Toddler & Preschooler News, 2003

Sometime over the last six months, your child participated in one of our studies. We are writing first of all to **THANK YOU** for your participation. We couldn't do our research without your help and we really appreciate your interest in our work.

We also wanted to let you know what what's been going on at our lab. We are very excited about the recent opening of our new research space in the Vanserg building. It has a great play-space with a toy tree house, and two new high-tech re-orientation rooms that we have just begun to use. Vanserg is our THIRD research space on Harvard's campus – we hope you have a chance to see all the places we're working!

In this newsletter, you will find out the results of several different studies that are ongoing or recently completed in our lab. Your child participated in one or more of these studies, and we wanted to let you know what we've learned so far.

If you have any questions about these studies or the lab in general, please feel free to call us at (617) 384-7930 or (617) 384-7777. Or, check out our website: www.wjh.harvard.edu/~lds.

We hope to have you come visit for more studies soon!

Toddler Verb Learning Study

Sylvia Yuan, *Researcher*
Becky Huang, *Research Assistant*

This study explored how toddlers understand words for actions (verbs like "tickle," "run," or "push"). In this study, children sat on their parents' laps and watched short videos that were projected on a large screen. The screen was split and different actions occurred on each side of the screen. A camera behind the screen videotaped the child's face as she watched the videos, allowing us to go back after the study and determine which video the child was watching.

In the first half of the study, the children heard familiar verbs used in sentences (for example, "She is tickling her"). The video on one half of the screen showed an action that matched the verb (one woman tickling another). The other video showed a different action (one woman feeding another). We found that the children spent most of their time watching the video that matched the sentence that they heard. This shows that the children understand the verbs, even when they are parts of larger sentences, and that our technique is effective.

In the second half of the study, the children heard new verbs that we invented. Our goal was to find out how children learn the meaning of a verb that they never heard before. We think they may use the sentence that the verb is in to figure out what it means. Some children heard the new verb in a "transitive sentence" (a sentence with two nouns like "She is daxing her"). Other children heard the new verb in an "intransitive sentence" (a sentence with one noun like "She is daxing"). One side of the video showed an action involving two people (a woman spinning another woman on a chair). The other side of the video showed an action with just one person (a woman doing jumping jacks). We expected that the children would look at the two-person event when they heard the transitive sentence and the one-person event when they heard the intransitive sentence. The initial results are unclear and this study will be continuing this fall.

Understanding Irony Study
Daniel Garcia-Pedrosa, Researcher

The purpose of this study was to examine the development of children's ability to understand irony. Studying irony comprehension has proven challenging both because it is difficult to measure and because the definition of "irony" itself is often unclear. In this study, we defined an ironic statement as one in which the surface or semantic meaning of what the speaker says is the opposite of the speaker's intended meaning. The study involved listening to brief stories and answering questions about them. The questions were about a comment made by one of the characters in the story. In some stories, this comment was literal, and in others, it was ironic.

There were two types of ironic comments in the stories – "ironic compliments" and "sarcasm." In one story, for example, the character Bobby thought he was a poor soccer player (a negative expectation), but then he scored the winning goal in the next soccer game (a positive outcome). Bobby's teammate Jim said to him, "You sure didn't help the team." This is an ironic compliment. Sarcasm involves a positive expectation, a negative outcome, and a comment along the lines of "You did a great job" (which seems positive on the surface but is meant negatively). Participants were asked to identify, in the example of Bobby and Jim's soccer game, whether Jim meant that Bobby had helped the team (the ironic interpretation) or that he hadn't helped the team (the literal interpretation).

We found that 6-year-olds were clearly able to interpret the speaker's intended (ironic) meaning correctly, albeit not as consistently as adults. Previous research has indicated that before age 6, irony comprehension is very rare. An especially interesting result of this study is that children (as well as adults) do equally well with both types of irony. Since sarcasm is much more prevalent in children's lives, including on television, than ironic compliments, we conclude that children's ironic comprehension is not limited to what they are commonly exposed to. Instead, most 6-year-olds seem to have a broad ability to understand irony, and are not simply imitating what they hear on television or elsewhere. Your child's participation in this study formed part of an important contribution to our understanding of how children comprehend irony.

Geometry Study
Andrew Shtulman, Graduate Student

For thousands of years scholars have been fascinated by geometry and geometrical reasoning. How do five simple rules about points, lines, and planes, first articulated by Euclid, form the basis of a complex but logically coherent set of proofs and theorems? Although formal geometry can be extremely challenging even for experts, the rudiments of geometry surround us every day in simple shapes and structures. Even very young children can learn about shapes and lines just by viewing the space in which they live. In the present study, we hypothesized that children as young as five could at least partially grasp the fundamental postulates of Euclidean geometry, especially when visual aids were available. We expected, however, that it would be more difficult for them to generalize the rules and apply them abstractly when visual aids were absent.

To test this hypothesis, children were asked to complete two tasks. In the first, children were given an assortment of triangles, and were asked to trace out the angles on top of a circle. We recorded how many trials it took for them to generalize the rule that all triangles make a semicircle (180 degrees), regardless of the relative sizes of the angles. After this task was complete, children were given a brief training on the properties of a line and were then asked a series of questions based on Euclid's five postulates. We used a multi-dimensional drawing space composed of small unit blocks coated with a chalkboard-like surface. In order to answer all our questions correctly, children would have to imagine lines and circles not as drawings, but as abstractions beyond the given plane. For example, in one question children were given two points, one on a horizontal plane and one on a vertical plane, and were asked to imagine a straight line between them. Although the line could be inferred (because straight lines exist between any two points), it could not be drawn on the given surface.

We tested 15 adults and 19 children between the ages of 5 and 7. Our results, as expected, showed that children's reasoning about geometrical relations is stronger for pictorial representations than for abstract generalizations. However, many of our subjects displayed the same geometric competence as adults, even when faced with challenging constructions. This study gave us a window into children's pre-instructional reasoning about geometry, and we discovered a lot of creativity. For example, many children spontaneously suggested ways in which we could change the board to facilitate the drawing of certain shapes, and one child described an indefinitely long line as being "as long as a dinosaur." We also found that many children had difficulty understanding the correct definition of an angle, and we hope to look at the reasoning about angles more closely in later experiments.

Understanding Sentences Studies
Sylvia Yuan*, Researcher*

A typical conversation gallops along at about 3 words a second. When we are listening to someone talk we must rapidly figure out the meaning of each word and how it contributes to the meaning of the utterance. Research with adults and research on computer language processing has demonstrated that this is a very complex process – but preschool children seem to be quite good at it. These studies explore how children group words into phrases.

We think they may use the verb (or action word) in the sentence to figure out the meanings of other phrases.

In the study **Understanding Sentences: Using Verbs** children heard sentences like “Poke at the frog with the flower.” This could either mean use the flower to poke the frog (“instrument interpretation”) or poke the frog that has the flower (“modifier interpretation”). For some children, the sentences had verbs that are more compatible with the instrument interpretation (for example, “Hit the frog with the flower”). Other children heard sentences with verbs that were more compatible with the modifier interpretation (“Choose the frog with the flower”). Children were given sets of toys that were consistent with both interpretations (a frog holding a flower, a big flower, and 2 other objects). A camera placed behind the toys videotaped the child’s face as they heard the sentences. Later we went back and determined where the child was looking as the sentence unfolded.

We found that 4- and 5-year-old children use the verb to figure out how to interpret the sentence. When they hear a sentence like “Choose the frog with the flower” they quickly look at the frog holding the flower and then choose it. When they hear a sentence like “Hit the frog with the flower”, they rapidly look at the large flower and then use it to hit the frog. We have started testing younger children and children who are learning English as a second language to find out how rapidly this ability develops.

These findings raise questions about how children learn about this property of verbs. Do they have to discover whether each individual verb typically appears with instruments or attributes – or can they figure this out from the meaning of the verb? The study **Understanding Sentences: With New Verbs** explores this question. Many of the verbs that are associated with the “instrument interpretation” describe contact between two objects (e.g., *hit, poke, tickle*, and *bop*). In contrast many of the verbs that are associated with the “modifier interpretation” describe a form of communication (*yell, talk, whisper* and *sing*).

At the beginning of the study the researcher taught the child a new made up verb (“gorp”). For half of the children, the verb referred to a contact action (swiping something with your pointer finger); and for the other half, it referred to a kind of communication (babbling at something or someone). After the children had learned the verbs, they played a new game where they moved toys around on a table. Some of the instructions that they were given had phrases that could be interpreted as either instruments or modifiers (“gorp at the cow with the tube”). We expected that the children’s responses would depend on the meaning of the new verb.

This study is still underway. So far the results confirm our previous finding that children use the meanings of familiar verbs to guide their interpretation: kids who hear communication verbs (“yell”) interpret the ambiguous phrase as a modifier, those who hear contact verbs (“hit”) interpret it as an instrument. The results for newly learned verbs are less clear. It is possible that for newly learned verbs, it takes a while for the association to be formed. Another study called **Understanding Sentences: Using Intonation** looked at whether children can use the way that the parent speaks to figure out how the words of an utterance are grouped together. We know that adults can use pauses, emphasis and the intonation of the sentence to figure out its meaning. In this study we took the ambiguous sentences that we used in the verb studies but produced them with intonation that was consistent with only one of the two interpretations. For example, placing a pause after the verb ("Could you tap…..the-frog-with-the-flower") suggests the modifier interpretation, while placing a pause after the noun ("Could you tap the frog…..with the flower") suggests an instrument interpretation. The intonation that we used was based on an earlier study where we recorded parents' speaking with their children.

We analyzed the children's actions to figure out how they interpreted the sentence, and we analyzed where they looked during the sentences to find out more about the mental steps that they went through in interpreting the sentence. We found that intonation had a strong effect on children's ultimate interpretation. The effects of intonation on looking patterns were very rapid (beginning shortly after children hear the critical word). This suggests that intonation, like verb information, plays a role in the early stages of language comprehension.

Improbable-Impossible Study

Andrew Shtulman, *Graduate Student*

The uniquely human capacity to learn from the testimony of others frees us from the limitations of first-hand experience, yet it also leaves us vulnerable to believing in events that did not actually occur or, worse yet, events that could not, in principle, occur. Can children reflect upon their own knowledge as a way of assessing the possibility of non-experienced events?

In our first experiment, we attempted to answer this question by reading 4-year-olds, 6-year-olds, and 8-year-olds a story containing "probable events" (e.g. washing a car), "improbable events" (finding an alligator under the bed), and "impossible events" (walking through a wall) and asking whether or not they thought each of the events could occur in real life. Although subjects of all ages denied the possibility of most impossible events, the majority of 4-year-olds and a sizeable minority of 6- and 8-year-olds also denied the possibility of most improbable events (in contrast to adults, who virtually never did so).

Although children's possibility judgments suggest that they do not *explicitly* distinguish improbable and impossible events, their justifications suggest they might do so *implicitly*. That is, children gave significantly more factual and pragmatic justifications (e.g. finding an alligator under the bed is impossible because "alligators live in swamps" or because "alligators can't open doors") for improbable events than they did for impossible events. They also gave significantly more magic-based justifications (e.g., walking through a wall is impossible because "that would require magic") for impossible events than they did for improbable events. To assess the extent to which children implicitly distinguish improbable and impossible events, we performed a second experiment in which we presented 4-year-olds with two events – one improbable and one impossible – and asked them to pick the event they felt more certain could not happen in real life. On average, children picked the impossible event six times out of eight – a rate statistically different from chance.

If children distinguish improbable and impossible events implicitly, what might be keeping them from doing so explicitly? Are they perhaps misunderstanding the question? For adults, the linguistic distinction between *could* and *could not* maps onto the conceptual distinction between possible and impossible, not probable and improbable. However, if children initially adopt a probabilistic interpretation of *could*, then differences in children's and adults' responses to the question "Could [event x] happen in real life?" might simply reflect an error in communication. To assess 4-year-olds' understanding of *could*, we used this word in the context of concrete problem-solving tasks that did not require the child to reflect upon any abstract knowledge of what can and cannot occur in real life. For example, in one task the experimenter pulled a marble from a bag containing ten blue marbles and one red marble, and, while concealing the marble in his hand, asked each child three questions: (1) Could the marble in my hand be blue? (a probable event), (2) Could the marble in my hand be red? (an improbable event), and (3) Could the marble in my hand be yellow? (an impossible event). Virtually all children answered these three questions correctly (i.e., yes, yes, no), yet, when later tested on the storybook task, they once again failed to distinguish the improbable and impossible events.

This last finding confirms that 4-years-olds interpret *could* in the same way adults do, suggesting that children's inability to distinguish improbable and impossible events is not the result of a communication error. Therefore, we are now investigating a new hypothesis for why children do not explicitly differentiate between improbable and impossible events: they are unaware of the difference between constraints that pertain to all objects and constraints that pertain to just some objects (e.g., alligators). In other words, they have not yet distinguished what adults would consider the "laws of nature" (e.g., that objects cannot pass through one another) from less determinate causal constraints (e.g., wild animals do not live under beds), thus severely limiting their view of possibility. Further investigations are underway, and we hope you will bring your child back into the lab to participate!

Quantity Judgments and Language Study
Dave Barner, *Graduate Student*

This study examined how children interpret abstract structures in language, and whether the structure of sentences predicts meaning. Many theories of language acquisition propose that children use the meanings of sentences to decode what kinds of structures are being used. For example, seeing a dog pointed out in the presence of the expression "regarde le chien," the child might infer that the words refer to the object and that the expression must revolve around a noun rather than a verb. In this way, infants may map all physical objects to the category "count noun" and map all substances to the category "mass noun." The count nouns can follow numbers like 1 and 2, be pluralized, or follow the adjective "many." The mass nouns like "water" or "mud" that cannot follow numbers or be pluralized follow words like "little" or "much." For the most part, such mappings lead to the correct classification of words and help children quickly figure out the hidden structure of their language.

In the Quantity Judgment and Language study, we tested whether children used mappings between meaning and structure by studying their judgments of quantity. According to theory of language acquisition, things that fit in the count category should be quantified by number of things (e.g., more “cats” means more individual animals), while things that fit in the mass category should by quantified by mass or volume (e.g., more ketchup means a greater volume, not more individual portions). We tested 28 four-year-old children by asking them which of two characters had more stuff – the one with more things or portions, or the one with one big thing or portion. As predicted, children quantified by number for things like shoes, candles and cups, but by mass/volume for stuff like mustard, ketchup and butter. Words such as furniture, jewelry, clothing and mail, which referred to discrete physical objects yet fit in the mass category, were most interesting to look at.

Would children follow the predictions of meaning-to-structure mappings and quantify by volume, or would they violate the theory’s predictions and quantify by number of individual things? Results from the children tested in our lab suggested that for these terms children did not follow meaning-structure mappings, but instead quantified by number of things, judging, for example, three tiny letters to be more mail than one giant one. Based on this, we concluded that children may not be able to use meaning to discover the categories mass and count, and that children’s acquisition of such categories may use more sophisticated representations than previously suspected. More research is currently investigating the sources of these representations.

Word Extension and Quality Judgments Study

Dave Barner, *Graduate Student*

The “word extension” study investigated two aspects of how young children learn new words. First, we were interested in how children would extend novel words (e.g. blicket and fem) when they were used to refer to strange new objects. In this part of the study, children were shown a novel object made of an unfamiliar substance (e.g. a half egg made from textured sculpting material) and were told “this is some fem”, or “look at the fem.” Next, children were shown two objects: one that had the same shape as the “fem” but a different substance, and one that had a different shape but same substance. We then asked which one was the “fem.” In this way, we tested under what conditions children would extend words to refer to same-substance versus same-shape. After each new word was learned and the child chose which of the two additional objects was also some “fem,” we then showed the children two characters, each who had some fem. One character was shown with a giant piece, while the other had three tiny pieces. Children were simply asked, “who has more fem?”

Thus far, our study has found that children, unlike adults, extend most novel words on the basis of shape, even when the objects are relatively simple in form, and even when the sentences used favor a substance interpretation (e.g. this is SOME fem, versus this is A fem). Also, children are much more likely to think that MORE fem means more pieces, while adult subjects normally conclude that, when we are talking about SOME fem, more always means “more stuff” but not “more individual pieces.” This word extension study is part of a larger effort to understand how different types of sentence frames (e.g. *some* fem vs. *a* fem) come to have different interpretations for adults. It also looks at how children can acquire certain exceptional words that behave like substance words grammatically, but still refer to discrete physical things (e.g. furniture, jewelry, clothing). Since different languages treat these types of words differently (e.g. in French children say the equivalent of “spinaches” and “washing my hairs"), we believe that there should be a stage where children are not yet swayed by grammar in their word extension and quantification judgments for novel words. Thus far, the word extension study appears to be confirming this prediction. Results from this study and previous studies in our lab suggest that children's understanding of the world may be gradually shaped by very subtle differences in how their particular languages divide up the world.

Spatial Reference

Linda Abarbanell, *Graduate Student*
Anna Shusterman, *Graduate Student*
Peggy Li, *PhD*

In the Spatial Reference Study, we have been investigating how children learn spatial concepts and words like left, right, north, and south. Some studies show that most children do not understand or use these spatial words reliably until they are seven years old. In addition, words like left and right, which are relative to the body, may be learned in very different ways than words like north and south, which are relative to the environment. To explore these differences, we attempted to teach four-year-old children some of these spatial words by using feedback and clear examples of the words' usage. We varied our teaching by using different terms (left and right or north and south) with different groups of subjects. Within each of these groups, half of the children were taught the words as they pertained to their bodies (e.g., "Can you flap your north/right arm?") and the other half were taught using objects at their sides ("The surprise is in the box on the north/right side. Can you find it?").

Children showed a strong tendency to interpret the words relative to the environment, yielding a correct first hunch for north and south, but an incorrect first hunch for left and right. Children trained in the Left-Right condition were often unable to overcome their incorrect first guess, and this group (on average) did not learn the words during our training session. By contrast, children in the North-South condition were very successful with the training, mastering these terms rapidly and robustly. Learning was especially dramatic for the children who were taught north and south using objects at their sides.

To see how thoroughly children had understood the terms north and south, we conducted a follow-up study. Children were quickly taught north and south using objects and then asked to generalize these terms to new puzzles. In the first puzzle, a stuffed animal was placed at the child's side with two objects on each side of the animal. In this situation, all of the toys would be on one side (e.g. the north) of the child, but we could ask for the toy to the north or south of the stuffed animal. We expected this to be quite difficult, but we were proved wrong: children found this game trivially easy (over 80% correct answers). In the second puzzle, we took children out of the training room into the hallway and asked them to point to the north and south from various points in the hallway. Children were incredibly successful at this game as well (again over 80% correct).

These results make a very surprising point: children learning spatial reference terms find it much easier to learn words that are defined relative to the environment (north and south) than words that are defined relative to themselves (left and right). We are continuing with more studies to understand better children's spatial concepts and language learning.

Count Comprehension Study
Mathieu LeCorre, *Graduate Student*

Number is a very abstract dimension of our experience of the world. For instance, though steps and planets have nothing in common, it is possible to assign the very same number to both types of objects. For example, one could ask a friend to take as many steps as there are planets in the solar system. Also, the same item – e.g. a pair of boots – can be described with multiple numbers: one can not only talk about the number of boots but also about the number of holes, the number of laces, the number of dirt spots on the boots, etc. These properties of number concepts show that they cannot be derived from perceptual experience in any simple way. Thus, since the beginnings of research on children's thinking, researchers have been very interested in how children acquire number concepts.

Much of the research on children's number concepts has been focused on their understanding of counting. That is, researchers have been interested in determining how children learn that "five" means five because it is the fifth word in the count list. Recently, this has been studied with the Give-a-Number task. In this task, children are asked to give between 1 and 6 objects to a researcher. Over and over, this task has shown that, between age 2 and 4, children can count up to "10" but do not use their count list to give sets of objects, and are only able to give the correct number of objects if the requested number is no greater than 3. If they are asked for larger numbers, they give some number that is larger than 3, but the number given is unrelated to the number requested. It is only between 3.5 and 4 years of age that children begin to use counting to give sets of objects, and to be able to correctly give any requested number of objects.

Many have taken this to suggest that children don't understand their count list until they are about 4 years old. Yet, it could be that younger children actually do understand it but don't do as well as older children because the Give-a-Number task is too hard. To give the correct number, children have to co-ordinate the process of giving objects with the process of counting. Because this could be too difficult for young children, we decided to examine whether they would do better on a much easier task.

In our task, children are introduced to a puppet who likes to put little toy animals in a tall opaque bucket. The puppet is asked to put 5, then 6, then 7 animals in the bucket. It does so by slowly putting animals in the bucket one at a time, counting each one as it goes in the bucket. Sometimes the puppet is right, but sometimes it is wrong. When the puppet is done, the researcher asks children if the puppet put the right number of objects in the bucket (e.g. "Is that 6?"). Surprisingly, we found that most of the children who fail on the Give-a-Number task also fail on this task; only those children who succeed on the Give-a-Number can tell whether the puppet is right. Because this task is as easy as a researcher can devise, this is solid evidence that, despite the fact that they memorize a count list by age 2, children do not understand it until they are about 3.5 to 4 years old.

Approximate Arithmetic
Kristen La Mont, *Graduate Student*
Hilary Barth, *Ph.D*

This study investigated preschool children's intuitions about number and arithmetic. Past research has shown that human adults, infants, and many species of animals have the ability to judge how many objects are in a set. If it is a small group of objects (less than four), humans and animals have an instant and exact understanding of the number of objects. If the group is more numerous, babies and animals have an approximate sense of the number of objects. Naturally, human adults and school-aged children can form exact representations of the numbers of objects in a set (we know if there are exactly 16 pencils on a table), but we can do this because we use language and symbols to put exact labels on the number of objects in a set.

In the current study, we wanted to see if preschoolers could use the approximate system of representing number to tell us which of two sets were more numerous. Beyond that, could they also use their sense of approximate number of objects in each set to do "addition." We showed children a group of blue dots and a group of red dots and asked them which group had more dots ("comparison"). We also ran a version of the study in which a group of blue dots came onto the screen and got covered up by a box, after which another group of blue dots came on screen and also went behind the box. Then a set of red dots appeared on the screen. The children told us if there were more blue dots (all together) or more red dots. We designed the problems to make sure that they could only get the answer right by adding the blue arrays – not by comparing one blue array to the red array. And we also played with the size of the dots, so that we could see if children were just calling the set with more total stuff the more "numerous" set, instead of making a judgment based on the discrete number of items in the sets.

The children did extremely well, getting about 70 percent of the problems correct. They did not base their judgments of numerosity on the size of the dots or the amount of stuff in each set. Also, by varying the difficulty of the problems we presented, we were also able to gather data about how closely preschoolers can represent the true amount of dots in the sets. It turns out that they can discriminate large numbers that are in a 2:3 ratio (e.g. 20 and 30), and sometimes they do as well as 4:5. (The ratio for 6-mo-old human infants is 1:2, which suggests that this ability improves over development.) We found that children did as well on the "addition" problems as they did on the "comparison" problems. This study suggests that even young children, who have not been trained in mathematics, have an intuition about number and how sets combine. We are investigating the nature of their understanding and how to tap it to teach formal arithmetic.

Large Number Representation Study
Miles Shuman, *Graduate Student*

In this series of large number representation studies, we have young children look at paired sets of dots, or listen to paired sets of tones, and try to guess which set consists of a larger number of elements. We're interested in what kinds of sets children will be able to tell apart.

More deeply, we hope to determine whether there is a single, abstract "number representation" system used for evaluating the numerosity of any kind of set, independent of perceptual "modality" (auditory, visual, etc.) – or whether there is a different system for estimating and comparing number in each modality.

Previous work has shown that adults' ability to discriminate between sets on the basis of number depends only on the ratio between the numerosities of the sets – not the absolute difference. That is, most adults can reliably tell that 6 is more than 5, and that 18 is more than 15 (both ratios of 1.2:1), but have a hard time discriminating 9 from 8 (1.125:1), or 11 from 10 (1.1:1). Previous work in our lab has shown that infants seem to have a similar kind of limitation – their ability to discriminate between sets depends only on the ratio – but with much lower acuity: 6-month-olds can tell sets are different when the numerosity ratio is at least 2:1, but fail when the ratio is 3:2 or smaller; 9-month-old infants succeed at 3:2 and larger ratios, but fail for 4:3. For infants, these thresholds seem to be the same for both visual and auditory sets.

In the first **"**Large Number Representation Study**,"** we wanted to find out at which ratios young children would succeed on a number comparison task. We also wanted to find out whether discrimination thresholds would be the same, for any individual child, for visual sets (arrays of dots) and auditory sets (sequences of tones). We found that 4- and 5-year-olds generally performed as expected with the dot-array visual comparisons (with better acuity than infants, but poorer acuity than adults). However, they performed poorly overall with the auditory sequence comparisons – as a group, they performed nearly at chance even for "easy" ratios like 3:2, which we know (from previous work) that 9-month-old infants can discriminate!

One possible explanation for this failure is that we used irregular – or "arrhythmic" – sequences, whereas the studies with infants used regular, rhythmic sequences. A second experiment is underway to explore this hypothesis, which would have interesting implications for theories concerning the mechanisms of number perception.