



## The Laboratory for Developmental Studies at Harvard University

Greetings from LDS! Recently, your child participated in one of our studies. We appreciate your interest and support, and want to share with you what we've found! We have included in this newsletter summaries of many of the studies that we've run over the last few months. Some are new, some you might recognize from our last newsletter. Many are still in progress, but some are finally finished! None of them, however, could be possible without your help.

A lot has been happening with us recently. Our new built-in navigation lab in the Vanserg building is now fully functional and in constant use for studies. Our most heartfelt thanks to the many children who came in to help us test it!

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. We also have a webpage for the lab where you can find out more about us and our studies (and also view copies of past newsletters):

[www.wjh.harvard.edu/~lds](http://www.wjh.harvard.edu/~lds)

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

***Thank You!***

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This project investigated how young children learn color adjectives such as *red*, *green*, or *yellow*. Color adjectives are usually very difficult for children to learn, and they appear in children's speech several months later than size and texture adjectives.

We hypothesized that children may be able to learn novel color adjectives when

## Learning Adjectives

*Genya Steingold, Post-Doctoral Fellow*

they are applied to substances, because when children reason about substances they don't need to attend to other salient features such as shape and size.

To probe how children begin to learn color adjectives we introduced them to a puppet, who taught them a special puppet word from his puppet language. Thus, when we showed children red and yellow shampoo, the puppet called the red shampoo the "blicket" shampoo. After children learned the new puppet word "blicket" applied to the original substance, we investigated how children extended this adjective across different substances. For example, after children learned that the red shampoo was the "blicket" one, we showed them some red and some yellow lotion, and asked them which lotion was "blicket."

Our first study showed that children between 2 and 3 years old can learn nonsense color adjectives that were applied to substances and generalize these adjectives across different

substances. We replicated this finding for both edible (e.g., frosting, jelly) and non-edible substances (e.g., lotion, soap).

The second study tested how children generalize novel color adjectives from substances to solid objects in the domains of food (e.g. apples, pears) and artifacts (e.g. combs, hairclips). We

hypothesized that generalization in the domain of food might be easier, because

food objects may also be presented as substances. We found that young children easily generalized novel color adjectives from edible substances to solid foods and vice versa. We also found that young children can generalize novel color adjectives from non-

edible substances to solid artifacts, however this was more difficult for children than in the domain of food. We think that this performance cost when generalizing to the domain of artifacts

was due to the fact that solid artifacts cannot be constructed as substances.

Our most recent study tested how very young children (24-29 months old) learn novel color adjectives applied to edible substances and solid food objects. Preliminary results suggest that, although young

children can learn novel color adjectives applied to the original food objects, generalization by color across many different objects and substances is difficult for this group of very young children

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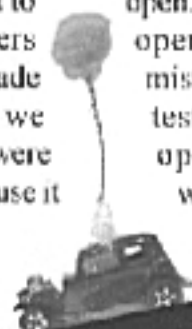
In the toddler ramp studies we have been examining the conditions under which toddlers are able to successfully search for an object that goes out of view.

Toddlers are introduced to a small toy car that rolls down a ramp. On each test trial, a panel with two doors is placed in front of the ramp, the car is released to roll down the ramp, and then the toddler is asked to simply "find the car" by opening one of the two doors. The car can stop behind either door depending on where the experimenter places a bright green stop wall.

In previous studies like this one, we found that toddlers are not very good at using the location of the stop wall to determine where the car will stop even when the experimenter draws a lot of attention to the wall (for example, by

the panel as it rolled down the ramp. This change helped toddlers a little bit, but not much. In Study 2, we attached a short antenna with a bright pink pompom to the car AND we made little "windows" in the previously opaque doors so that toddlers could see part of the car (i.e. the pompom) behind the door they needed to really helped toddlers open the right door – they rarely made mistakes!

In Study 3, we tested whether toddlers in Study 2 were opening the correct door just because it was more interesting (since it had a pompom w u s



## Toddler Ramp Studies

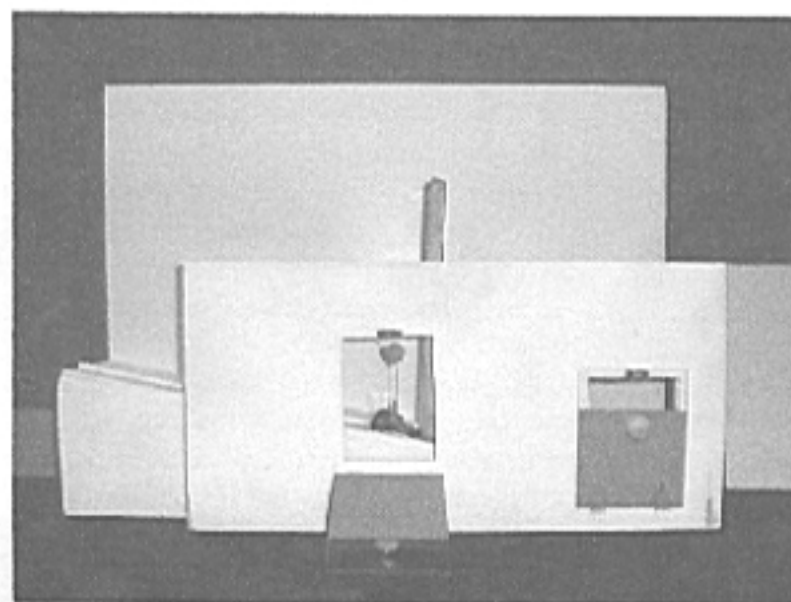
Kristin Shutts, Graduate Student

tapping on it and saying "the wall stops the car").

In these newest toddler ramp studies, we were interested in asking whether we could help toddlers succeed by changing various things about the game. In Study 1, we attached a tall antenna with a bright pink pompom to the car so that toddlers could see part of the car (i.e. the pompom) sticking up above

behind it) or if they really understood the pompom was attached to the car. Therefore, in Study 3, we placed a distractor (e.g. a little blue flag) in the wrong door on each trial. Toddlers in Study 3 did as well as toddlers in Study 2 (they rarely opened the distractor door), demonstrating that the children were really using the pompom to find the car.

We think these studies suggest that in order to succeed on a complex search task, toddlers might need a little more help than we previously realized. Specifically, it seems that they need to be able to see part of the object they are trying to retrieve and that the cue might need to be close to where they need to reach. We are currently testing this hypothesis with further studies on the ramp. We'll be sure to keep you posted!



In the absence of geometric information in the environment that could assist in reorientation, how do children use features of objects to perform a search task? We know from a number of previous studies that human children, as well as human adults and nonhuman animals, are very sensitive to the geometry of their surroundings; however children seem to ignore the red wall landmark when trying to reorient themselves in the rectangular room. To find out whether this is due to the fact that geometric information dominates over featural information when presented simultaneously, or whether it is actually the nature of the information itself

The setup was simple: we arranged three containers, one red bucket and two identical blue boxes, in an equilateral triangular layout inside a perfect circular room.



Children watched as an experimenter hid a sticker in one of the three containers. The experimenter then blindfolded and disoriented the child, and asked her to search for the sticker after the blindfold was removed. Each child performed three trials in each container, and we varied the direction that the child was facing at the time of removal of the blindfold in each trial. After 24 subjects, our results

## Featural Information and Reorientation

*Sang Ah Lee, Research Assistant*



(geometric vs. featural) that determines how it is applied in certain tasks, we designed an experiment that required the children to reorient themselves using a unique landmark to successfully find the hidden sticker each time in an environment that provided no geometric information.



clearly showed that children were consistently correct when the sticker was hidden in the unique red container (93%), while at chance between the two identical blue boxes when the sticker was hidden in either one of them (41%, 56%). This provided evidence to our claim that although children are very good at using featural information as direct markers of location, they do not reorient using a featurally unique landmark to disambiguate between two identical objects.

We ran several versions of this study, including hiding two stickers in one trial (one in the unique red container, and another in one of the two identical blue boxes), and all results strongly show that even when attention is called to the unique container as well as one of the identical ones, children do not use the relationship between them to distinguish between the two identical boxes in the search task.

Ultimately, this study speaks to the claim that different types of information are encoded, recalled, and utilized in different ways, specific to the task at hand.



**T**he verbal count list ("one, two, three, four...") may seem like the foundation of our understanding of arithmetic. However, many recent experiments have shown that the count list is supplemented by an unconscious, non-verbal, non-count based approximate number sense. For example, researchers asked adults to produce different numbers of key presses (up to 40) while saying "the, the, the..." to prevent counting. They found that while individual adults' answers were variable, their average answer was close to

correct. Other experiments suggest that the meaning of numbers seems to be founded on this approximate number sense. For example, adults with damage to the brain area that supports the number sense have a hard time saying which of "six" or "ten" denotes the largest number, even though they still know that "ten" comes after "six" in the count list.

We have been investigating the role this "number sense" plays in our understanding of number by looking at the effects of the development of a connection between the number sense and the number words in the verbal count list. We chose to study children between three and five years of age because, by this time, most

children understand how their count list represents number. In one task, children were rapidly presented with sets of up to ten dots and were asked to guess how many dots were in the sets without counting. If children's number words are connected to the number sense, they should be able to use larger number words for larger numbers, though their answers might be variable. For example, they might use "eight," "nine," and "ten" to describe

ten dots and "five," "six," and "seven" to describe six dots. In the other task, the same children were introduced to a stuffed animal who loved to eat

fish. They were then presented with two closed opaque boxes, were told how many fish were in each box (e.g. 1 vs. 2) and were asked to pick the box with more fish for the animal. If the meaning of number words is founded upon the number sense, children who haven't yet connected their number words with it (i.e. children who didn't use larger number words for larger numbers in the previous task) should make many more errors than children who have, even though all of them understand counting. Preliminary results suggest that this is the case. Therefore, this experiment so far suggests that there is more to arithmetic than meets the eye in that our intuitions of numerical order are informed by an unconscious, non-verbal, non-count-based number sense.

## The WORD Study

*Mathieu Le Corre, Graduate Student*

**I**n the Spoodle Detector study, we are interested in how language influences children's understanding of pictures as symbols between the ages of two and two-and-a-half. Children are introduced to a special machine that makes sound and lights up when a new picture is placed on it. Some children will be in a "Label" condition; these children will be taught a name for the picture. Other children will be in a "No Label" condition, in which they will be taught an association between that picture and an event (the machine lighting up). In the test trial, children are presented with the newly learned picture, the object

### *Spoodle Detection Study*

*Luke Butler, Undergraduate Researcher*

it represents, and a novel other object and we will ask your child to show us which item will make the machine go off. We wish to see whether naming the picture highlights the role of a picture as a symbol for an item in the world.





**D**o 4-year-old children form mental maps of their surroundings? This experiment used the same sticker-hunt reorientation procedure as the one described on page 7 in *Cued*

*Reorientation*, with one difference: children were asked to remember the location of the door as well as the hidden sticker on each trial. The door was not distinguishable from the other panels that formed the walls of the room, except by its relation to the distinctively colored red wall.

We exploited the fact that children tend to search equally for the sticker in the correct corner and in the corner at a 180-degree rotation. If children form coherent mental maps, then on trials where they search correctly for the sticker, they should also correctly identify the door. Likewise, when they make a typical 180-degree error in searching for the sticker, they should also make a 180-degree error in locating the door. On the other hand, if children encode the properties of their surroundings in a more piecemeal fashion, then there should be no consistency between their searches for the door and for the sticker.

Our results provide evidence that children form piecemeal representations of their

## Do Children Form Coherent Mental Maps?

*Anna Shusterman, Graduate Student  
Sang Ah Lee, Research Assistant*

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surroundings and argue against the idea that they quickly form coherent mental maps. Children searched as if they had a coherent mental map 35% of the time, but as if they had a piecemeal mental map 61% of the time. We isolated the trials with typical search behavior (the trials with correct or 180-degree search for both the sticker and the door), giving coherent and incoherent search behavior each a 50% chance. Children searched coherently on 56% of these trials and incoherently on 44% of these trials, not statistically different from chance performance.

Other studies have suggested that children sometimes do develop coherent mental maps of familiar environments, like their home or their local playground, so these results might be limited to how children encode and navigate around novel environments. We do not know how much experience it takes for a child, or an adult for that matter, to form a coherent mental map of a new environment, but we are curious about the answer to this question.

## Space-Time Metaphor Study

*Anna Shusterman, Graduate Student  
Laura Wagner, Visiting Research Fellow*

**W**e are investigating the developmental basis of a much-celebrated aspect of human thought: the connection between the conceptual domains of space and time. For example, in English, the word "long" can refer to both space (e.g. a long stick), or time (e.g. a long meeting). Our experiment



investigates 5-year-olds' understanding of the "space-time metaphor" by teaching them concepts like "long" in one domain using nonsense words, and seeing how easily they transfer their learning to the other domain. We have recently completed collecting data and look forward to sharing our results from this study in the next newsletter!

In this study, we wanted to investigate how language guides children's attention during navigation. We used a

classic reorientation

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task. Four-year-old children watched the experimenter hide a sticker in one corner of a small rectangular room with one distinctive red wall and three identical white or gray walls. Children were blindfolded, turned a few times, and then asked to search for the sticker after the blindfold was removed. In many previous studies children, as well as rats and other animals, have shown that they pay attention to the shape of the room, but not the color of the walls, to guide them in their search. They ignore the distinctive red wall despite many creative attempts by researchers to focus their attention on this landmark.

In our first experiment, we told children, "Look! I'm hiding the sticker at the red wall!" or "Look! I'm hiding it at the white wall!" (depending on the hiding place for that child). We thought that verbally labeling the wall color might help them to use wall color in their search. In combination with the shape of the room, which children use automatically, remembering wall color should help children zero in on the single correct corner. Indeed, the verbal cue helped children dramatically. On the portion of the trials where children received the

## Cued Reorientation

Anna Shusterman, Graduate Student

Sang Ah Lee, Research Assistant

cue, they found the sticker on the first try over 75% of the time. On the trials where we provided no cue, children only found the

sticker on the first try 45% of the time.

In our second experiment, we wanted to understand whether this type of verbal cue would only work if it included spatial terms like "at" or, alternatively,

if any verbal mention of wall color would help. We told a new group of children just before hiding the sticker, "Look at the pretty red wall! Let's put it for good luck" or other non-spatial phrases which mentioned the relevant wall color. This verbal cue did not help children. On average, children found the sticker about 50% of the time with or without the cue.

These results suggest that language can help to orient children's attention, but that specifically spatial language is required to orient children's attention to location.



How do children represent

and

remember what they see? In this experiment, 3-year-old children are shown a white page with a blue dot. Then they are given their own white page and a blue marker, and asked to make a blue dot in the same place on their page.

## Dot Study

Anna Shusterman, Graduate Student

Sarah Gocdin, Undergraduate Researcher

This task is surprisingly difficult for many children of this age. The goal of our study is to document this

effect and

to understand the patterns of errors children make, as well as to uncover reasons for these errors.



The main question of the word extension study was how children understand how language expresses quantities. While children have various explicit tools for talking about quantity (e.g. number words), language also provides some more subtle cues to amount, such as pluralization and a grammatical distinction between nouns that can be pluralized and nouns that cannot. Nouns that can be pluralized typically refer to countable things like "a cat," "these dishes," and "an idea," whereas nouns that cannot be pluralized mostly refer to substances or uncountable things, such as "some mustard," "some smoke," or "some fun."

Although children seem to know which words to pluralize by as early as 2.5 years of age, our studies suggest that they may not understand the distinction in an adult way until much, much later. Of the 32 3-year-old children we tested in our lab, almost none treated words that can be pluralized differently from those that cannot when making "more-less" judgments. For example, when asked "who has more



some smoke:  
uncountable



who has more blocks). Furthermore, even 4.5-year-old children tested in our lab continued to choose mainly by number for non-plural nouns.

Based on this, it seems that children's understanding of how quantity relates to language may emerge relatively late in language development, long after the fundamental principles of grammar, and even basic knowledge of counting, have been established. Other



an idea: countable

questions that we have begun examining are: how children talk about quantities of solid objects

## The Word Extension Study

*Dave Barner, Graduate Student*

compared to quantities of non-solid stuff (e.g., gooey substances), and how children figure out which words can be pluralized (e.g., ball – balls) and which ones cannot (e.g., mail)

Future studies will continue to explore these interesting relationships between children's language and thought, and how children master the subtle meaning differences encoded by grammar. For example, one very intriguing question that this research poses is whether children acquiring different languages have different knowledge of quantity. Do children learning Japanese or Mandarin, which do not have plural nouns, develop notions of quantity differently from children learning English? Pursuing such questions, our lab hopes to better understand how language affects the way we think, and how much of language is created from concepts we have before word learning begins.



# The Object Individuation Study

Peggy Li, Post-Doctoral Fellow

**T**he *Object Individuation* study investigates why we see some things as kinds of objects and other things as kinds of substances.

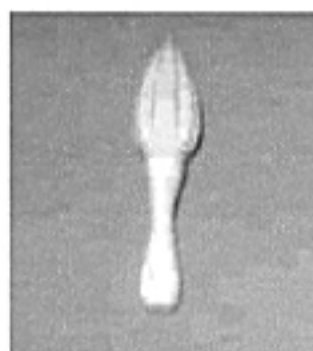
Any time we see something (e.g., a wooden whisk), it is possible to think of that particular thing as a kind of object (whisk) or as a kind of substance (wood). Our classification is heavily influenced by the nature of that something we see. For example, as adults, we are more likely to think of a wooden whisk as a kind of object (whisk) and a rectangular-shaped wooden board as a kind of substance (wood). This is perhaps because when we think of something as an object, we think of its shape or structure as being important, whereas the shape of a substance is typically unimportant. A whisk is a whisk because of its particular shape, whereas a piece of wood can be of any shape and

shape, like a metal whisk) or a substance choice (something of the same material, like a chunk of wood).

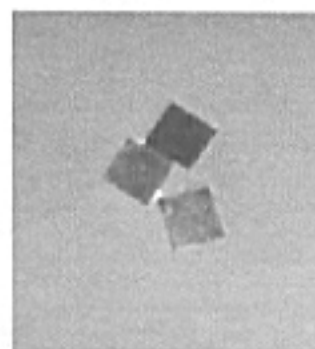
Previous work shows that children are very much like adults. For complex-shaped things like wooden whisks, children pick the object choice as being more similar. For simple-shaped things like wooden rectangular boards, children pick the substance choice. However the previous study confounds shape complexity with the likelihood of the thing having a shape-dependent function. For instance, wooden whisks are not only more complex in shape than a rectangular wooden board, but they are also more likely to have been intentionally created to serve a shape-dependent function. Is it shape complexity or functionality (or both) that is affecting children's choices?



**Original:**  
**Wooden Reamer**



**Object Choice:**  
**Plastic Reamer**



**Substance Choice:**  
**Wooden Pieces**

still be wood. One question is whether children are like adults when classifying novel things as objects or substances. Compared to adults, children are less experienced with the nature of things. Perhaps the difference in amount of experience would lead to differences in how children and adults classify novel things.

In our studies, children are first shown a test item (e.g., wooden whisk) and then asked to pick another example like the first. The choices are either an object choice (something of the same

In our new study we manipulate the test items' shape complexity and whether they were likely to have been intentionally created to serve a shape-dependent function. Results show that it is not shape-complexity that explains children's choices. They preferred to pick the object choice when the item has a high likelihood of serving a shape-dependent function regardless of whether the item is simple or complex in shape.



**B**ased on several previous studies, this study involves a column-like apparatus with two or four doors built into the front panel. A shelf is placed at one of several locations in the column so that when a ball is dropped behind the front panel, the ball will land on top of the shelf. The doors are aligned with each shelf position such that in order to locate the ball, the child must open the door that lines up with the shelf.

Since even young infants are sensitive to many of the factors that seem to be necessary to solve this task, it was surprising that similar

studies demonstrated that toddlers did not tend to solve such tasks until approximately three years of age. For example, young infants appear to have a concept of solidity (that two solid objects cannot occupy the same space at the same time, so the ball couldn't magically pass through the shelf). They also seem to understand that objects continue

to exist when unseen (thus the ball shouldn't magically disappear or change positions), and they can even perform planned reaches for unseen objects. This study therefore attempts to determine what else must be involved in solving this task.

Since we feel that children are having trouble representing the relationship of the ball to the shelf in these tasks, we hypothesized that perhaps having the spatial language to represent this relationship might aid in children's

success at finding the ball. However, we are finding that many toddlers do seem to



## Toddler Search Task

*Rebecca Rosenberg, Graduate Student*

have the language we are testing, yet still don't tend to solve the task until about three years of age! Thus the search continues, and we will keep you updated on any insights we come across. Many thanks to all the children and families who have participated in these studies, as we would have no studies without you!

## Language & Reorientation

*Anna Shusterman, Sung Ah Lee*

**C**an language learning help children in tasks that seem language-independent, like navigation? In this study, we are continuing a line of work in which children are taught the words "left" and "right" in order to see the effects of learning these words on spatial behaviors like reorientation.



## Spatial Reference: Learning Left, Right, North & South

*Anna Shusterman, Peggy Li, Linda Abarbanell*

**H**ow does children's spatial knowledge interact with word learning? For instance, how do 4-year-olds learn abstract spatial words like left, right, north, and south? Our previous studies have suggested that children learn and generalize environment-based terms like north and south more quickly than body-based terms like left and right. We are currently attempting to replicate and better understand these results by teaching children these concepts using novel nonsense words in order to eliminate effects of children's having heard the real English words in their daily lives.

**P**ast research shows that adults, children, and even infants and many animals have an approximate sense of numerical quantity: when shown two sets of objects, they can tell when one of them contains more elements than the other. Adults and older children can tell the difference between the sets even when they are relatively close in number (for example 12 dots vs. 15 dots). Young infants and animals need something easier (for example 8 dots vs. 16 dots) in order to detect the difference, but they can do it. So this rough "number sense" doesn't depend on learned language skills or counting routines.

In our earlier studies, we found that 5-year-olds can use this sense of approximate number to perform arithmetic on large sets of objects, too big to count exactly. We showed children animations on a computer that "acted out" addition problems with groups of dots. Here's an example: 16 blue dots would appear on the screen, and then they would be covered by a box. Then 16 more blue dots would move across the screen and go behind the box (to make a total of 32 blue dots behind the screen). Then 40 red

dots would move onto the screen, and the child would be asked, "Are there more blue dots, or more red dots?" The sizes of the dots were adjusted so that could tell if children were picking the set with bigger dots, or with a larger number of dots, or with the larger total amount of blue or red "stuff." We found that 5-year-olds were successful at this task, even though they had no formal exact addition training with numbers this large.

Based on that study, we don't know if children performed this task by using an abstract sense of the numbers of dots present, or if they used some kind of strategy based on visual imagery. To find out, we tested children's ability to perform the task even when they never saw the red dots at

all; instead, they would only hear beeps representing the red dots. This is complicated for 5-year-olds, so we started with an easier version using a simple comparison task instead of addition. Here's an example: We started out with an introduction, showing the child 14 red dots and saying "Look, each dot beeps one time, like this!" [beeping] "And when the red dots hide behind their red box, you can't see them but you can still hear them, like this!" [beeping] "And when we take away the box, there they all are, see?" Then, in the actual task, 25 blue dots moved across the screen and hid behind the blue box. Then a red box appeared, and the child heard 15 beeps (representing red dots). We asked, "Are there more blue dots behind the blue box, or more red dots behind the red box?" We found that 5-year-olds could understand this complex sequence surprisingly well - just as well as they did in a comparison task when all the

dots were visible. We went on to perform a version of the addition study with dots and beeps: for example, 15 blue dots went behind the blue box, and then 10 more blue dots joined them. Then the red box appeared and 40 beeps sounded.

Though this is a complicated sequence of events requiring a fairly long attention span and the integration of quantity information from very different sources, our group of 5-year-olds performed well. In fact, they performed as well as the group that completed the task with all the dots visible. This shows not only can young children perform approximate addition before they are formally trained to add large number, but that these accomplishments are based on an abstract ability to estimate number, not an imagery-based strategy that is only useful with visual information. The more we know about children's intuitive math abilities, the better we will know how to guide their later formal learning.

## NUMBER SENSE STUDY

Hilary Barth, Post-Doctoral Fellow  
Jennifer Lipton, Graduate Student

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In this study children played a short computer game where they saw pictures of insects and flowers and heard good and bad words (e.g., happy, nice, good, fun, mean, mad, bad, yucky). Depending on which picture the child saw or which word the child heard, he or she had to press one of two response buttons. Of interest is whether your children are faster to

concepts of these two categories. This research has been done primarily with adults, and this is the first time researchers have explored the development of these associations between concepts. While this work is still on-going, the data we have collected suggests that by age 5 children have already developed positive

## **The Implicit Association Test Study**

*Andy Baron, Research Assistant*



respond on trials when certain categories share the same response button (e.g., faster to respond when flowers and good words share the same response key compared to flowers and bad words sharing the same response key). If children are faster to respond when certain categories are paired together then this suggests that they have a stronger association between the

associations with flowers (faster to respond when flowers and good words share the same response button) and negative associations with insects (faster to respond when insects and bad words share the same response button). We hope to extend this work with younger children in the future and to include other categories besides insects and flowers.

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