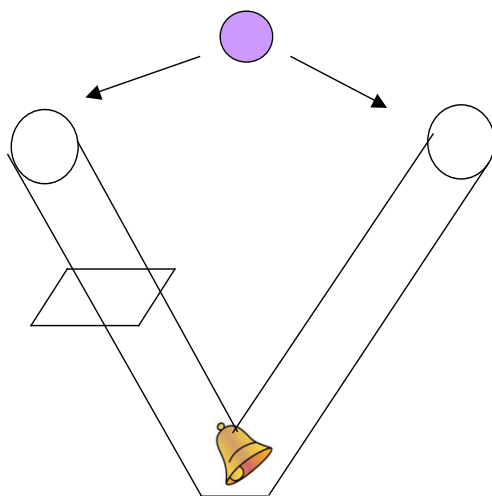
prised to see a solid object pass through another solid object. Other studies with young children have shown contradictory results for the same concept of solidity. In one such study, two-year-old children were presented with a ramp that was covered with an occluder with four small doors. A solid barrier was placed behind one of the doors, and a ball was placed and rolled down the ramp. If children understood that the solid barrier should have stopped the ball, they should have opened the door that was close to the barrier in order to find the ball. However, two-year-old children failed to choose the right door when they were asked to search for the ball.



Further studies tried to figure out why young children failed on this solidity task using a search method, while young infants passed the same solidity task using a looking pattern method. These follow-up studies have focused on representations of objects and events, toddler's use of cues in a search task, visual access, attention, and memory. More recent research has used point-of-gaze measures, but all of the studies consistently showed young children's failure on the solidity task using the search method.

This current study used a different method: a prediction test of the solidity concept utilizing fully visible events. This prediction test minimized memory load, attention load, and also minimized contact mechanics unlike previous studies that involved the actual motions of objects.

In this study, 1 ½- to 3 ½-year-old children participated. Two identical clear plastic cylinders that converged into a single tube were placed on a table facing the child. A golden bell was then placed inside the tube. A ball was dropped inside one of the cylinders and hit the bell, making a ringing sound. The same procedure was repeated with the other cylinder. Next, a small, wooden rectangular block was placed in the middle of one cylinder, and this obstruction kept the ball from passing through the tower and from hitting the bell. After this presentation, the child was asked to predict and place a ball into one of the cylinders in order to make the bell ring. If they understood that the ball would not pass through the obstructed cylinder but that it would pass through the unobstructed one, they would choose the unobstructed cylinder.



This is an ongoing study, and does not have final results yet, but preliminary findings show that young children (1 ½- to 3-year-olds) did not choose the unobstructed cylinder more often than obstructed one. However, this does not mean that children do not have a solidity concept. In order for them to pass this task they needed to do several things: have good perceptual comparison, have a concept of solidity, have the ability to make predictions in quite complicated sequential tasks, be able to make decisions and understand goals (to ring a bell), have the motivation to pursue their goal, and understand object space in a clear, plastic tube used in this experiment. Further studies with some of these variables are now being explored.

PREDICTION, SEARCH AND PERCEPTION OF OBJECT MOTION

In this study, developmental changes in physical knowledge of gravity, inertia, and support were studied. This study compared participants' perceptual and cognitive physical knowledge by using three different types of tasks: a prediction task, a perception task, and search for hidden objects task. Each task asked participants to make judgments about the expected movements of a rolling ball.

Four- to eleven-year-old children and adults were presented with a ramp and four small containers placed immediately in front of the ramp. In the first condition (prediction task), participants were asked to predict which container the ball would fall into if it were released from the top of the ramp and allowed to roll down the length of the ramp. In the second condition (search task), an occluder with four drawers that could be opened was placed immediately in front of the ramp. Participants were asked to search for the ball after it was released from the top of the ramp, rolled down the ramp, disappeared behind the occluder, and fell into one of the four drawers. In the third condition (perception task), participants were presented with four different fully visible computer animated motions of a ball rolling down the ramp and falling off the edge of the ramp. Participants were then asked to choose which trajectory of the ball they believed most closely resembled the natural motion of the ball.

Results showed that most of the younger children predicted that the ball would fall into a container closest to the ramp, but most of the older children chose containers that were farther from the ramp. Results also showed dissociation among the three tasks for younger children. Specifically, younger children were more accurate in their search patterns than they were in their responses on the prediction and perception tasks. Unlike the younger children, older children and adults did not demonstrate task dissociation and also did not have significantly more accurate responses on the search task compared to the prediction and perception tasks. Instead, their reaction patterns were similar for all three tasks (perception, search, and prediction).

COUNTERINTUITIVE CONCEPTS

Koní Banerjee, Lab Manager

What do a talking tree, an invisible rabbit, and a frightened hammer all have in common? They each violate our psychological, physical, and biological expectations about how objects and agents in the natural world typically behave. In other words, these concepts are all counterintuitive. When counterintuitive concepts violate just a few of our expectations but conform to all others, they are called minimally counterintuitive. One interesting characteristic of minimally counterintuitive concepts is that they are highly memorable. In fact, research with adults has shown that minimally counterintuitive concepts tend to stick out in our memory better than entirely intuitive concepts that fit our expectations perfectly. For example, we are more likely to remember a plant that can turn invisible at will over a plant that always stays rooted into the soil.



We know that adults remember minimally counterintuitive concepts better than intuitive concepts, but do children do the same thing? One thing we know for sure is that children are highly familiar with counterintuitive concepts such as Santa Claus, the Tooth Fairy, and the magical creatures and characters of fairytales and fantasy books that are all common features of children's cultural narratives and traditions.

In this study, we read children a story about two kids who explore a new neighborhood and encounter a number of objects along the way. Six of the objects were minimally counterintuitive (MCI) and six were entirely intuitive (INT). For example, the children came across a crying mailbox (MCI) in one part of the story and a rusty stop sign (INT) in another part. Children were asked to listen to the story and to try to imagine the events in their heads, because they would be asked questions about it later on.

Next, children completed a short computer task in which they were asked to pick which two of three

angles shown on the screen looked the most similar to each other. This task was intended to temporarily distract the children from the story they had just heard. Afterward, they were asked to think back to the story and to recall as many details from the story as they could remember. Their answers were recorded and coded so that we could determine whether children recalled the MCI and INT concepts at different rates.

We were also interested in whether children recalled the two types of concepts differently after a delay of one week. To study this, we called families at their homes one week after their lab visit and asked children to recall everything they could remember about the story they had heard a week before. Children did not know that they would be contacted for this delayed recall task, so they had not rehearsed the story during the week since their lab visit.

So far, we have found that children, like adults, recall MCI concepts better than INT concepts, both during the immediate recall task in the lab and also one week later. Children consistently recalled the six objects paired with a MCI description better than the six objects paired with an INT description. They also remembered the MCI concepts in greater detail than the INT concepts both immediately and after a delay. These findings suggest that minimally counterintuitive concepts enjoy a memory advantage not only for adults, but for children as well. Thanks so much for your participation in this study!



MUSIC AND SPACE

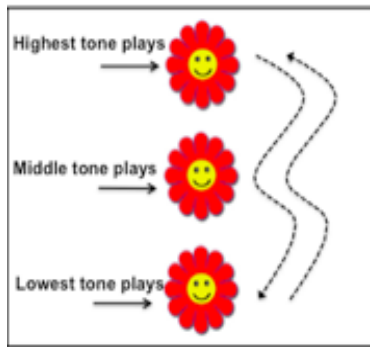
Rachel Katz, Researcher

We often use spatial metaphors to represent dimensions that are not spatial in nature. For example, in the domain of music, we speak of tones being “high” or “low” in pitch. This study investigates whether infants share this same intuition. Previous

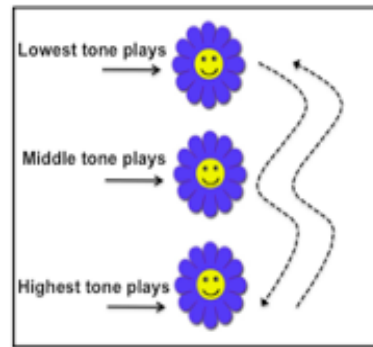
studies in our lab have shown a connection between music training and spatial abilities, but the origins and development of this association are unknown. Past studies have also shown that adults link changes in pitch to changes in height, suggesting that we may represent sounds in various spatial positions when we hear a melody or tone sequences. There is also evidence that infants are sensitive to this relationship as well. This study explores the origins of the association between musical and geometrical processing in four-month-old infants. We are interested in whether infants can detect relationships between sequences of musical tones and sequences of spatial positions.

In the first study condition, we presented infants with movies in which a flower danced in two vertical spatial positions (high or low) while sequences of musical tones played. Flower positions and tones were presented in either a forward pairing in accord with the pitch/height relation that adults judge as congruent (the flower appeared in the low position when the lowest tone played and the high position when the highest tone played) or a reversed pairing (the flower appeared in the low position when the highest tone played, and the high position when the lowest tone played). We were interested in whether infants preferred the forward pairing of tone and space over the reversed pairing. We found that infants looked equally long at both pairings, suggesting that they may not have an inherent preference for a particular type of pairing.

Next, we were interested in whether infants would find



Forward Mapping



Reversed Mapping

it easier to learn the forward pairing of tone and space than the reversed pairing. In the second study condition, one group of infants was shown movies of flowers dancing in three vertical positions (high, middle, low) in time to three-note sequences presented in

the forward pairing. A second group of infants was presented with the reversed pairing of tones and flower positions. When infants were no longer attentive to these movies, both groups saw the same test movies shown to infants in the first study condition. We found that infants preferred to look at the forward mapping of tones and flower positions only when they were familiarized to this forward pairing beforehand. Infants who initially saw the reversed pairing of tone and space did not show a preference for either the forward or reversed pairings during the test movies. This suggests that although infants may not show an intrinsic preference for the forward over reversed pairing of tone and space, they do distinguish forward from reverse mappings and are predisposed to learn the forward mapping of tone pitch and height over other mappings.

In the third study condition, we wanted to know whether infants continue to perceive a relationship between tone and space when these two types of information are presented separately. Infants initially heard either ascending or descending five-note sequences without any corresponding spatial display. They then watched movies with purely spatial information, in which a flower moved silently up and down on the screen, with no accompanying music. We hypothesized that if infants automatically map spatial and tone information congruently, then if they initially heard one pattern of musical tones (for example, ascending notes), then they should prefer to look at a novel pattern of spatial movement (for example, descending flowers). Data analysis for this condition is still in progress. Stay tuned!

FOUR-YEAR-OLD CHILDREN'S USE OF REFERENTIAL CONTEXT- Three Part Study

Carlyn Friedberg, Lab Manager

In this three-part study, we investigate young children's use of visual and verbal information when processing spoken language. Children as young as four years use similar moment-to-moment processes as adults when interpreting an instruction like "scratch the fox with the paper." Depending on the accompanying visual scene, this sentence can mean use the paper to scratch the fox or scratch the fox that is holding the paper. Like adults, four-year-olds rapidly use prosody, knowledge of verb meanings, and the plausibility of the sentence when resolving these ambiguous sentences. However, while adults may integrate the visual scene into their processing, children are not as sensitive to the visual scene until age 7 or 8.

The use of visual scene, or referential context, can yield different interpretations depending on how many foxes are in the scene. If there is one fox present, adult listeners may take the ambiguous "with" phrase as an instrument for the verb and interpret the sentence as use the paper to scratch the fox. With two foxes present, adult listeners may take the ambiguous "with" phrase as a modifier for one of the foxes, and interpret the sentence as scratch the fox that is holding the paper (rather than the one holding the flower). We want to figure out how and why this sensitivity to referential context changes

over the course of young language learners' development.

In this three-part study, we investigate whether four-year-old children can learn to use the visual scene when interpreting ambiguous instructions. Their ability to use and generalize this cue will help us understand how young children quickly determine the grammatical structure of spoken language.

Children who participate in this study come into the lab on three separate occasions. For the first (pre-test) and third (post-test) sessions, we record their eye-movements as they look at a set of toys and listen to pre-recorded instructions. As the sentence unfolds, eye-movements give us an idea of how they are processing the sentence and what they expect to hear during real time. We also record their actions, or responses to the instructions, during each session.

During the first and third sessions, children hear ambiguous instructions like "scratch the fox with the paper" when there is one fox or two foxes present. Both the modifier and instrument interpretations are possible. To teach children that the visual scene is useful in resolving ambiguous instructions, they hear unambiguous instructions during the second session. If there is one animal-referent present, only the instrument interpretation is possible; two animal-referent scenes can only result in the modifier interpretation. We compare their eye-movements and actions before and after the unambiguous second session to see if they can learn to more consistently utilize visual cues when processing ambiguous language.

Data collection continues. So far, children's actions across the pre- and post-tests reveal that they may be able to distinguish between one-referent and two-referent contexts during processing.



INTUITIONS FOR MULTIPLICATION

*Véronique Izard, Post-doc
Danielle Hinchey, Researcher*



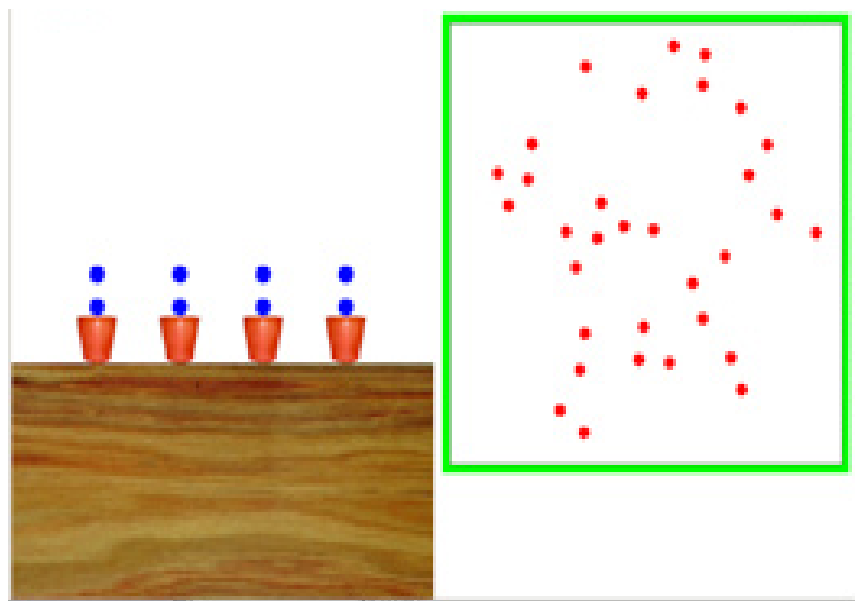
By the age of 5 or 6, children start to have a good understanding of numbers: they can count flexibly, and even engage in some arithmetical operations. For example, in kindergarten children can guess the approximate results of additions and subtractions. These intuitions are very useful in school, when children learn about additions and subtractions.

In this study, we asked whether these intuitions extend to the case of multiplication. Indeed, multiplication seems to be much less intuitive than addition or subtraction for adults, and most adults rely on root-learned tables when they have to compute a multiplication.

The test was presented on a computer. Children were introduced to two characters, Dora and Sponge Bob, playing with marbles. We explained that Dora was very organized and liked to keep her marbles in buckets; she had many buckets, and put the same amount of marbles in each bucket. The children were not shown the to-

tal amount of marbles that Dora owned at first; rather, they were shown how many marbles Dora kept in each bucket, and how many buckets she had. So, to guess how many marbles Dora had, children had to mentally multiply the number of marbles shown in one bucket, by the total number of buckets. Sponge Bob, however, was messy, and just kept his marbles in the floor. In each trial, children were invited to compare the number of marbles owned by Dora and Sponge Bob.

The animation went very quickly, but children were very good at guessing, even sometimes better than the experimenter! In this study, we tested children of various ages ranging from 5 to 12, and found that intuitions for multiplication are present very early on, even before children learn multiplication tables in school. Such kind of intuitions should be now exploited at school, to design education programs capitalizing on the children's initial knowledge.



INFANT SYMBOLIC UNDERSTANDING

Nathan Winkler-Rhoades, Graduate Student

We're currently seeking an answer to the question "what do babies think pictures are?" Because objects like photographs are such recent technological innovations, and because they so powerfully resemble what they depict, there is reason to wonder whether babies might initially make the mistake of treating a picture as if it were an instance of what it depicts. To assess this possibility, we've been interviewing infants ages 9-13 months by simply showing them a short book of color photographs while they sit in their caretakers' laps. We measure how the infant interacts with the book: does she pat the surface or play with the binding, as if interested in the form of the book, or does she touch or grasp at the depicted object, as if trying to interact with the content of the book?

We're finding that the majority of infants try, at least once, to grasp at the depicted object. These adorable at-

tempts could of course owe to many causes—perhaps they are merely exploring the book to see whether the depiction has a different texture from the background, like in the popular children's book *Pat the Bunny*. We suspect, however, that these gestures might reflect infant's underdeveloped understanding of symbolic media. Because slightly older infants do better interpreting pictures when they are labeled, we wondered whether labels might influence even young infants. Does labeling a picture make infants less likely to manually explore it? We don't have an answer yet, but the early results suggest that there is indeed less picture-grasping when the content of the picture is named.

In a second study along similar lines we investigated infants' abilities to interpret symbolic acts. We know that adults have a very general talent for interpreting symbolic acts. If I want you to pass me the phone, I could use my words to ask you, I could draw you a picture of a phone, I could point to the phone, I could make a phone-answering gesture, and so on. Some researchers have taken this phenomenon as evidence -31- that human language isn't special—it's just one of

many ways that we are able to communicate with each other. If this were true, we would expect this general talent to be reflected in children, too. Is it?

In this study, we wanted to know whether 18-month old infants might be able to use a picture in the way we know they can use a word—to update their beliefs about reality. We showed infants a box with a spandex opening, and demonstrated that interesting objects could be hidden in the box. In one condition, infants weren't allowed to see what was in the box. Instead, after hiding an object out of view, we showed infants a picture of the hidden object and told them that it showed what we had hidden (we either named the object—"look, this

is a dax! There is a dax in the box!"—or we referred to it without naming it—"look at this one! This is what is in the box!"). When infants were finally allowed to reach in the box, we played a

trick on them: on some trials, we lied about what was hidden. Our prediction is that if infants can use the picture to make a prediction about what is hidden in the box, they will be surprised (and therefore reach back into the box more persistently) when they find something different from what the picture showed.

So far, we haven't confirmed this prediction; infants seem to reach back into the box just as often when the picture was true as when it was false. So, in another condition, we wanted to figure out whether this owed to their symbolic understanding, or to something funny about the task. So we designed a version of the task that had no symbol involved—infants simply watch as an object is hidden in the box, they get to reach in and find it, and they find either what they saw us hide or something different (a feat enabled by a secret trap door on the back of the box). So far, infants seem to be performing better in this condition, which suggests that they may not yet be able to use a picture as a symbol in quite the way they are able to use words.



MAPS for 2-YEAR-OLDS

Nathan Winkler-Rhoades, Graduate Student

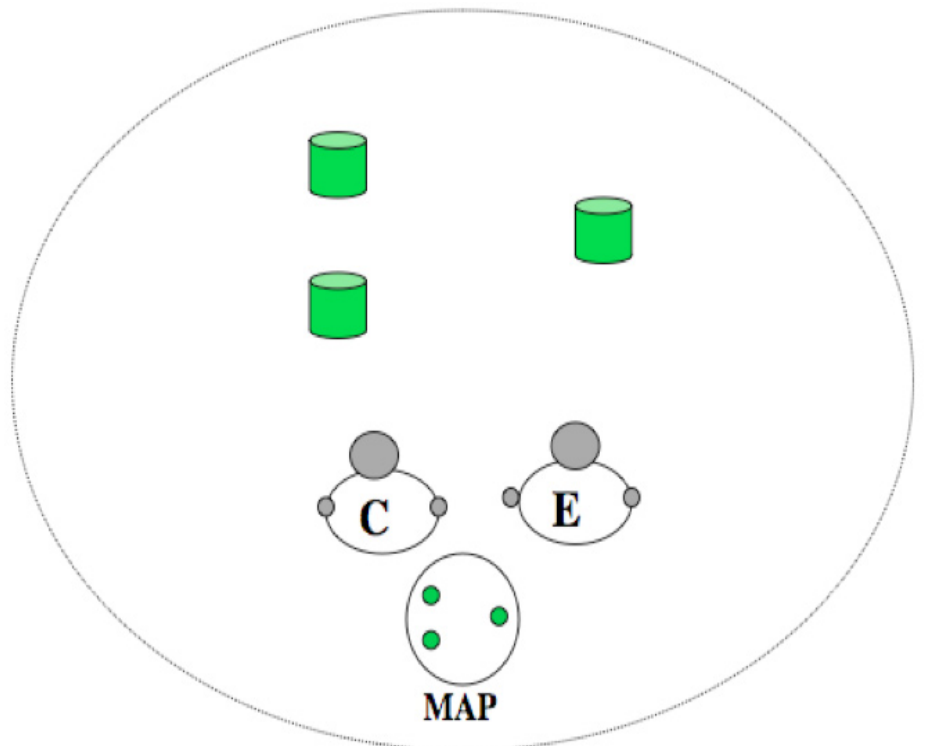
This year has seen the continuation of several closely related studies on children's symbolic development in the domain of pictures and maps. We study children's intuitions about symbols with which they have had varying degrees of experience, because these intuitions shed light on the nature of human communication. How readily do young children appreciate that a picture can carry information about the world? What factors determine when children see a picture as just a piece of paper versus an object that refers to something else?



Two ongoing studies address these questions. In the first study, we wanted to know if children could use the iconic nature of pictures—the way that they bear a visual similarity to their referents—to figure out what they represent. It may seem obvious to adults that they can (how else might children understand pictures??), but studies in our lab suggest a powerful mediating role for language, wherein children seem incapable of reasoning about pictures whose contents are unnamable. To get to the bottom of this question, we reasoned that, if names are necessary for understanding the reference of pictures, children should have more trouble reasoning about a picture of a novel (unnamed) object as opposed to a picture of a familiar (named) object. We designed a made-up object and asked chil-

dren to find it using a drawing of the testing room. As we predicted, when the object was left unnamed children were unable to locate the object, even though the picture was highly iconic, suggesting a powerful role for language. (Previous studies confirm that 2-year-olds are capable of passing this test with familiar objects.) We are now following up to see whether children succeed when we tell them a name for the object.

In the second study, we ask how readily children can use different kinds of symbols as cues to the location of a hidden object in a hide-and-seek game. We have found that from 24 months, children can use a photograph for this task, and that from 30 months they can use a small model room. As in the above study, though, there is a powerful role for language: children (C) are much better at the game when experimenters (E) give them names for the locations of the hidden object. This is further support for the idea that the language faculty is critically involved in children's ability to interpret pictures.



SOCIAL and SPATIAL RELATIONS

Lotte Thomsen, Graduate Student

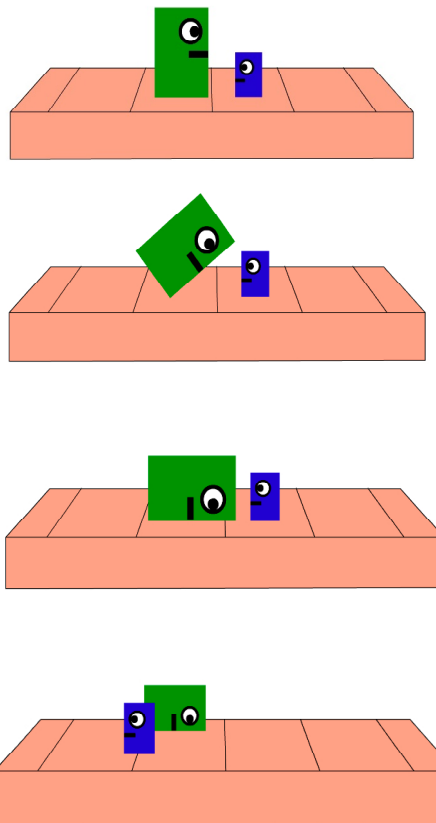
Our Focus

In the last newsletter, we described a study that tested if infants understand when the goals of two agents conflict and if they expect the bigger agent to “win” over the smaller one in this case. Specifically, we showed infants a large and a small agent walking towards one another across a stage and meeting in the middle, blocking each other’s way. After this, one of the agents prostrated itself for the other and scooted to the back of the stage, yielding the way to the first agent. Since the last newsletter we have continued this research program, first pin-pointing the age at which infants start to understand the social dominance aspects of these situations: Whereas 8-month-old infants have no expectations as to whether the larger or the smaller agent will yield to the other one when one blocks the other’s path of motion, by 9 months infants begin to expect that the smaller agent will get out of the way of the bigger one. By 10 months, infants are robustly surprised if a small agent “wins” over a larger one.

Additional control studies

When we submitted these results for publication, the reviewers asked us to make sure that infants were not simply surprised because they expected small agents, but not big agents to trip over. After all, older infants have plenty of experience with falling over when trying to walk, and plenty of experience that adults tend not to fall. To test this possibility, an additional control study showed infants a large or a small agent walking across a stage, but this time one agent walked to the end of the stage before the second agent appeared behind him. The second agent then walked to the center of the stage where it performed the exact same bowing action as in the original study. If infants were simply surprised in the original study because

they expected small, but not big agents to trip over, then they should have been equally surprised in this case. However, if infants were surprised when the large agent bowed down and moved away from the path of the small agent because of their expectations about social dominance in situations of conflicting goals, then they should be no more surprised if a large agent bows down in this situation than if a small one does so, because the goals of the agents no longer conflict. This is the result we found.



At the moment we are also finishing an additional control study designed to exclude the possibility that our original results were simply due to infant preferences for full versus partial occlusion: In the original study, when the large agent bowed down and moved to the back of the stage, the small agent partially occluded it when passing. In contrast, the large agent fully occluded the small agent when passing it in the back of the stage. In the new control study we use the exact same differences of full versus partial occlusion, but this time we have taken out the conflicting goals of the situation by showing infants that the two blocks can easily pass each other. Again, if our original results were simply due to the differences between partial and full occlusion, then we should also

find differences between this in the control study. Conversely, if our original results were due to expectations about conflicting goals, then infants should no longer differentiate between full and partial occlusion now that the goals between the agents no longer conflict in this situation. Our preliminary results suggest that this is indeed the case.

We’re looking forward to resubmitting this work for publication—thanks for all your help!!

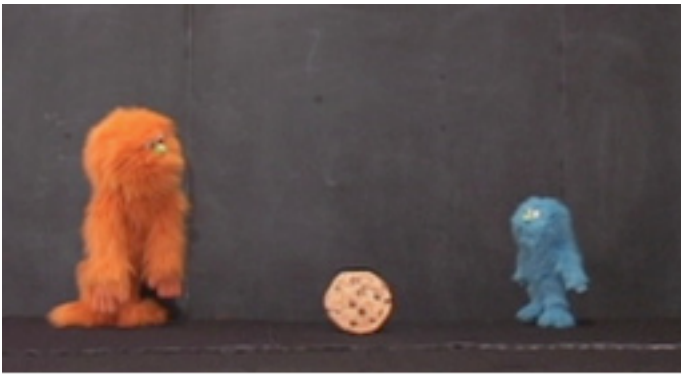
SOCIAL and SPATIAL RELATIONS- The Cookie Study

McCailla Ingold-Smith, Lab Manager

This study builds on our previous work with social and spatial relations—the animations of rectangles battling for “right of way.” We are curious to see whether infants understand other types of shared goals. To do this, we created a paradigm with puppets. Both puppets want a cookie on the stage. In the test event, the puppets bump heads as they reach for the cookie at the same time. Then, either the larger puppet gets the cookie and

eats it, or the smaller puppet does. If infants view this event in the same light as the “right of way” study, they should be more surprised when the little puppet “won” the competition for the cookie over the larger puppet.

We tested 12-14 month-olds as well as 18 month-olds, and what we found surprised us. Neither age range looked longer at any one of the test events. This is especially surprising considering how actively engaged children were in the videos. We had many children coo, point, clap and even dance with the monsters. These results could be due to the fact that something is special about food-sharing and the same rules regarding dominance don’t apply. They could also be due to the fact that the puppets themselves are so engaging that children aren’t paying attention to the crucial elements of the videos. To follow up, we’ll be running the same study with animations and we look forward to sharing the results with you in the future!



MAGNITUDE: 3 and 4 year-olds

Lola de Hevia, Post-doc

When we adults think about numbers we tend to generate spatial images. With this experiment we are trying to understand if the relationship between space and number that we find in adults and infants is specific to number and space, or whether it extends to other continuous dimensions, like brightness. In fact, some experiments with adults have shown that if we are presented with a small number like ‘2’ with a high level of brightness, we are slower in deciding that that number is small, in contrast to the situation in which the same number ‘2’ is presented very dark. Similarly, if the number ‘2’ is written with a large font, we are slower to think of that number as a small magnitude.

In this experiment we have devised a board game that consists of matching cards across the three dimensions: number, length, and brightness. Thus, the cards present different numbers of dots, lines of different lengths, and objects with different levels of brightness. At the

beginning we show the kid how to play the game, so that the experimenter matches some cards, and leaves the last card without a match. The kid is then asked help to find the missing match.

We have found that children are above the chance level when matching number to length: they understand the rule that the larger the number is, the larger the line should be. However, they perform at chance in the other matchings, for number and brightness, as well as for length and brightness: they do not accept the rule that the larger the number, the brighter the object, or that the larger the line, the brighter the object. These results suggest that there is a more natural and intuitive relationship between certain continuous dimensions, like space and numbers, than between others. This special link might be on the basis of the predisposition of generating spatial images when thinking about numbers.

GEOMETRY in TWO-DIMENSIONAL SHAPES

*Véronique Izard, Post-doc
Danielle Hinchey, Researcher*



When learning about geometry, there are many different aspects of shapes to attend to: the length of the sides, the angles at the corners, the relative disposition of the elements of the figures... On the contrary, children must learn that other types of variations are not very important: a rectangle is still a rectangle whether it is presented in horizontal orientation, in vertical orientation, or tilted. We know very little about children's sensitivity to these different aspects of shapes.

The goal of this large exploratory study was to learn what aspects of geometrical figures children are sensitive to at different ages. We tested children of very different ages, ranging from 4 years to 12 years. In each trial, children saw a sample of 6 shapes, and were asked to indicate which shape they thought was "very different" or "most different".

The task was difficult for the younger children; still, even at 4 years of age, children were sensitive to variations of length and of angle. Impressively enough, we found that children were sensitive to angle, even when the images presented pairs of lines that did not cross (as in the right illustration). In these cases, the two lines on each image were slanted with respect to each other, so

that they could still be considered to form an "angle" (if you imagine extending the lines until they cross).

These studies enabled us also to investigate another question, namely: when do children start recognizing remarkable figures as special? We studied two types of remarkable figures: right angles, and parallel lines. Would children say that a right angle is a "different" type of angle, when presented amongst different acute or obtuse angles; or would they say that two parallel lines are "different", when presented amongst other pairs of non-parallel lines?

We found that children become specifically tuned to right angle, around the age of 8-10 years, probably as a result of learning about right angles at school. In contrast, parallel lines appear much more intuitive: even 4 year old children pointed out the parallel lines as different.

These results help us understand what aspects of geometry are most intuitive; and perhaps it could inspire teachers to present activities centred on angles and parallelism starting in preschool.



FRAGMENTED MAP STUDY

*Véronique Izard, Post-doc
Danielle Hinchey, Researcher*

Studies run these past years in the lab have shown that preschoolers are able to read simple maps referring to their environment. For example, in one study we had a big triangle structure, and a “map” or “picture” showing a triangle, that looked just like the big triangle, except it was much smaller. Children proved able to use that map to navigate in the real triangle, and find the places corresponding to different cues on the map.

There are various types of information that can be used when reading such maps: children could use the relative lengths of the sides of the triangle (“I need to go to the smallest side”), or the angles at the vertex (“I need to go to the smallest angle”), as well as left/right distinctions (“I need to go to the right of the small angle”). In the current study, we tried to find out which type of information preschool children are able to read from a map.



Children were introduced to a frog, Lucy, who lives in a house made of big orange walls. Because Lucy can not talk (indeed, she is a frog), she uses a picture to tell us where in her house she would like to go. Children were invited to help Lucy find the places she had indicated to them on her map.

In some trials, we introduced one further trick. Sometimes, Lucy had a “magic picture”, where pieces could be taken out. This enabled us to present some kind of information in isolation, without the full context. With this manipulation, we tested whether children could still solve the task, given only angle, length, or color information.

Children solved the color problems very easily. This indicated to us that they really understood that the map referred to the real house, even after the pieces had been taken out. In contrast, around the age of 4, children seemed to have difficulties with the angle trials. We think this may be because it is hard for them to extract the angles from the 3D triangle structure that served as Lucy’s house. However, when children reach the age of 4 ½ to 5 years, they progressively grasp the angle trials: children seem to learn a lot about angle in their fifth year of age. What exactly they learn, and how they learn it, still remains a mystery at this point! We hope that further research will help resolve this puzzle.

NUMBER and the INFANT BRAIN

Dan Hyde, Graduate Student

For several newsletters we have reported progress on our investigation of the neural basis of numerical abilities in infants. We are pleased to announce that the first wave of these studies is now complete. Below you will see a summary of the findings and suggestions to where we are going in the future.

Optical imaging shows right parietal specialization for number in infants

Using a newly emerging technology (Near-infrared Spectroscopy/NIRS), we observed brain specialization for number in 5-6 month old infants. In this experiment, infants saw different pictures of the same number of objects over and over with an occasional “test” image that either contained a different number of objects (number change) or differently shaped objects (shape change). Responses to “number change” were isolated to a right inferior parietal region of the brain. Responses to “shape change” were isolated to right lateral occipital regions of the brain. Importantly, the regions that responded to number and shape changes showed specialization for these properties. That is, they responded to only one type of change. The area that responded to number in infants corresponds to the area shown in other studies to respond to both non-symbolic (collections of objects) and symbolic (like Arabic digits) number in human adults.

One difference between this study with infants and findings from other studies with adults is that the infant brain response was restricted to the right side of the brain in infants, where adults show activity in both sides of the brain. We are planning to follow up on this finding by systematically studying when left-lateralized activity for number emerges and what it means. We are also planning to use this technology to study other topics like the neural basis of social thinking in infants.

Brain electrophysiology shows two distinct systems of number in infants

Under most circumstances we can easily recognize the exact numerical value of 2 or 3 objects instantly but fail to identify amounts of larger numbers without counting them. Why is this so? We investigated the possibility that this phenomenon is based in a distinction the brain makes very early in life. Using measures of scalp electrophysiology (EEG/ERP), we observed small quantities (1-3) to be represented differently by the infant brain compared to larger quantities (8+).

In this study, infants viewed blocks of novel images that either contained the same number of objects (no change), alternated back and forth in the number of objects by a small magnitude (small change), or alternated back and forth in the number of objects by a large magnitude (large change). Half of the infants saw only small quantities in these three conditions (1, 2, & 3) and half the infants saw only larger quantities in these conditions (8, 16, & 32). What we found was that the brain response to small quantities was sensitive to the actual number presented, but not the amount of change. The brain response to larger quantities was sensitive to the amount of change, but not the actual number presented.

The observed patterns of response, specifically the distinction between large and small number processing, parallel those observed in our lab with adults. Together, this evidence suggests that difference in the way we experience small and large quantities arises naturally before formal language or numerical abilities. In future work we would like to see if there are individual differences in the brain signatures of number processing and if these can be used as markers of later mathematical achievement.



BOX SEARCH STUDY

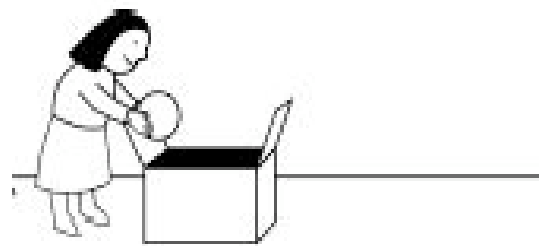
Lindsey Powell, Graduate Student



During the preschool years, children learn many new things, including conspicuous skills like how to count or recite the alphabet. Lots of less obvious learning is going on as well, however, and one major change that occurs around 4 years of age affects how children think about other people. It seems to be around this time that children begin to talk and reason about other people's beliefs. Two- and 3-year-olds often talk about people's feelings, but only rarely bring up beliefs. More importantly, these younger kids often fail to take others' beliefs into account when predicting what they'll do. For example, if a girl puts some candy in a drawer and her mom later moves it to the kitchen, 2-year-olds and young 3-year-olds are likely to predict that when the girl wants to find the candy she'll look for it in the kitchen, even if she doesn't know her mother moved it there. In contrast, 4- and 5-year-olds are much better at using the girl's belief about the location of the candy to predict where she'll look for it.

Our research investigates the mental skills that children need to consider others' beliefs. In particular, we think that the development of self-control may be important for thinking about others because kids (and adults) may need to actively inhibit their own knowledge in order

to think about someone else's point of view. The Box Search Study tested this hypothesis with two groups of kids. For one group, we first tried to deplete the children's self-control resources by leaving them alone with a box of toys for 5 minutes while instructed not to play with the toys. The other group simply got to play with the toys for those 5 minutes, presumably not depleting their self-control. Afterward, we told both groups several stories involving two characters and some objects they hide in a box. In two stories, one character ended up with a false belief about the location of an object, while in the third story he knew where everything was. After each story, we asked kids to predict where the character would look for the object. The children who went through the self-control depleting wait in the first part of the study were more likely to ignore the character's false beliefs in the second part, predicting that he would simply look for the object where it was. Thus, it seems like our hypothesis was correct – self-control is an important tool for children when they need to change perspectives and think about how someone else sees the world.

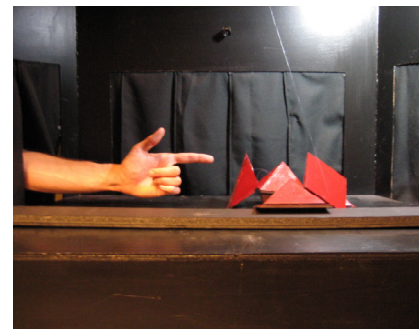
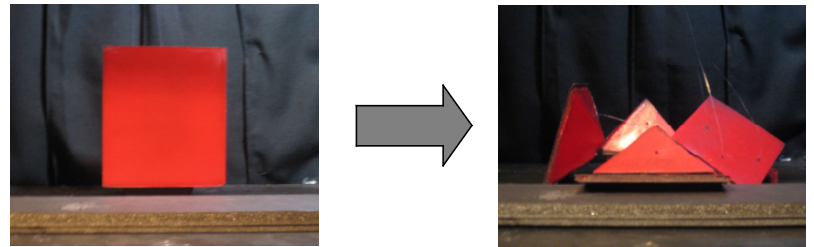


CAUSAL REPRESENTATION STUDIES

Paul Muentener, Graduate Student

What do infants understand about causal events? How do they think different objects and people should interact in their environment? As adults we can reason about the causal relationships between any two individuals (object and people) and in any type of event (such as moving an object or popping a balloon). Over the past few years, however, we have found that infants' causal representations seem to be much more limited. In our prior studies, we have explored infants' causal representations by asking whether infants were surprised by action-at-a-distance. Infants were shown occluded events in which a hand acting intentionally, a hand acting unintentionally, or a toy train moved behind a screen towards a box that then broke apart into several pieces. We then showed infants unoccluded events in which the hand/train either contacted the box and the box broke or stopped short of the box and the box broke. If infants thought that the hand/train caused the box to break apart, we reasoned that they should be surprised if the hand/train stopped short of the box, but the effect still occurred. We have found that infants were only surprised by these events when the hand acting intentionally was the agent. This suggests that infants only thought that the hand caused the box to break apart, and that infants may only represent hands (or people) acting in a goal-directed manner as likely causal agents.

Over the past year, we have been working on a study that aims to find a similar pattern of results. In this study, rather than asking whether infants are surprised by action-at-a-distance, we asked whether infants cared about the order of events. Eight-month-old infants were again shown occluded events in which the hand/train went behind a screen towards a box that then broke apart. Therefore, they saw two mini-events: The action of the hand/train and the effect of the box (its breaking). If infants represented the hand/train as causing the box to break, then they should be surprised if the box breaks before the hand/train's action. This is



what we asked in the final portion of the study. Infants saw either a consistent event, in which the hand/train approached and contacted the box, which then broke apart, or an inconsistent event, in which the box broke first, and then the hand/train approached and contacted the box.

Since last year's newsletter, we have completed the full study and have found a pattern of results similar to our prior studies. Infants seem to be surprised when the box broke first only when the hand acted in an intentional manner, but not when it acted unintentionally or when a train was the potential agent. These studies continue to advance our understanding of the development and origin of causal reasoning. These findings suggest that causal reasoning may be rooted in infants' understanding of human action as capable of causing events in the world. Early in development there may be a bias for infants to better understand that their own intentional actions (and other people's intentional actions) are causal actions, and then gradually come to understand that other types of actions (unintended actions) and objects can cause effects to happen in the world.

SYNCHRONY and SOCIAL PREFERENCES

Adena Schachner, Graduate Student

Singing and dancing are a big part of childhood-- but how does moving to music effect our social relationships? Recent work with adults has shown that after one person has moved in synchrony with another, the two people like each other better and will be more willing to cooperate. In comparison, adults who have made the same movements, but not in synchrony with one another, cooperate to a much lesser extent. We're wondering: how do these social effects develop? Does synchrony enhance social bonds even in infancy?

To get at this question, we showed one-year-old infants pairs of videos of people dancing: one with a person moving in synchrony with the musical beat, and another one with a person producing the same movements, but this time not lined up with the musical beat. Then, both of these people appeared on-screen at once and offered the infant an identical toy. The real versions of the toys then appeared on the table, within reach of the infant. The question was: Will infants prefer the person who had been synchronized with the music? That is, will infants choose the toy that is associated with the synchronized person, and will infants smile more at this person than at the non-synchronized person?

Surprisingly, we've been finding that infants don't seem to use synchronized movement as a cue for social preference. In this

study, infants did not consistently choose the synchronized person-- they seemed to instead choose randomly between the two people. In addition, infants did not smile more at the synchronized person, suggesting that they truly do not have a preference.

While this is not what we expected, it is an interesting finding-- it suggests that even though infants love music and often spontaneously move in response to music, they don't have a social preference for those who synchronize, like adults do. This preference does not seem to emerge until later in childhood. In future studies, we hope to document this developmental change, by looking at how music and dance affect social preferences in older children.



MAPPING NUMBER WORDS to NUMERICAL REPRESENTATIONS

Lynneth Solís, Researcher

Previous studies have shown that children learn to count before they fully understand that numbers refer to exact quantities and that counting can help to determine the exact quantity of a set. It seems that children starting at around 2½ years of age slowly map number words to their corresponding quantities and finally begin to count to determine the magnitude of a set at around 4 years old. We have designed three different experiments to explore the intricate development of “numerosity.”

In Experiment 1, children are asked to give different quantities of known or unfamiliar objects (dogs or “blik”) and make known or unfamiliar sounds (barks or blik) using a computer, in order to determine the highest number they can consistently produce. The expectation is that if the number concept of the highest number they produce, for example three, is truly abstract, they will be able to give that number even when it is paired with a novel word (e.g., blik) and with both objects and sounds. Children who can accurately and consistently produce two or three objects continue to Experiments 2 and 3, respectively.

In Experiment 2, children are taught what “three” means by using cards depicting three beagles contrasted with cards depicting a different quantity of beagles. Then



they are shown cards with three vs. a different quantity of beagles, poodles, or cats and asked to point to the card with three. In one condition, children hear the experimenter label the animals as “beagles,” “poodles,” and “cats;” in another she labels them as “dogs and cats;” and in the last one she labels them all “animals.” We are interested in exploring whether children will generalize their knowledge of three equally well across the different labels.

In Experiment 3, children are taught what “four” or “eight” means on animal cards (e.g., birds, turtles, etc.). Similarly to Experiment 2, they are shown cards with four or eight animals contrasted with cards with a different quantity. Then children are tested on whether they can generalize the learned number to cards with new animals. Previous research has shown that children who initially know three, can generalize four to new animal cards. The expectation is that children will learn and generalize eight just as well as they do four, because these higher numbers are thought to be learned approximately rather than exactly. Therefore, we believe children learn to estimate more or less what four or eight look like.

We have just finished piloting all three experiments and are in the process of collecting data. We are excited about the potential results and look forward to sharing them with you soon.

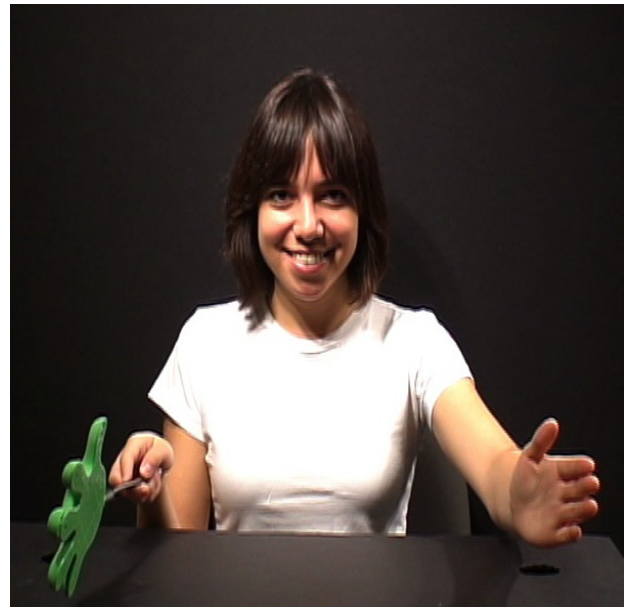
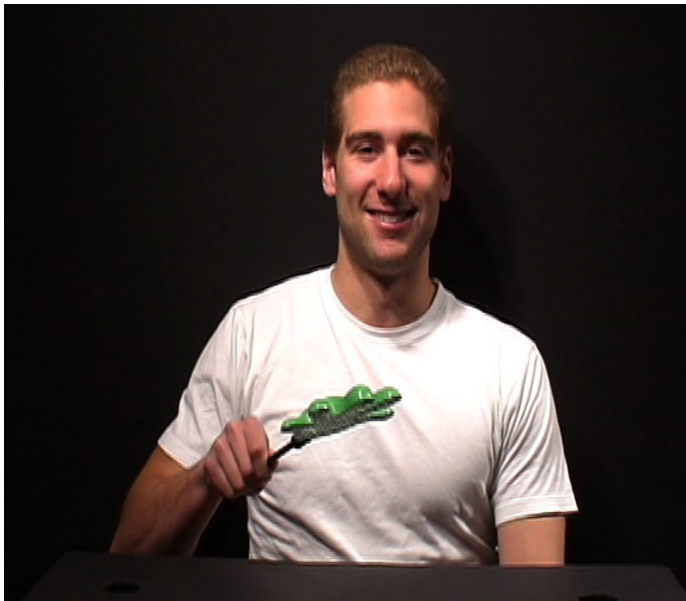
IMITATING PEOPLE

Talee Ziv, Graduate Student

In this line of research we have been investigating whether 2-year-olds are sensitive to social-category information when learning how to use an unfamiliar object. Your child was presented with video clips of either one male and one female performer (the “gender condition”), or two male performers—one African-American and the other Caucasian (the “race condition”). In both versions of the study the unfamiliar object was a hand shaped flyswatter with which one actor clapped and the other actor tapped on a table. After viewing the presentation the hand was given to your child and we observed which of the actions she or he preferred to imitate first. As you may recall from our previous newsletter, we have been finding that participants in the race condition do not show a preference for either of the actions, meaning that they do not care about the actors’ race when deciding which action to perform. Conversely, when actors differed in gender we saw a general preference to perform the action presented by the female actress, however this preference was much more pronounced in girls compared to boys.

The results of the above gender condition prompted us to use the same procedure to test only girls in an additional race contrast, this time with two female performers. Participants saw video clips of one Caucasian actress and one African-American actress, again using the hand shaped fly swatter either to clap or to tap on a table. Since it seems like girls are more eager to imitate females, we thought that participants in this version of the study might respond differently compared to the girls in our original race condition (who saw two male actors).

Despite our intuitions, it turns out that girls in the female race version still did not show a preference toward either action. They were equally likely to imitate the African-American actress, as they were to imitate the Caucasian actress. The results strengthen our conclusion that at this age race does not have a strong influence on children’s behavior in these types of learning situations.



Toy Choice

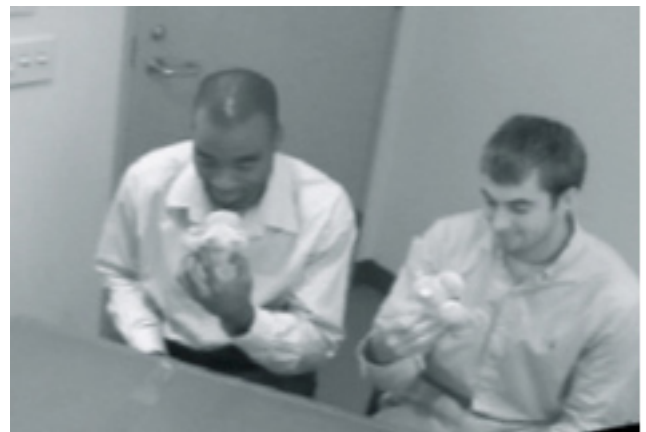
Rachel Katz, Researcher

What influences infants' early social preferences? Previous research suggests that social categories such as gender, race, and language guide infants' preferences and selection of social partners. Over the past year, two lines of work investigated infants' attention to gender and race when deciding on their own object preferences.



In the first line of work, we explored whether infants demonstrate early gender-based social preferences. Previous research has found that infants show a visual preference for faces of people whose gender matches their primary caregiver. However, little research has been done to investigate whether this visual preference indicates a social preference. Current work in our lab (see article called “Learning About People”) has shown that 5-month-old infants who spend a significant amount of time with a female caregiver display more positive emotional reactions and behaviors when watching a novel female actor on video compared to a novel male actor. In order to further investigate the social factors that influence these early preferences, we tested whether infants' attention to gender had an effect on their desire to engage in social interactions.

During the study, 10-month-old infants watched short video clips featuring a friendly male and female actor speaking a series of phrases. After each actor spoke, both simultaneously held up identical toy animals and offered the animals to the infant by extending their arms forward. At the same time, a “magical” bar moved onto the table in front of the infant. The same toys featured in the video clips were attached to the bar, thereby creating the illusion that the toys being offered in the video by the actors were the same toys that now appeared in front of the infants on the table. Infants were then given the opportunity to reach for the toys, and reaching behaviors were analyzed. We found that infants did not show a robust preference for the toy offered by either the male or female actor, suggesting that gender may not be a factor that influences infants' social preferences at this age.



In our second line of work, we tested whether 13-month-old infants attend to race information when accepting toys from adults. Previous research has revealed that infants look longer at same-race compared to other-race faces, but it is unclear whether these looking patterns reflect social preferences. In order to further explore infants' preferences in relation to race, we presented 13-month-old infants with a toy choice task designed to assess their social preferences in a live interaction with novel same- and other-race individuals.

Most recently, we have added a new component to both lines of work, investigating whether infants' willingness to take toys remains the same when actors speak in an infant-directed manner or an adult-directed manner. In addition, in our live toy choice study, infants are also given the opportunity to offer the toys back to the actors, and we measure infants' reaching toward the different objects and giving behaviors as a measure of their preference for the different people. Previous research has shown that infants respond more positively to novel individuals who speak to them using infant-directed speech (in comparison to adult-directed speech), so we hypothesize that infants will be more likely to choose an object from the actor speaking in an infant-directed manner. We look forward to sharing these findings with you in the next newsletter!



As always, thank you so much to all the families who have participated.

None of our research would be possible without your support!

If you have any questions, if you'd like to refer a friend, or if you'd like to participate in more research, please get in touch with us!

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