

Symposia Abstracts

The Cognitive Development Society Fourth Biennial Meeting Program includes two plenary invited symposia and four symposia sessions with three concurrent symposia.

Friday, October 21			
10:15 - 12:30	Plenary Symposium in Aviary Ballrooms: Celebrating Elizabeth Bates' Contributions to Cognitive Development		
	Cockatoo Room	Macaw Room	Toucan Room
2:00 - 3:45	Development of Induction: Top-Down or Bottom-Up?	Bridging Cognitive Development and Education	Hey Kid, Wanna Buy the Brooklyn Bridge? Children's Acceptance and Rejection of Information Offered by Adults
4:00 - 5:45	Cognitive Mechanisms in Statistical Learning	Ontogenetic and Phylogenetic Perspectives on Tool Use: How Infants, Monkeys and Children Use Tools	Unpacking 'Executive Function': What are the Factors, and How Do They Develop?

Saturday, October 22			
10:00 - 12:15	Plenary Symposium in Aviary Ballrooms: Cognition in Non-Human Primates		
	Cockatoo Room	Macaw Room	Toucan Room
1:15 - 3:00	The Diversity of Children's Spatial Representations	Language and Cognitive Development: The Effects of Labeling in Infancy and Early Childhood	New Venues in Memory Development Research: Investigating Recollection and Familiarity Across the Life Span
3:15 - 5:00	Culture, Cognition, and Folkbiology	When Knowledge Looks Different Depending on How We Tap It	Influences on the Accuracy and Completeness of Children's Event Reports

FRIDAY, OCTOBER 21, 2005: 10:15 AM – 12:30 PM

CELEBRATING ELIZABETH BATES' CONTRIBUTIONS TO COGNITIVE DEVELOPMENT

ORGANIZER: J. Steven Reznick, University of North Carolina, Chapel Hill

SUMMARY: Elizabeth Bates (1947-2003) was a productive and creative scholar with broad interests in cognitive development and specific contributions in fields including language development, cognitive neuroscience, and communicative disorders. Our goal in this symposium is to highlight Liz's contributions that are particularly relevant for cognitive development, discuss the ongoing relevance of her ideas, and project ways in which Liz's work is likely to affect the field in years to come.

LIZ'S CONTRIBUTIONS TO OUR UNDERSTANDING OF INDIVIDUAL DIFFERENCES AND THEIR IMPLICATIONS FOR THEORIES OF LANGUAGE DEVELOPMENT

Donna J. Thal, San Diego State University & University of California, San Diego; Virginia Marchman, Stanford University

Elizabeth Bates was a prolific writer and dedicated researcher who argued persuasively that a satisfactory theory of human language development had to explain individual differences as well as central tendencies. For much of her career she pioneered methods of examining individual differences in young children that could meet rigorous research standards. Her contributions were both wide and deep. We will discuss those contributions in the contexts of variations in rate of development, dissociations between components of early language, variations in learning style, and variations at the extremes of the normal range (i.e., atypical populations).

LIZ'S CONTRIBUTIONS TO LANGUAGE ASSESSMENT

Larry Fenson, San Diego State University; Philip Dale, University of Missouri-Columbia

Liz played a central role in the development of the MacArthur - Bates Communicative Development Inventories (CDI) – as the name recognizes. Like all of the members of the CDI team, Liz was committed to rigorous, well-controlled laboratory-based research. But it was her boldness that led her to explore the possible value of a method (parent report) that had largely been held in scorn for well over a half century of child study. We will trace the roots of the CDIs in Liz's work with her colleagues in Italy and at Colorado, highlight her pivotal role in securing early funding from the MacArthur Foundation to standardize, norm, and evaluate parent report measures of early language, and describe her leadership in expanding the scope and credibility of this set of instruments. We will characterize some of the ways in which the availability of reliable parent input on their young children's communicative skills has transformed both the academic study and the clinical assessment of language development. Next, we will illustrate ways in which the existence of CDI-based instruments in more than two dozen languages around the world has opened opportunities for new approaches to cross-language studies of development. Finally, we will relate Liz's broad aspirations for future uses of the instruments – a reflection of her usual "big thinking".

MODULES ARE MADE, NOT BORN: LIZ'S VISION OF LANGUAGE EMERGENCE

Brian MacWhinney, Carnegie Mellon University

Connectionists are good at accounting for interaction and cognitive transfer, but how can they manage to deal with systems in which information seems to be strictly compartmentalized? The approach to this issue that Liz Bates pioneered was configured about the motto that "modules are made, not born." I will examine the ways in which Liz's insights have illuminated our understanding of modularity, critical periods, and universal grammar. Much of this work was conducted within the framework of the Competition Model. By extending that model beyond basic cue competition to deal with storage processes, code interactions, cognitive resonance, and embodied cognition, we can construct a Unified Model of both first and second language acquisition. One specific achievement of this model is the construction of an alternative to critical periods that emphasizes the varying roles of competition and entrenchment across the lifespan. The Unified Model can also be extended to the areas of language evolution, aphasia, and early focal lesions to provide an eventual full integration of the many insights Liz obtained in her work across these diverse areas.

LIZ, NATURE, AND NURTURE

Jeff Elman, University of California, San Diego

Liz was a connectionist before there were connectionists. From the outset of her career, her work embodied insights that are at the core of the connectionist approach: the importance of nonlinear change; the need for mechanisms that permit complex interactions between multiple components; the importance of representations that are distributed and gradual. And above all, she appreciated the power of learning. At the same time, she had a deep understanding of the importance of biology, and notably,

she realized that biology is about constraints, not about innate knowledge. There are genes that are crucial for language, but these are not the same thing as genes "for" language. I will discuss some of the many proposals and discoveries Liz made over the years that reflect this rich understanding of the interplay between our biology and our experience. Those who had the pleasure of hearing Liz speak will recognize pictures of giraffes, honeycombs, and the famous purple shoe.

FRIDAY, OCTOBER 21, 2005: 2:00 - 3:45 PM

DEVELOPMENT OF INDUCTION: TOP-DOWN OR BOTTOM-UP?

ORGANIZER: Anna Fisher, The Ohio State University

SUMMARY: The ability to generalize is fundamental to cognition, however the mechanisms underlying this ability remain unclear. The focus of this symposium is an ongoing debate concerning the mechanisms of induction early in development. According to the knowledge-based approach, even early in development, conceptual knowledge (such as category and linguistic assumptions) plays a prominent role in induction. According to the alternative, early induction (unlike mature induction) is driven by multiple similarities among entities, with conceptual knowledge playing little or no role early on. This symposium will bring together proponents of both positions to present their latest findings, and debate the merits of each approach. Each position will be represented by two researchers and one discussant. The goal of the symposium is not only to present new data, but also to have researchers consider the key theoretical claims that distinguish the positions. Participants will address the following questions: What is the core of the difference between similarity-based and theory-based approaches to induction? Knowledge-based theorists: If there is a theory guiding early induction/categorization, how does it get there? Is there any point in development when there is no theory guiding induction? Similarity-based theorists: Is there top-down knowledge guiding mature induction? If yes, how does this knowledge emerge from similarity - based processes present early in development? Induction and categorization: What develops? This symposium will bring together proponents of different theoretical positions, and will focus on an important issue in cognitive development. The symposium will result in better understanding of induction, its mechanisms and development.

CHILDREN'S USE OF EVIDENCE TO MAKE INDUCTIVE INFERENCES: THE BURDEN OF PROOF

Chuck Kalish, University Of Wisconsin-Madison

Children's inductive inferences are best understood as (sometimes) category-based. The central point is that children reason abductively: Like adults they have assumptions about likely categories supporting inductive projection. When faced with inductive problems they attempt to identify which category is the relevant one.

Two elements of an abductive process are prior hypotheses (e.g., categories) and inferential procedures for relating evidence to hypotheses. It is clear that even young children have biases that guide induction. I'll describe a recent study showing that such expectations can lead violations of a basic principle of similarity-based inference (homogeneity: the more similar base and target the stronger the inference). Debate must concern the origins of such biases, not their existence. I will present new data on children's sensitivity to contrast and diversity in evidence. Results suggest abductive processes. Young children integrate evidence to form hypotheses, rather than engaging in similarity-based matching.

The basic conclusion is that children's inferences differ only in degree, not in kind, from adults'. It is possible to elaborate similarity-based models to account for these (and likely any) results (e.g., Rogers & McClelland, 2005). However, such models sacrifice parsimony (e.g., depend on reasoners having just the right set of prior experiences). Given that abduction is a powerful and fruitful explanation for adults' inferences (see Ahn & Kalish, 2000; Medin, Coley, & Lynch, 2003), the burden of proof is on those who would deny children use abduction, and who posit a sharp separation between the inferential abilities of children and adults.

LANGUAGE AS A MECHANISM OF CONCEPTUAL CHANGE: OBJECT INDIVIDUATION AND INDUCTIVE INFERENCE IN INFANCY

Fei Xu and Anjula Joshi, University Of British Columbia

We will present two lines of research addressing fundamental issues in inductive learning in infancy, focusing on 1) how similarity and more theory-based mechanisms guide development, and 2) how language learning may be a mechanism for theory building. In the domain of object individuation, research from several laboratories suggests that early on infants may rely on perceptual similarity to determine how many objects are in an event (e.g., Wilcox & Baillargeon, 1998; Xu & Baker, in press). Towards the end of the first year, however, learning words for object kinds changes the infants' initial criteria for object individuation (e.g., Xu, 2002; Xu, Cote, & Baker, 2005). Language may play a causal role in the construction of object kind concepts. In the domain of

inductive inference, perceptual similarity also plays an important role early on (e.g., Welder & Graham, 2001; Joshi & Xu, 2005). However, the presence of a common label changes the infants' behavior: labeling overrides perceptual similarity and infants generalize non-obvious properties of objects to new exemplars that do not look like the demonstration object. Furthermore, the language effect is specific to count nouns (not adjectives) and is specific in guiding kind-relevant induction.

THE BASIS FOR INDUCTIVE INFERENCE IN INFANCY AND BEYOND

David Rakison, Carnegie Mellon University

A number of experiments will be presented that examine a similarity-based view of early inductive generalization. According to this view, infants' initial concepts of objects are intimately tied with specific features (e.g., things with mouths drink, things with legs walk) (Rakison, 2003); thus, early generalizations for actions are based on shared features and not category membership. A corollary of this view is that induction in preschoolers is based on nonobvious properties not because of an underlying theory of category membership but because children learn they are more predictive of an object's identity than surface similarity (Rakison & Hahn, 2005). In support of this view, I will present one set of studies with the generalized imitation paradigm that examined 14- to 22-month-olds' induction of motion properties. Results revealed that younger infants generalized on the basis of surface features and older infants generalized on the basis of category membership. I will also present a set of studies in which preschoolers and adults were taught new categories of animals, birds, and insects that varied in the degree to which nonobvious or perceptual properties predicted category membership. The results showed that preschoolers as well as undergraduates use surface properties or nonobvious properties when each was the better predictor of category membership. The data will be discussed with regard to the format and structure of early representations, the mechanisms involved in their acquisition, and the developmental course of their emergence.

EFFECTS OF CATEGORY LABELS ON EARLY INDUCTION AND RECOGNITION MEMORY: SUPPORT OR INTERFERENCE?

Anna Fisher and Vladimir Sloutsky, The Ohio State University

The ability to generalize from known to novel is crucial for learning, and this ability appears early in life. Furthermore, even early in development, linguistic labels influence induction, however, the mechanism underlying this influence remains controversial. Some researchers argue that labels are category markers promoting category-based induction, whereas others suggest that early in development labels are features of objects driving similarity-based induction.

It has been recently demonstrated that category-based and similarity-based induction result in different memory traces, with category-based induction resulting in a specific pattern of recognition memory for presented items (Fisher & Sloutsky, 2005; Sloutsky & Fisher, 2004). These studies suggest that unlike adults, 5- and 7-year-olds do not spontaneously perform category-based induction, but they can be trained to do so. However, it can be argued that introduction of category labels during induction should promote spontaneous category-based generalizations in young children, thus leading to the pattern of recognition memory characteristic of category-based induction. This possibility was investigated in three experiments. There was no evidence that category labels promoted spontaneous category-based induction in 5-year-olds. Furthermore, introduction of labels appeared to interfere with children's ability to encode visual information during induction, whereas no interference was found in adults. However, training to perform category-based induction eliminated interference effects in children, and resulted in the pattern of recognition memory characteristic of category-based induction. These results suggest that early in development effects of labels on induction stem from allocation of attention in the course of cross-modal processing, rather than from conceptual importance of labels.

BRIDGING COGNITIVE DEVELOPMENT AND EDUCATION

ORGANIZER: Lindsey Richland, University of California, Irvine

SUMMARY: This symposium will draw cognitive developmental researchers' attention to the rich research opportunities available in projects that bridge education and cognitive development. While education is frequently considered an applied avenue for study that lies outside the scope of basic cognitive developmental research, these disciplines are intimately connected in ways that have been underutilized. Cognitive developmental research has enormous promise for leveraging high-quality education research that can help the nation solve its challenging educational problems. At the same time, incorporating analyses of educational contexts into cognitive developmental research has great potential as an avenue for exploring the complexity of everyday factors that guide and interact with children's cognitive development.

This symposium is timely, as recent funding priorities and technological advances have led to greater feasibility for research that bridges cognitive development and education. Disciplinary boundaries in student training, publications, and funding avenues have historically created challenges for this type of research; however, this situation is rapidly changing. Integrating cognitive

and educational research has become a federal funding priority, as evidenced by the new Institute for Education Sciences (IES) Cognition and Student Learning (CASL) grant competitions, as well as IES-funded pre-doctoral and post-doctoral training grants, and National Science Foundation Science of Learning Center grant competitions.

TRAVERSING THE INTERFACE BETWEEN BASIC RESEARCH AND THE CLASSROOM IN ELEMENTARY SCIENCE INSTRUCTION

David Klahr, Mari Strand Cary, Junlei Li, and Stephanie Siler: Carnegie Mellon University

We summarize a research program that traverses the interface between basic research in cognitive development and applied research in elementary science instruction. Our focus is on an extended series of studies of the teaching, learning, and transfer of the "Control of Variables Strategy" in elementary school science. Beginning with investigations motivated by basic theoretical questions, we situate subsequent inquiries within authentic educational debates – contrasting hands-on manipulation of physical and virtual materials, evaluating direct instruction and discovery learning, replicating training methods in classrooms, and narrowing science achievement gaps. We urge research programs to integrate basic research in "pure" laboratories with fieldwork in "messy" classrooms. Finally, we suggest that those engaged in discussions about implications and applications of educational research focus on clearly defined instructional methods and procedures, rather than vague labels and outmoded "-isms".

COMPARATIVE REASONING IN CLASSROOM CONTEXTS: A CROSS-CULTURAL STUDY

Lindsey E. Richland, University of California, Irvine; Osnat Zur and Keith J. Holyoak: University of California, Los Angeles

Comparative reasoning can play an important role in children's learning and reasoning, as noted in the above paper and others. However, children also demonstrate systematic failures to notice and use structural comparisons (e.g. Holyoak, Junn & Billman, 1984), suggesting that the reasoning context can have serious consequences for effective use of structural comparisons. Particularly in content areas such as mathematics in which learning is based on generalized skills that transfer across problem contexts, it becomes important to understand how learning by comparison can be facilitated. This is also highly important because children in the United States typically perform low on internationally-normed mathematics achievement tests. In order to bridge from cognitive developmental research to classroom contexts, we explored the types of comparisons typically used in 8th grade mathematics classrooms in the United States, Hong Kong, and Japan. Hong Kong and Japan were selected based on their high performance on international mathematics achievement tests (TIMSS-R, 1999).

Quantitative analyses were conducted on 30 lessons videotaped in randomly sampled US, Hong Kong, and Japanese classrooms. The videodata were selected from the sample collected in Third International Mathematics and Science Study – Repeat (TIMMS-R). Findings reveal that US teachers provide fewer supports for comparative reasoning than Hong Kong or Japanese teachers. Supports include reductions in working memory load through visual representations, directed attention through gesture and structural alignment in visual representations, and use of familiar imagery. Data reveal cultural differences in patterns of comparative reasoning as well as correlates with international math achievement patterns.

CONTRASTING EXAMPLES IN MATHEMATICS LESSONS SUPPORT FLEXIBLE AND TRANSFERABLE KNOWLEDGE

Bethany Rittle-Johnson, Vanderbilt University; Jon Star, Michigan State University

A key feature of expertise is selective attention to important information in problems. As a novice in a domain, it is very difficult to know what information is important and how to use that information, especially with a single example. There is growing evidence that multiple, contrasting examples facilitate attention to key features (e.g. Gibson & Gibson, 1955; Schwartz & Bransford, 1998; Gentner, Loewenstein, & Thompson, 2003). We investigated whether contrasting examples would support procedural transfer and flexibility in mathematics. Seventy seventh-grade students worked in pairs in their regular mathematics classrooms for 2 1/2 class periods. Student pairs studied worked examples and solved practice problems on algebra equations under one of two conditions: 1) *Compare*: Study pairs of worked examples illustrating two different solution procedures to the same problem and compare and contrast the procedures or 2) *Sequential*: Study the same solution procedures, but shown separately on isomorphic problems, and think about the individual solutions. At posttest, pairs in the compare condition were better able to solve similar and novel problems correctly and had more flexible knowledge of procedures (e.g. when and why you would use a particular procedure). These findings support that comparison, above and beyond exposure to multiple examples, is an important learning mechanism and an effective teaching technique.

DEVELOPMENT OF PURE NUMERICAL ESTIMATION

Robert S. Siegler, Carnegie Mellon University

This talk focuses on *pure numerical estimation*, a process that has the goal of approximating some quantitative value; uses numbers as inputs, outputs, or both; and does not require real-world knowledge of the entities whose properties are being estimated. Three examples of pure numerical estimation are approximating the product of 395 X 112, the location of 26 on a number line, and the number of marbles in a jar. The process seems especially central to estimation because it eliminates non-mathematical knowledge of specific entities and particular measurement units as sources of variability in performance, and because recent research on a pure numerical estimation task revealed an interesting developmental shift in understanding of numerical magnitudes that may influence all types of numerical estimation.

The recently discovered developmental shift involves a change from reliance on logarithmic representations of numerical magnitudes to reliance on linear representations of them. This shift has been found between kindergarten and second grade for estimates of numerical locations on 0-100 number lines (Siegler & Booth, 2004) and between second and sixth grade for estimates of numerical locations on 0-1,000 lines (Siegler & Opfer, 2003). It occurs across at least three types of estimation tasks in the same age range (Booth & Siegler, in press). Individual differences in each of these types of estimation are correlated with individual differences in overall math achievement. In this talk, I discuss the studies that have yielded these findings as well as applications of the research to improving children's estimation.

LEARNING FROM SYMBOLIC OBJECTS

David H. Uttal, Meredith Amaya, Loren Marulis, Northwestern University; Judy S. DeLoache, University of Virginia

Many theories of cognitive development and early education assume that young children's thinking is inherently concrete in nature. Children often are encouraged to play with concrete objects, such as letter or number magnets, to facilitate early learning.

We believe that concrete objects have a dual nature; they are interesting objects in their own right, but they are also intended to represent something else (e.g. letters, numbers, etc.). Playing with the concrete objects may actually make it harder for children to see the connection to symbolic representations. We have tested this hypothesis by having children play with toy letters and numbers and assessing whether this helps them learn to recognize or use letters and numbers. We have found no positive effects of playing with letters or numbers. In fact, in some cases, playing with letters or numbers has had a negative effect. We will discuss the implications of our work for cognitive development and for early childhood education.

HEY KID, WANNA BUY THE BROOKLYN BRIDGE? CHILDREN'S ACCEPTANCE AND REJECTION OF INFORMATION OFFERED BY ADULTS

ORGANIZERS: Judy DeLoache and Megan Bloom, University of Virginia

SUMMARY: Many important aspects of reality are unobservable, and many require explanation by other people. In learning about the world, children need to incorporate into their knowledge system much of what adults tell them. However, it is also important for them to develop the ability to judge the truth value of what they hear. Although adults usually provide accurate information to young children, they can make mistakes, and sometimes they intentionally provide false information (e.g., Santa Claus).

Our symposium explores young children's reactions to adults' efforts to influence their thought, and we will show that they can be remarkably credulous in some situations, but relatively astute judges of an adult's credibility in others. We identify a variety of factors that affect whether children accept or reject information communicated to them.

The symposium participants are an ideal group to reflect upon this general topic. In their presentations, Vikram Jaswal and Kang Lee find that even young preschool children can be appropriately skeptical of an adult's message in certain situations—specifically, when social information indicates an adult may not be a reliable informant or may actually be trying to deceive them. In contrast, Jacqui Woolley and Judy DeLoache find that much older children accept quite outlandish claims made by adults about fantastical beings or marvelous machines when there seems to be evidence to substantiate the claims. As discussant, Susan Gelman will consider these findings in the context of early conceptual development.

LIMITS ON CHILDREN'S CREDULITY IN LABELING SITUATIONS

Vikram Jaswal, University of Virginia

Children treat adults as experts about what things are called. From an early age, they request labels from adults, and they replace their idiosyncratic words with the conventional terms they hear adults use. This presentation describes work exploring the limits of preschoolers' credulity in the labeling domain.

In one set of studies, 3-year-olds heard an adult refer to an object that looked like a member of one familiar category with the label of a different familiar category. When the adult called a key-like object a "spoon," for example, children accepted that anomalous label 64% of the time. However, when the speaker acted in a distracted manner while providing anomalous labels (by rummaging around in a box) or when she expressed uncertainty ("I think this is a spoon"), children accepted only 39% of the labels.

In another set of studies, 3- and 4-year-olds heard an adult and a child provide different labels for the same novel object. For example, an adult speaker referred to a garlic press as a "blicket," and a child speaker called it a "toma." Participants favored the label the adult provided unless she had previously mislabeled familiar objects. Willingness to accept a label from an adult may be the default for preschoolers, but there are limits on their credulity. When an adult's behavior suggests she is unreliable, children treat the information she provides with a healthy dose of skepticism.

YOUNG CHILDREN'S ACCEPTANCE AND REJECTION OF INFORMATION IN DECEPTIVE SITUATIONS

Kang Lee, University of California, San Diego

We conducted three sets of studies examining 3- to 6-year-old children's reaction to information conveyed by a deceptive individual. In Study 1, an adult made a false claim about an event that violated children's world knowledge. Children's rejection or acceptance of the claim was significantly correlated with their world knowledge. Nevertheless, until 5-6 years of age, most young children believed the false claim.

In Study 2, children saw an actor whose public message contradicted her private message in a politeness situation. The older children relied on the private messages to infer the true state of affairs, whereas the 3-year-olds had no consistent preference for either the private or public messages.

In Study 3, children saw an actor who displayed contradictory verbal and nonverbal (eye gaze) cues. The person's deceptive intent was made clear to the children. The older preschoolers were more inclined to rely on the deceiver's nonverbal cues to evaluate the truth of the communication. In contrast, 3-year-olds mainly relied on the verbal cues.

Taken together, these findings suggest that there is a marked developmental change in children's skepticism about information provided by others. Beginning around 4 years of age, children no longer accept at face value information provided by others, especially someone they have reason to think may be trying to deceive them. They become sensitive to inconsistencies within such information or between the information and their world knowledge, and use such inconsistencies to make judgments about the true state of affairs.

CHILDREN'S BELIEFS IN A NOVEL FANTASY FIGURE

Jacqueline D. Woolley, University of Texas at Austin

Adults in Western culture introduce children to numerous fantastical entities, such as Santa Claus and the Tooth Fairy. Although these entities have properties that violate fundamental aspects of children's naive theories, children develop rich, enduring beliefs in their existence. In this paper I explore some of the factors that affect children's beliefs in such fantastical beings.

Our paradigm involves introducing children, at their school, to a novel fantastical entity, the Candy Witch. Children are told that on Halloween night the Candy Witch (CW) will bring toys to children in exchange for their candy. The parents of the children in our experimental group clandestinely swapped their child's candy for the new toy. The control children simply heard about the CW at school.

In earlier work, we found high levels of belief in the CW in preschool children (Woolley, Boerger, & Markman, 2004). In the present study, we found similarly high levels of belief in the 5- and 6-year-olds, who actually displayed higher levels of belief than 4-year-olds.

"Actually being visited" by the CW at home resulted in higher levels of belief among the oldest children than just hearing about the CW. Although children attributed similar physical, biological, social, and psychological properties to both the CW and an ordinary witch, belief level for the CW was substantially higher. Finally, repeated questioning about the CW's reality status and existence served to strengthen, not weaken, the children's belief level. Thus, when given substantiating evidence for a fantastical entity, even six-year-olds accept it as real.

CHILDREN'S ACCEPTANCE OF IMPOSSIBLE PHYSICAL TRANSFORMATIONS

Megan Bloom and Judy DeLoache, University of Virginia

Even infants have been shown to understand important aspects of the physical world, including that objects exist without change through time and space. At the same time, older children appear to believe in a variety of impossible things (e.g., the Tooth Fairy, a machine that can shrink a room). Often these beliefs are based on information provided by adults. The present research examined the extent to which children accept an adult's claim to use a machine to physically change objects (that is, a claim to perform physically impossible transformations).

In a series of studies, an experimenter told 4- to 7-year-olds that a highly technical-looking machine could shrink objects or change toys or photographs into real objects. The children then watched as each object was placed in the machine, the machine was activated, and the apparently transformed object emerged. Their belief in the events was assessed with a semi-structured interview conducted by their mothers. The mothers were not present during the demonstration, so it was natural for them to ask their children what had gone on, and the children had no reason to mislead them.

Remarkably, most children under the age of seven were judged to believe that the purported transformations had really occurred. Only the 7-year-olds were likely to tell their mothers that the experimenter had tried to deceive them. These results demonstrate that adult input, supplemented with apparent evidence, can induce children as old as 6 to believe something that violates basic principles of physical reality.

DISCUSSANT: *Susan Gelman, University of Michigan*

FRIDAY, OCTOBER 21, 2005: 4:00 - 5:45 PM

COGNITIVE MECHANISMS IN STATISTICAL LEARNING

ORGANIZER: Rebecca Gómez, University of Arizona

SUMMARY: Research on statistical learning has revealed infants to be opportunistic learners, ready to capitalize on a variety of different types of structure. Although much work has concentrated on detecting infant learning abilities, recent research has begun focusing on cognitive mechanisms in learning. A pressing question is the extent to which statistical learning factors more broadly in cognitive development. The goal of this symposium is to explore the role of statistical learning in mechanisms of change and development. The presenters are experts in statistical learning focusing on language, visual perception, sleep and memory. In bringing together research in varied domains, we will address crosscutting issues in cognition and learning. Erik Thiessen investigates the attentional and correlational effects of prosody on statistical language learning. Jill Lany and Rebecca Gómez examine the prior role of experience in learning, showing how experience with simple structure can bootstrap more complex learning. Natasha Kirkham explores the role of multiple probabilistic cues in learning and presents a developmental theory of multiple cue integration. Rebecca Gómez, Richard Bootzin, and Lynn Nadel investigate the role of sleep and memory consolidation in statistical learning, finding that naps result in qualitative change in memory and hence greater flexibility in learning. The discussant, Scott Johnson, has a history of investigating early learning abilities and mapping out the emergence of those abilities in developmental time. He will discuss the perspectives represented in the four speakers' approaches as they relate to mechanisms of statistical learning and change in cognitive development.

EFFECTS OF PROSODIC STRUCTURE ON INFANTS' STATISTICAL LEARNING

Erik Thiessen, Carnegie Mellon University

The complexity of natural speech is often considered to be an obstacle for infants learning language. Very little is known about how statistical learning – the ability to detect linguistic units, and discover which units predict others, by tracking patterns of words and sounds – operates when confronted with natural speech. In two experiments, we explore the interaction between prosody (the pitch and rhythmic structure of speech) and statistical learning. Experiment 1 indicates that infants are able to segment words from fluent speech with the exaggerated pitch contour of Infant Directed speech more easily than from fluent speech with the more monotonic pitch contour of Adult Directed speech. This result may reflect the fact that Infant Directed speech maintains infants' attention more effectively than Adult Directed speech. Prosody likely plays a more important role in language acquisition than maintaining infants' attention, though, because prosody is correlated with many aspects of linguistic structure (e.g., word and phrase boundaries). In Experiment 2, we explore the role of consistent prosodic structure in sequential learning. Our results indicate that infants learn sequences more easily when they are accompanied by predictable melodies than when they are produced in a monotonic manner, or accompanied by unpredictable melodies. Taken together, these results

indicate that the additional information in natural speech – for example, its prosodic structure – may facilitate statistical learning. In particular, infants are sensitive to correlations across levels of linguistic structure, and are able to learn more easily when redundant cues indicate structure in the environment.

TWELVE-MONTH-OLD INFANTS BENEFIT FROM PRIOR EXPERIENCE IN STATISTICAL LEARNING

Jill Lany and Rebecca Gómez, University of Arizona

The role of prior experience in perceptual development, particularly vision, has gained interest in recent years (e.g. Needham, 2001; Needham & Baillargeon, 1998; Quinn & Schyns, 2003). Does prior experience also play a role in language development? We tested this by exposing 12-month-olds to a relatively simple adjacent syntactic dependency and asking whether prior experience would enable them to track a more difficult nonadjacent one.

Twelve-month-olds can learn adjacent dependencies between word categories (Gómez & Lakusta, 2004), but do not appear to track nonadjacent dependencies in sequential structure (Gómez & Maye, 2005). We tested whether prior experience with adjacent dependencies enables them to generalize these relations to nonadjacent occurrences when they do not otherwise. Experimental infants were first familiarized to strings from an artificial language containing adjacent dependencies between word categories. They were subsequently habituated to strings containing nonadjacent dependencies. These infants dishabituated to nongrammatical strings in which the nonadjacent relations were disrupted. Control infants were exposed to strings lacking adjacent dependencies, but preserving the language's vocabulary, phonetic and prosodic characteristics. The controls were subsequently habituated to strings containing nonadjacent dependencies, but they did not dishabituate to nongrammatical strings.

The results suggest that infants' experience with adjacent co-occurrence relationships facilitated subsequent sensitivity to that structure embedded in more complex strings. In other words, infants' experience with simple syntactic structure can bootstrap learning of more complex structure. Moreover, learners, and the structure they can learn, change as a function of experience.

THE RICHNESS OF THE INPUT: MULTIPLE CUE INTEGRATION IN STATISTICAL LEARNING

Natasha Kirkham, Stanford University

Infants have access to a powerful domain general learning device: In laboratory experiments they can quickly learn statistical patterns in both auditory and visual domains (Fiser & Aslin, 2003; Kirkham et al., 2002; Saffran et al., 1996). In the outside world it is rare, however, that events come in a single modality, and infants are very sensitive to cross-modal synchrony (Lewkowicz, 2000). Experiments in statistical learning presenting only one modality may have underestimated infants' learning ability. Models of adult language learning have shown that multiple probabilistic cues (e.g., lexical stress, phonemes, pauses), although they may be individually unreliable and present redundant information, can be integrated to produce faster learning of word boundaries and syntax (Christiansen et al., 1998).

In this talk, I will discuss a developmental theory of multiple cue integration, outlining the effect that richer, cross-modal stimuli have on infants' ability to learn statistical patterns in visual sequences and events, even though the information presented across multiple cues is redundant. The theory predicts that there are several factors that will affect an infant's ability to learn a particular sequence or set of events: The availability and coherence of multiple cues, and the age of the infant. I will present evidence that, at younger ages, infants will require a higher number of cues, and a higher degree of coherence between them. At later ages, infants will be able to learn statistical structure from a smaller set of cues, and be able to tolerate a degree of incoherence between multiple cues.

SLEEP AND MEMORY CONSOLIDATION IN INFANT LEARNING

Rebecca Gomez, Richard Bootzin, and Lynn Nadel, University of Arizona

Adult studies show that sleep sustains retention and enhances performance after learning involving rote memory and generalization. Sleep has also been implicated in qualitative changes in memory. Does sleep play a similar role in infant learning? We exposed 15-month-olds to 15 minutes of an auditory artificial language 4 hours prior to a lab visit. The language required infants to relate the first and last word in auditory strings. One group napped during the interval between training and test. The other group did not nap. A control group also napped but was exposed to a version of the artificial language that should not promote learning of the critical relation. At test infants listened to grammatical strings and to ungrammatical ones. Veridical memory of the critical relation would be reflected in differential listening times for grammatical and for ungrammatical trials. A more abstract rule would be reflected if the first trial sets the direction of preference for the remaining trials. Consistent with learning of an abstract relation, infants who napped and who heard a grammatical trial first had longer average listening times to grammatical trials (the opposite held for infants who received an ungrammatical trial first). Thus, instead of retaining veridical memory of the critical relation, napping resulted in a qualitative change, namely abstraction of the relation. No

learning was observed in the no nap and in the nap control conditions. We show that napping promotes a qualitative change in infant memory, one resulting in greater flexibility in statistical learning.

DISCUSSANT: *Scott Johnson, New York University*

ONTOGENETIC AND PHYLOGENETIC PERSPECTIVES ON TOOL USE: HOW INFANTS, MONKEYS AND CHILDREN USE TOOLS

ORGANIZER: Amy Needham, Duke University

SUMMARY: Tool use has been put forth as one of the prime movers of the evolution of human intelligence. Despite its importance to human behavior, we know relatively little about the origins and development of tool use. This symposium will provide cognitive developmentalists with a comprehensive account of the current research on tool use being conducted with infants, monkeys, and children. Integrating across research subjects and across age groups offers leverage on issues of evolutionary and developmental origins of these important skills.

The use of tools is a textbook case of the integration of multiple functions in the brain, because tool-users must engage physically with the tool but must also select ways of using the tool that are appropriate for their goals. Further, the mapping of tool to object is not one to one—rather, any tool can be applied to a whole class of objects (e.g., screwdrivers to screws). The bases on which tools can be applied to tasks is discussed by all of the speakers, and Greif, Lockman, and Needham all describe a narrowing of this flexibility with development.

These four speakers have important linkages with each other. Lockman and Needham are both looking for the developmental origins of tool use at much earlier ages than have been studied before, leading us to see the continuity in the basic behaviors underlying tool use. Greif and Needham both consider transfer and flexibility in applying tools to new contexts. Santos and Lyons have used methods developed for use with human infants to study monkeys' understanding of others' tool use. It is important to bring the comparative perspective to this topic especially because so much more monkey work than human work has been done on this topic. We plan to convey the cutting edge of this field to cognitive developmentalists who may wish to examine this field as an interesting way of assessing the "what" and the "how" of development in infants and children.

DEVELOPMENTAL ORIGINS OF TOOL USE: THE ROLE OF INFANT OBJECT MANIPULATION

Jeffrey J. Lockman, Tulane University

The ontogenetic and phylogenetic origins of tool use remain controversial, but a dominant view is that tool use constitutes a discontinuous advance across these time scales, dependent on the emergence of higher-order representational or relational reasoning skills. In this presentation, I offer an alternative view by considering how perception-action theory may shed new light on the psychological capacities required for tool use. Specifically, I will discuss new empirical findings that suggest that infant object manipulation establishes a foundation for the emergence of tool use. Like object manipulation, tool use requires individuals to adapt their manual actions to a held object and to exploit potential relations between the material properties of that object and those of nearby environmental surfaces.

I will review our research with 6- to 10-month-old infants ($N = 60$) that suggests that object and object-surface exploration show a significant increase in specificity with development, with infants tailoring their manual actions to the physical properties of objects, surfaces and their combination. Additionally, I will discuss new research that indicates that in the second half year, infants (new sample, $N = 60$) show similar kinds of specificity in their manual actions when they hold objects by their handles. In such situations, infants gear their manual actions not to the physical properties of the handle, but to the object attached to the end of the handle. The presentation will conclude with a general discussion of how a perception-action perspective on object manipulation and tool use development can provide new insights into the evolutionary origins of tool use.

INFANTS' LEARNING ABOUT USING NEW TOOLS

Amy Needham and Evan F. Davis, Duke University

What experiences allow infants to learn how to use a new tool? This question will be addressed in two lines of work: one involving 3-month-old, pre-reaching infants who may not typically be thought of as tool users, and the other on more traditional tool use in infants beginning the second year of life. In both cases, we acknowledge the two integrally related components of tool use: the motoric demands of using the tool must lie within infants' repertoire of action, and the cognitive demands of which tool to choose and how to apply it must lie within infants' cognitive abilities.

Early in infancy we look at how infants can use a tool to extend the existing capabilities of their hands, and we see how infants apply the tool to available objects in a relatively indiscriminant way. Later in infancy, we see how infants' tool using has become

somewhat more rigid, as they are unlikely to use a familiar tool in a novel way. To better understand this increasing specificity in infants' use of tools, we have studied infants' learning about tools by conducting training studies with novel tools. These studies have suggested that one of the first things infants learn about a tool is which part is its handle. This bias is just as strong after merely watching someone use the tool as it is after they use it themselves. Results will be placed into a developmental and evolutionary context.

HOW PRIMATES REASON ABOUT ARTIFACTS: PHYSICS VERSUS INTENDED DESIGN

Laurie R. Santos and Derek Lyons, Yale University

Although many primates make and use tools, it is often unclear what these tool-using species understand about the tools they flexibly use? Do primates understand the physics behind the tools they use? Similarly, do they, like human tool-users, represent tools in terms of their intended design and function? To explore this question, we ran a series of looking time experiments with rhesus monkeys (*Macaca mulatta*), a species that does not normally use tools in the wild. Monkeys were familiarized with an event in which a human experimenter used an L-shaped pushing tool to move a grape down a ramp. We then changed the features of the pushing tool and observed how long subjects looked at each of these changes. Subjects looked reliably longer at causally-relevant feature changes (e.g., a shape change) than causally-irrelevant changes (e.g., color). We then examined whether subjects' understanding of these changes was mediated by the intentions of the tool user. We discuss our results in light of similar findings in human children and the connection between theory of mind and artifactual understanding.

WHAT CAN CHILDREN'S EXTENSIONS OF FUNCTION TELL US ABOUT THEIR "TOOL CONCEPTS"?

Marissa L. Greif, Duke University

Innovative tools abound to solve everyday problems. Disk-shaped vacuums roam our floors; our can openers look like computer peripherals. Many such tools lack familiar physical affordances, and we often rely on others to learn about their functions. Still, a cognitive dilemma remains: After watching someone use a novel tool in a particular context, how far should we extend its function? The breadth of our attributions should influence how we use tools solve future problems and may also differ with age and experience. Two studies will address these questions.

Adults and children in kindergarten, second-, and fourth grade watched actors transform objects with novel tools, or listened to vignettes about tools' functional capacities. Participants then decided if these tools could transform objects that varied in color, size, the actions required to effect change, and problem-solving context. Overall, young children extended tool use on more objects than older children and adults. This disparity was strongest when the actions required to transform the objects differed from those modeled by the actors or described in the vignettes. Further, highlighting actions with verb labels did not help restrict young children's extensions of tool function.

Results suggest that older participants delineate particular actions required to reach overarching functional goals, such as 'prying' or 'cutting' open an object. Younger children extend tool function according to users' broad goals, such as 'opening', but do not consider the specific manner in which these goals are reached. Mechanisms for conceptual change will be discussed.

UNPACKING 'EXECUTIVE FUNCTION': WHAT ARE THE FACTORS, AND HOW DO THEY DEVELOP?

ORGANIZER: Gedeon Deák, University of California, San Diego

SUMMARY: In the past decade research on 'executive function' (EF) in children has greatly increased, yet the construct remains vague. Some researchers (e.g., Miyake et al, 2000) have proposed frameworks of EF skills, focusing on coherent factors and processes, and specifying how they interact. Any comprehensive EF framework must also account for the development of EF skills, not just in the preschool period, but also in transitions through middle childhood and adolescence. Later EF changes, like earlier ones, are defined by complex interactions of brain development, experience, and behavior. To explain all of these changes we must use experimental paradigms as well as studies of brain functions and structures, investigations of children's experiences (e.g., cultural practices), and special populations like children with developmental disorders. In this way we can identify dissociations and unique relations among components of EF in development.

The speakers will define and debate crucial questions about the development of EF, with the goal of refining a framework of developing EF skills. The data will focus on changes during the preschool years, early middle childhood, late middle childhood, and adolescence. A recurrent theme is the relation of inhibition, working memory, processing speed, and flexibility in EF. To address this and other issues, the speakers will call upon studies of brain development, individual differences (e.g., clinical samples), cultural differences, and experimental paradigms. These studies reveal changes and coherence in development of EF, and highlight questions for future research.

FLEXIBILITY AND INHIBITION IN YOUNG CHILDREN: TOWARDS A MORE REFINED TAXONOMY

Gedeon Deák, University of California, San Diego

Cognitive flexibility (i.e., changing representations to fit task demands) and cognitive inhibition (i.e., suppressing attention and thoughts) both develop rapidly from 3 to 5 years of age. The two processes seem related insofar as preschoolers' inflexibility (e.g., perseveration) could be caused by immature cognitive inhibition. However, there is evidence that this is not the case.

First, cognitive flexibility is not one ability, but at least two (quite likely more) defined by specific task demands. One is the ability to flexibly use linguistic cues to figure out a speaker's meanings (e.g., Deák, 2000). Another is the ability to flexibly switch rules or response contingencies (Zelazo, Frye, & Rapus, 1996). There is correlational and cross-cultural evidence that these are largely independent skills.

Second, individual differences in preschoolers' cognitive inhibition (as it is often assessed) do not predict differences in cognitive flexibility. Experimental evidence supports this dissociation. Moreover, the very construct "cognitive inhibition," as used in studies of young children, lacks internal validity. Consequently, the construct should be refined or differentiated.

Two other questions will be addressed. One is the relation of working memory to cognitive flexibility in preschool children. Our data shows a weak relation, like in middle childhood (Cepeda et al, 2000). The other question is how experience affects the development of cognitive flexibility. Recent cross-cultural and experimental data suggest that children's ability to flexibly switch rules particularly depends on culture-specific experience.

THE STRUCTURE OF EXECUTIVE FUNCTION IN EARLY CHILDHOOD: HOW MANY FACTORS?

Sandra A. Wiebe and Kimberly Andrew Espy, Southern Illinois University School Of Medicine

The preschool years are a time of rapid transition in the development of executive function, as children become increasingly able to regulate their behavior in a variety of settings. Recent years have seen the development of a variety of different tasks that have been used to assess EF status in preschool children (e.g., Espy, Kaufmann, Glisky, & McDiarmid, 2001; Hughes, 1998; Zelazo, Frye, & Rapus, 1996). The next step is to assess relations between performance on different tasks, and to improve our understanding of constructs that underlie performance on these tasks. Executive function has been conceptualized as including a number of separable cognitive abilities such as inhibition, working memory, and cognitive flexibility (e.g., Miyake et al., 2000). Factor analytic techniques have proven useful in identifying latent variables that underlie task performance. In the present study, 242 normally developing children between 2.5 and 6 years of age completed a battery of EF tasks. We have used confirmatory factor analysis (CFA) to compare several models of EF, beginning with a three-factor model (working memory, inhibition, set-shifting), and comparing this model with models intended to capture finer distinctions between processes, and models collapsing together tasks expected to index working memory and inhibition. For the full sample, a single-factor general model is sufficient to account for the data. We also examine the degree to which factor fit is invariant across subgroups of children divided by age and gender.

DEVELOPMENT OF PROCESSES UNDERLYING TASK SWITCHING IN ADHD AND NON-ADHD CHILDREN AND ADOLESCENTS

Nicholas Cepeda, University Of Colorado, Boulder

Successfully shifting tasks requires many skills - most notably, keeping the current task in working memory and inhibiting rules that are relevant to other tasks. In addition, processing speed has been proposed as a general factor that underlies the execution of most cognitive skills (Kail & Salthouse, 1994). Processing speed greatly increases in childhood, but its relation to executive function is not well understood. Evidence for differential development of processing speed, working memory, and ability to switch tasks, from early-middle childhood through adolescence, will be discussed. Evidence for distinct roles of perceptual interference and prior-task interference in children's task switching also will be discussed.

Even though working memory improves during development, neither this improvement, nor individual differences in working memory, is predictive of developmental changes in task switching. Instead, change in processing speed predicts almost all developmental improvement in switching. This suggests that a single construct of processing speed is sufficient to explain most age-related changes in task switching.

Further insight into the development of task-switching comes from studies of atypically developing children. Children with ADHD are impaired at shifting tasks, and more specifically, at shifting tasks in the presence of perceptual interference. ADHD medication moderates the deficit associated with perceptual interference, but does not moderate performance in the non-interference condition. Thus, processes associated with resolving interference can be distinguished from processes in task shifting.

Together, these findings suggest a more refined model of the development of task-switching skill.

TEENS MAKING CHOICES: 'HOT AND COLD' EXECUTIVE FUNCTIONS ARE SERVED BY DIFFERENT PREFRONTAL REGIONS DURING ADOLESCENCE

Monica Luciana, University Of Minnesota, Twin Cities

Recent neuroimaging studies suggest that the prefrontal cortex (PFC) continues to mature throughout adolescence and into young adulthood. Specifically, there is evidence of gray matter decline as well as refinement of white matter. These changes serve to stabilize neural networks that are controlled by various PFC subregions, such as the dorsolateral PFC and the ventromedial PFC. Whether these changes in brain structure are mirrored by advances in PFC-mediated behaviors has not been extensively investigated. In our laboratory, we are attempting to associate the development of PFC-mediated behaviors with structural changes in frontal white matter in healthy children who span the time period from late childhood to young adulthood. Participants, ages 9 to 23 years, complete a brain scan using diffusion tensor imaging (DTI). They also complete a battery of tasks designed to recruit dorsolateral versus ventromedial PFC subregions. Constructs that are investigated include memory span, spatial and verbal working memory under increasing demands for executive control, set-shifting, response inhibition, and decision-making under varying motivational conditions. Behavioral findings support the notion that dorsal and ventral regions of the PFC might be developing at different rates throughout adolescence. The dorsolateral PFC, which modulates executive control processes, appears to reach functional maturity prior to the ventromedial PFC, which controls motivated decision-making. Moreover, white matter integrity in ventral versus dorsal PFC subregions is differentially related to performance on "cold" versus "hot" behavioral tasks that are linked to each region. These findings represent one of the first reports of PFC structure-function relations in an adolescent sample. Implications for risk-taking behaviors that emerge between late childhood and adolescence will be discussed.

DISCUSSANT: *Akira Miyake, University of Colorado, Boulder*

SATURDAY, OCTOBER 22, 2005: 10:00 AM– 12:15 PM

COGNITION IN NON-HUMAN PRIMATES

ORGANIZER: Susan Gelman, University of Michigan

THE TRANSMISSION OF CULTURE IN APE AND CHILD

Andrew Whiten, University of St. Andrews, Scotland, UK

In this presentation I use selected examples to illustrate components of our research programme, that seek to gain a deeper understanding of both the evolution and development of the capacity for culture. The first of these is pursued by comparative research, particularly with our closest relative, the chimpanzee. The second focuses on children. In both lines of research, we have developed experimental approaches that tackle both population-level cultural phenomena and the psychological processes that support these. In the case of chimpanzees, we have recently succeeded in developing an experimental model for cultural transmission, in which each of two groups is seeded with an expert model, who tackles a foraging problem in a manner different to their counterpart in the other group. This method has recently demonstrated not only the persistence of alternative traditions of tool use consistent with our cultural interpretation of population differences in behaviour across Africa, but a measure of conformity to local norms hitherto regarded as a hallmark of human cultural propensities. We are now embarked on complementary studies that constrain transmission along 'diffusion chains'. In the case of children, our recent studies using this technique have identified predicted variations in fidelity of transmission according to the nature of the task concerned, and created an experimental microcosm for further study of these phenomena. Direct comparisons between children and chimpanzees engaged on the same social learning tasks will be described, further dissecting the similarities and differences between the two species in their approaches to social learning.

EXTREME MAKEOVER IN CHIMPANZEES: ENCULTURATING COGNITION

Sarah T. Boysen, The Ohio State University Chimpanzee Center

Findings will be discussed from a series of replicated tool tasks, all of which were failed by adolescent chimpanzees from another laboratory. Two decades of studies with our chimpanzees at Ohio State suggest that the enculturation process, that is, the immersion of ape subjects in an artifact-laden culture, with long-term, highly social, and stable human relationships, affects the animals' access to attentional resources and other executive functions in significant ways. Because attention plays a pivotal role in information-processing mechanisms that subservise higher-order cognition, such changes may facilitate acquisition of complex cognitive abilities. These may, in turn, encourage emergent skills, and in some situations, override behavioral predispositions that might otherwise interfere with acquiring of new concepts or meeting task demands. In light of these findings, the role of such capacities and their potential relationship to the evolution of cognition in chimpanzees and our own species will be discussed.

THE MANY FACES OF IMITATION

Francys Subiaul, Cognitive Evolution Group, University of Louisiana, Lafayette

After more than a century of research, the question: 'What is imitation?' remains controversial. Here, I contend that imitation is not a unitary phenomenon but rather involves two qualitatively distinct concepts: imitation as a type of behavior (behavior-matching) and imitation as a type of learning (imitation learning). The basis for this conceptual dissociation rests on neurobiological research demonstrating that different mechanisms mediate imitation learning and behavior-matching. Consistent with these two concepts, are individual classes of rules that can be learned by imitation. These include: vocal imitation (the imitation of vocal/auditory rules), motor imitation (the imitation of motor rules), and cognitive imitation (the imitation of cognitive rules). Developmental and comparative research has demonstrated that children, for example, do not imitate actions that are irrelevant to the execution of an outcome (Carpenter et al., 1998), monkeys ignore specific movements and copy only the sequential structure of actions (Subiaul et al., 2004), and both apes and children appropriately alternate between copying exact actions and copying results (and/or goals) alone (Gergely, 2002; Horner & Whiten, 2004). These results support the view that individuals imitate adaptively, parsing observed events in terms of different classes of rules.

EVOLUTIONARY AND DEVELOPMENTAL PRECURSORS TO A CONCEPT OF NUMBER

Elizabeth M. Brannon, Duke University

Adult humans quantify, label, and categorize almost every aspect of the world with numbers. The ability to use numbers is one of the most complex cognitive abilities that humans possess and is often held up as a defining feature of the human mind. In my talk I will present a body of data that demonstrates that there are strong developmental and evolutionary precursors to adult mathematical cognition that can be seen by studying human infants and nonhuman primates. In the first part of the talk I will

describe recent research from my lab where we have found strong evidence that monkeys and adult humans rely on a shared evolutionarily primitive system for comparing visual arrays based on number. For example, in one experiment we tested monkeys and humans in the identical task with the numerosities 2-30 and found that accuracy and latency to respond was systematically influenced by the ratio of the two values contrasted and that the Weber fraction was similar for both species. In a second study we found the first evidence of a semantic congruity effect in a nonverbal organism whereby monkeys were faster at choosing the smaller of two small numerosities and the larger of two large numerosities. In the second part of the talk I will describe parallels between infant and primate numerical cognition and highlight a recent finding that both rhesus monkeys and 7-month-old human infants have multisensory representations such that they spontaneously match the number of voices they hear to the number of faces they see.

DISCUSSANT: *Henry Wellman, University of Michigan*

SATURDAY, OCTOBER 22, 2005: 1:15 – 3:00 PM

THE DIVERSITY OF CHILDREN'S SPATIAL REPRESENTATIONS

ORGANIZER: Anna Shusterman, Harvard University

SUMMARY: Research suggests that humans, like other animals, simultaneously maintain multiple representations of their spatial environment. What is the content of these representations early in life, and how does it change over development? This set of papers integrates current research addressing these questions from diverse vantage points, focusing on two questions. First, how should we characterize children's spatial representations? The first two papers explore the representation of the geometry of the spatial layout, arguing that this controversial concept needs to be refined to account for different aspects of environment shape (wall lengths vs corner angles) and different modalities of spatial perception (visual vs locomotor space). Second, how do developing representations of space interact with other cognitive modalities? The next two papers explore the interface of spatial, visual, and language processes in children. The third paper investigates argues that children in a word-learning context favor allocentric representations over egocentric ones, making words like "north" and "south" easier to acquire than "left" and "right." Our final paper suggests that color and direction are processed separately, but that language can serve to bind these independent representations. Each of these papers is contributed by a different laboratory focused on children's spatial representation, and each one makes a unique empirical and methodological contribution to this field. As a whole, this work provide a fresh look at central issues in the development of spatial reasoning and the integration of spatial cognition with other mental processes.

ACTION AND REORIENTATION ABILITY: THE ROLE OF RESTRICTED MOVEMENT AT 3 AND 5 YEARS

Amy Learmonth, Manhattanville College; Nora Newcombe, Natalie Hansell, and Meredith Jones, Temple University

Research across a variety of species has revealed that mobile organisms share a powerful sensitivity to the geometric properties of enclosed spaces, and can use this information to reestablish spatial orientation after being disoriented (for review, see Cheng & Newcombe, in press). However, research with children investigating the use of nongeometric (or featural) information in spatial reorientation has produced conflicting results. When tested in a large enclosure (8'x12') children as young as 18 months can use features to reorient (Learmonth, Newcombe & Huttenlocher, 2001). The contrast between these results and those of Hermer and Spelke has been shown to depend on the size of the space (Learmonth, Nadel & Newcombe, 2002). But why is size important?

One explanation is that the size of the space influences the extent to which a child can engage in movement. In three studies we investigated the role of action by restricting movement to the smaller space within the dimensions of a larger enclosure. When boxes were located in the corner of the inner enclosure neither 3-year-olds nor 5-year-olds were able to use featural information to locate the correct corner. When boxes were placed in the corners of the large room and children pointed to their choices results differed sharply by age, with 3-year-olds not using featural information but 5-year-olds searching correctly. When the enclosure was removed and replaced with markings on the floor results were identical. These findings further illuminate how children's ability to integrate geometric and nongeometric information changes over development.

YOUNG CHILDREN'S REORIENTATION IN A RHOMBIC SPACE: NO EVIDENCE FOR AN ENCAPSULATED GEOMETRIC MODULE

Almut Hubbach, McGill University; Lynn Nadel, University of Arizona

Reorientation behavior of young children has been described as dependent upon a geometric module that is incapable of interacting with landmark information. Whereas previous studies typically used rectangular spaces that provided geometric

information about distance, we used a rhombic space that allowed us to explore the way children use geometric information about angles. Reorientation was studied in manipulatory space (Experiment 1) and locomotor space (Experiment 2) in the presence and absence of a salient landmark. In the absence of salient landmarks, 4-to 6-year-olds used geometric features to reorient in both spaces. When a salient landmark was available in manipulatory space, 4 year-olds used the landmark and ignored the geometry. Five- and 6 year-olds used the geometry, but in combination with the landmark. In locomotor space this combined use was already seen at age four, and increased with age. Taken together, these results offer no support for the notion that reorientation behavior in young children depends on an informationally encapsulated geometric module. These findings show that environmental parameters influence which spatial cues are used for reorientation and that spatial cognition develops in a more flexible way as originally conceptualized.

SPATIAL REPRESENTATION AND WORD LEARNING IN 4-YEAR-OLDS: FAST MAPPING AND GENERALIZATION OF NORTH AND SOUTH

Anna Shusterman, Peggy Li, and Linda Abarbanell, Harvard University

What spatial representations do children use when learning abstract spatial terms? We taught 4-year-old children (n=40) nonsense spatial words (ZIV and KERN) in an ambiguous training, without specifying whether the words meant north and south or left and right. Half of the children were taught with a Body game ("This is your ZIV arm") and half with an Objects game ("This toy is on your KERN side"). To assess whether they initially interpreted the terms egocentrically (as left-right) or geocentrically (as north-south), children were turned 180 degrees and asked to perform actions using these terms. Children in both games showed a bias to interpret the terms geocentrically. Consistent with this bias, 19 out of 20 children who were given structured feedback providing an unambiguous north-south interpretation of the terms succeeded in a post-test, but only 11 of 20 children receiving left-right training succeeded. To probe children's understanding of the geocentric terms, we trained 12 new subjects on the terms north and south, followed by three generalization tests: facing a new direction, using a new center of reference (a stuffed animal), and moving outside the training room. Mean scores on all three tests exceeded 80%, indicating that children spontaneously applied their understanding of the terms north and south to novel situations. Thus, children readily interpret novel spatial terms geocentrically, and rapidly acquire and generalize geocentric word meanings. These findings suggest that children have a geocentric representation of space, and that this representation is invoked in word learning.

RELATIONAL LANGUAGE BINDS VISUAL-SPATIAL INFORMATION

Banchiamlack Dessalegn and Barbara Landau, Johns Hopkins University

Can language help children form a stable representation of otherwise fleeting visuospatial distinctions? Four year-olds saw squares split by color and matched them after delay. In Experiment 1, children saw the target and were told either "Look, this is a blicket" (Label Condition) or "Look!" (NoLabel Condition). Then, three choices appeared: the target (e.g. vertical split with red left, green right), its mirror image, and another square that had a different internal split (e.g. horizontal). Overall, children performed better than chance. However, their errors were almost exclusively mirror image confusions, suggesting that children failed to visually bind color and location (e.g. red left, green right). There was no difference between the NoLabel and Label conditions, suggesting the whole-object novel label did not enhance color-location binding. Experiment 2 tested whether color-location binding can be improved by providing language that might bind these features. Children were shown a target and were told, e.g. "The red is on the left." Performance was reliably better than in Experiment 1, suggesting language did help children bind color and location. Experiments 3 and 4 explored whether the same performance improvement could be accomplished by increasing nonlinguistic attention to the target (i.e. flashing the red part, Experiment 3) or by using neutral relational language (e.g. "The red is touching the green"). Neither experiment showed enhanced performance, suggesting language can augment visual-spatial representations only if there is very specific lexical information. Generally, the results suggest language can play a powerful role in binding properties of the visual-spatial world.

LANGUAGE AND COGNITIVE DEVELOPMENT: THE EFFECTS OF LABELING IN INFANCY AND EARLY CHILDHOOD

ORGANIZERS: Bruce Homer, New York University; Sophie Jacques, Dalhousie University

SUMMARY: There is little doubt that the acquisition of language dramatically transforms children's cognitive abilities. However, although many theories have attempted to describe the general relation between language and thought, it is less than clear how best to characterize the impact of language on children's cognitive development. Furthermore, we still know relatively little about specific processes that might mediate the relation between language and the development of children's cognitive abilities. This symposium brings together researchers engaged in state-of-the-art research on ways in which language might

influence cognition and its development in infancy, early childhood, and even early adulthood. Each presentation goes beyond simply claiming that language affects cognition, but instead identifies ways in which specific features of language transform unique aspects of children's cognitive functioning. Although the presentations discuss different aspects of language, each has a primary focus on how labeling of objects affects the way that children reason about these objects. The specific cognitive abilities examined include the ability to make inductive inferences, symbolic understanding, and cognitive flexibility. The ages of the participants in the studies focus primarily on the late infancy and early childhood period, a time of rapid language acquisition and dramatic changes in children's cognitive abilities. Together, these presentations begin to provide a coherent framework for how language, particularly the use of labels, comes to serve human cognition and its development.

THE INFLUENCE OF NAMING ON INFANTS' INDUCTIVE INFERENCE

Susan A. Graham, University of Calgary

In a series of studies, we have examined the influence of naming on infants' inductive inferences. In our procedure, we present infants with novel target objects with or without a nonobvious property, followed by test objects that vary in shape similarity. When the objects are labeled with a novel or familiar count noun, 13- and 18-month-old infants will overlook shape similarity and generalize the nonobvious property to both high and low similarity objects. We have also demonstrated that 14-month-olds will rely on both novel count nouns and novel gestures to guide their inductive inferences. However, by 22 months of age, infants will use count nouns, but not gestures, to guide their inductive inferences. Taken together, the results of these studies provide insight into both the powerful role of naming on infants' inductive inferences and the types of symbolic information infants use to guide their inferences.

LANGUAGE AND THE DEVELOPMENT OF DUAL REPRESENTATION

Bruce D. Homer, New York University

Theory and research will be presented arguing for the importance of language in children's development of symbolic understanding. Recent research will be presented on the role of language in children's development of dual representation, which is the ability to see something both as an object and as a symbol (DeLoache, 2000). In two studies, 2.5-year-old children's ability to engage in dual representation was tested using two versions of DeLoache's model task. In the standard condition, children were shown an object (e.g., "Little Mickey") being hidden in a model of a room and were then asked to find a comparable object (e.g., "Big Mickey") in the same location in the actual room. In the language condition, children were asked to label the location of the object hidden in the model prior to retrieving the target object from the room. Data from these studies indicate that, controlling for age, language ability predicts overall success on the model task. Furthermore, children performed significantly better in the language condition of the model task than in the standard condition, suggesting that labeling facilitates dual representation. Based on these results and previous research, it will be argued that language is important for children's development of symbolic thought, particularly their ability to engage in dual representation. Specifically, it will be argued that language provides the "cognitive distance" that allows objects to be seen as symbols, and it provides a means by which children's symbolic activities can be "scaffolded" by adults, who model or verbally direct children's actions.

LANGUAGE SUPPORTS SYMBOLIC FUNCTIONING WITH PICTURES

Tara C. Callaghan, St. Francis Xavier University

Evidence will be presented from published (Callaghan, 1999; 2000) and recent research suggesting that picture symbol functioning is facilitated by language. Our task is a symbol-referent matching task in which children between the ages of 2-3 years are asked to find the item depicted in a realistic line drawing. Language availability has been compromised (Callaghan, 1999; 2000, Studies 1-3) by using items for which children do not have the verbal labels (e.g., fungus) or by having both choice items have the same basic level label (e.g., dog). Language availability has been enhanced (Callaghan, 2000, Study 4; 2005) by giving children subordinate verbal labels (e.g., tiger, cheetah) or by using items with highly familiar names (e.g., Tigger, Shrek). When the verbal label is available to children in this age range, they perform well on the task, but when it is unavailable, children younger than 3 years perform poorly. When highly familiar items are used and the choice items can not be distinguished by name (e.g., Shrek in peasant garb, Shrek in armour), children younger than 3 years revert to the typical pattern of random performance. These findings are discussed in the context of our model of pictorial symbolic development (Callaghan 2003; 2004; 2005; Rochat & Callaghan, 2004). This model suggests that children's symbolic functioning with pictures is driven by a variety of perceptual, learning and cognitive mechanisms, and by the cultural support provided by language and rich social interactions with others who interact with children using pictorial symbols.

MULTIPLE PERSPECTIVES ON THE ROLE OF LANGUAGE ON COGNITIVE FLEXIBILITY

Sophie Jacques, Dalhousie University

My colleagues and I have used correlational, experimental, and verbal-suppression approaches to systematically investigate the effects of language on cognitive flexibility – the ability to reason from multiple conflicting perspectives. I will discuss results of studies using labeling manipulations on the Flexible Item Selection Task (FIST; Jacques & Zelazo, 2001), a measure of flexibility. We found that performance on the task not only correlates with receptive language development in typically developing preschoolers and children with autism, but that when typically developing 4-year-olds are asked to label relevant information, their performance on the task improves significantly compared to children not asked to label or asked to label irrelevant information. However, unlike typically developing preschoolers who benefit from their own or an experimenter's labels, children with autism do not benefit from an experimenter's labels despite benefiting from their own. Finally, using a verbal-suppression approach, we found that when adults are asked to perform on a verbal secondary task along with the FIST, they experience significant difficulties even though they do not experience difficulties when they are asked to perform on a nonverbal secondary task (matched for difficulty with the verbal task). Taken together, results support the hypothesis that the emergence of flexible thinking in the preschool years may be mediated in part by language development and that difficulties with flexibility experienced by young children and children with autism may be due to their limited language abilities. Furthermore, language appears to continue to be important for the expression of flexibility in adults.

DISCUSSANT: *Katherine Nelson, CUNY Graduate Center*

NEW VENUES IN MEMORY DEVELOPMENT RESEARCH: INVESTIGATING RECOLLECTION AND FAMILIARITY ACROSS THE LIFE SPAN

ORGANIZERS: Simona Ghetti, University of California, Davis; Patricia J. Bauer, Duke University

SUMMARY: What are the processes through which children and adults recognize past experiences? Converging behavioral and neuroimaging evidence from adults indicates that recognition memory is sustained by at least two distinct processes: (1) recollection, the process through which individuals retrieve qualitative information associated with the context in which the event was originally experienced; and (2) familiarity, the process through which the strength of a memory trace is globally assessed. Although this distinction has radically transformed the field of adult memory research, developmental researchers have only begun to study the contribution of these processes to memory performance.

The proposed symposium focuses on the development of recollection and familiarity across the life span. The presentations will document and attempt to explain the divergent developmental trajectories of these two processes. The presenters were selected because they are leading researchers in the field of memory development and, collectively, their work on recollection and familiarity spans infancy throughout old age. Bauer's presentation will focus on the early signs of recollection and familiarity in infancy; Brainerd and Reyna's presentation will examine the contribution of recollection and familiarity to true and false recognition in childhood and adolescence; Ghetti and Angelini's presentation will explore factors affecting developmental change in recollection and familiarity during childhood and adolescence; and Light's presentation will document the differential decline of recollection and familiarity in older compared to younger adults. Together, the presentations outline the development of the foundational cognitive processes by which past experiences guide our present and future behaviors.

ON THE ROAD TO RECOLLECTION: DEVELOPMENTS IN RECALL OF SPECIFIC FEATURES OF EVENTS

Patricia J. Bauer, Duke University

By late in the first year of life, infants recall multi-step event sequences (as evidenced by deferred imitation). Whether they have one of the important ingredients for recollection—the ability to remember specific features of events—is an open question, however. Moreover, the extent to which developments in encoding, consolidation, storage, and retrieval of specific event features contribute to age-related changes in long-term memory (e.g., the length of time over which events are recalled), is just beginning to be explored. Using behavioral (forced-choice selection) and electrophysiological (event-related potentials: ERPs) measures, we have tested 9- to 20-month-olds' recognition memory for the props used to produce multi-step sequences, and related the accuracy of recognition to measures of recall (assessed via imitation). In the second year of life, there are age-related differences in children's accurate recognition of event-related props: Older children make more correct selections, suggesting more specific event memories. Accurate recognition relates to subsequent recall. By contrast, late in the first year of life, as a group, infants do not appear to have encoded the specific features of the materials used to produce multi-step sequences: Their ERP responses to pictures of event-related props versus distracter props largely overlap. Together the studies suggest that (a) with age, memories for

the features of events become increasingly specific; and (b) more specific feature memory relates to more robust event recall. The "fit" between the observed changes and developmental differences in recollection versus familiarity will be discussed.

CONJOINT RECOGNITION AND THE DEVELOPMENT OF RECOLLECTION AND FAMILIARITY

Charles J. Brainerd and Valerie F. Reyna, Cornell University

Adult findings converge on the conclusion that prior experience is remembered in two distinct ways: (1) recollection (vivid mental reinstatement of subjects' prior experience of an event) and (2) familiarity (compelling but inchoate feelings that an event has been previously experienced). Although this has been one of the most productive lines of experimentation in the mainstream memory literature, little is known about the early development of recollection and familiarity because the tasks that index these processes in adults, especially the remember/known paradigm, are too complex for young children. Fuzzy-trace theory provides low-demand, child-appropriate tasks (conjoint recognition and conjoint recall) that measure multiple forms of recollection and familiarity, and that separate "true" recollection and familiarity from parallel "false" experiences that underlie false-memory responses. Developmental conjoint-recognition studies have produced five key patterns: (1) True recollection improves more than true familiarity; (2) older children's true memories are more likely to be based on recollection than younger children's; (3) older children are better at suppressing false memories by vividly reinstating their actual experience; (4) false recollection improves during childhood; and (5) paradoxically, although false memories generally decline with age, their tendency to be based on illusory vivid mental experience increases.

DEVELOPMENT OF RECOLLECTION AND FAMILIARITY IN CHILDHOOD AND ADOLESCENCE

Simona Ghetti, University of California, Davis; Laura Angelini, Università Di Chieti, Italy

Recollection and familiarity show different developmental trajectories across childhood and adolescence: The former appears to improve steadily, whereas the latter shows little, if any, improvement. The present study examines the source of these divergent trajectories by exploring the role of semantic elaboration at encoding, that is, the ability to elaborate on the meaning of the material in the service of remembering. Semantic elaboration is likely to be important because (a) its use in facilitating memory improves across childhood and adolescence and (b) it affects recollection more than familiarity in research on adults. Previous studies of recollection and familiarity in childhood have used tasks that involve high levels of semantic elaboration. Thus, developmental changes in the ability to use semantic elaboration might account for the divergent development trajectories of recollection and familiarity. To manipulate semantic elaboration, participants aged 6, 8, 10, and 13 viewed drawings of common objects, and were oriented to either the semantic (deep encoding) or perceptual (shallow encoding) features of the objects. Participants subsequently performed an old/new recognition task. The recollection and familiarity parameters were estimated from ROC curves based on confidence ratings. Results showed that recollection increased from childhood to adolescence in the deep- but not the shallow-encoding condition. In contrast, regardless of encoding condition, familiarity remained relatively stable over time, except for an increase from age 6 to 8. These findings suggest that semantic elaboration, and perhaps the more general ability to perform complex strategic operations at encoding, are critical for the development of recollection, but play a less important role for the development of familiarity.

DUAL PROCESS MODELS OF MEMORY IN OLD AGE

Leah L. Light, Pitzer College

The research literature argues strongly for interpretation of adult age differences in memory in terms of two processes, familiarity and recollection. The former is generally thought to be rapidly recruited, more automatic in nature, and relatively preserved in normal aging, whereas the latter is slower in rise time, more strategy-dependent, and impaired in old age. We present evidence in support of this view from studies of associative recognition and plurality discrimination paradigms that involve recall-like processes. We show that older adults perform less well than young adults in these tasks under a variety of encoding and retrieval conditions. For instance, in both paradigms older adults demonstrate ironic effects of repetition and imposing a response deadline during recognition counters benefits of repetition in young adults. We also demonstrate that in associative recognition, young but not older adults benefit from instructions that foster elaborate encoding and retrieval strategies and that age differences in this paradigm are not eliminated by retrieval tasks that focus recognition decisions on aspects of the study experience. Finally, we describe modeling of receiver operating characteristics of young and older adults for item and associative memory and consider alternative theoretical approaches.

SATURDAY, OCTOBER 22, 2005: 3:15 – 5:00 PM

CULTURE, COGNITION, AND FOLK BIOLOGY

ORGANIZER: Karl S. Rosengren, University of Illinois

SUMMARY: Children's understanding of the natural world has provided a forum for researchers interested both in children's naive biology and in broader issues concerning children's conceptual development. A core question has been the nature of children's reasoning about natural, biological phenomena. Understanding how children acquire particular beliefs about the biological world and the nature of these beliefs has important societal implications, not the least of which is the need to educate the lay public about health and environmental concerns. There has been much debate regarding both the nature of young children's biological knowledge and the timing of the acquisition of distinctly biological reasoning, yet, no overall consensus has been reached. In part to resolve this impasse, researchers have begun to focus greater attention on social-cultural factors. This symposium brings together several researchers with diverse approaches examining cultural influences in the acquisition of children's folkbiological reasoning. In the first presentation, Waxman and colleagues explore the impact of naming practices on the acquisition of biological concepts, in Indonesian and English. In the second presentation, Tarlowski examines the role of experience with nature in urban and rural Polish children's folkbiology. Both Evans and colleagues, in Presentation 3, and Solomon and Wheeler, in Presentation 4, highlight how religious beliefs impact the acquisition of specific biological beliefs about species change (Evans, et al.,) and illness (Solomon & Wheeler). Rosengren, as discussant, will draw these diverse strands together and articulate what further questions must be addressed in order to move the field forward.

NAMING AND THE ACQUISITION OF FOLK BIOLOGICAL CONCEPTS: EVIDENCE FROM INDONESIAN AND ENGLISH

Sandra R. Waxman, Douglas Medin, Florencia Angorro, Northwestern University

Considerable research has been focused on the acquisition of biological concepts, including ANIMALS, PLANTS and LIVING THINGS. Although controversies abound, there is broad consensus that LIVING THING is acquired late. We propose that this persistent difficulty, documented in English, Japanese and Hebrew, reflects the naming practices of the language under acquisition. In each of these languages, the word animal has (at least) two senses: one that includes people and one that excludes them. Because the same word points to two nested categories, it may be difficult to settle on its scope. Children may attempt to resolve this difficulty by mapping one word (animal) to one sense and (mis)appropriating another word (alive) for the other. Although this would circumvent the polysemy, it could account for their difficulty including plants when identifying things that are alive. In Indonesian, there is no such polysemy. If our proposal is correct, then children acquiring Indonesian should show less difficulty acquiring the inclusive concept ALIVE or LIVING THING.

The results of several sorting tasks support the prediction the acquisition of folkbiological concepts is influenced importantly by the naming practices of the ambient language. Indonesian-speaking children readily include plants in their interpretation of alive; by 9 to 10 years of age, they reach near-ceiling performance. In sharp contrast, English-speaking children exhibit a slower developmental trajectory; by 9 to 10 years, only about 50% of the children demonstrate this inclusive interpretation. These results are interpreted within the larger context of theoretical accounts of the acquisition of folkbiological knowledge.

FRIENDLIER TASKS AND EXPERIENCE WITH NATURE HELP REVEAL DOMAIN SPECIFIC BIOLOGICAL KNOWLEDGE IN PRESCHOOLERS

Andrzej Tarlowski, Northwestern University

Within the arena of biological knowledge, there is controversy concerning a) whether preschool children hold abstract domain-specific biological knowledge, and b) how input shapes the process of acquisition. We present new evidence bearing on each of these controversies. We examined 4- to 5-year-old Polish children, who differed in their direct experience with nature (urban vs. rural) and cultural transmission of biological knowledge (expert biologist vs. lay parents). In a category-based induction task, children were introduced to an object, heard a novel feature (e.g., ladybug has lipids), and were asked to extend this feature to an array of nine simultaneously-presented targets. Rural experts' children systematically based their extensions on membership in the abstract category ANIMAL; urban-laypeople's children projected features indiscriminately. This suggests that with ample exposure to biological world, preschoolers move beyond similarity to use abstract categories in inductive inference.

In an adoption paradigm (a baby born to an animal of one species is raised by animals of a different species) epistemic hints regarding how adoptive and birth parents acquired their beliefs were provided. For example, geese (depicted in a pond) were said to "...know the pond". In this task, preschoolers in all four groups differentiated between the mechanisms of transmission of biological and psychological features. They judged that physical features are transmitted by birth parents, but that beliefs can be transmitted by adoptive parents.

Together, these results suggest that preschoolers' reasoning is guided, in certain contexts, by abstract, domain-specific biological knowledge, and that this knowledge is enhanced by rich input.

CULTURE, COGNITION, AND CREATIONISM

E. Margaret Evans, University of Michigan; Karl S. Rosengren, University of Illinois; Kristin Szymanowski, University of Toledo; Peg Hull Smith, University of Toledo; Karen Johnson, University of Michigan

Citizens in the United States are more likely than those in any other nation to deny that "humans evolved from other species" (Mazur, 2005). With approximately half the population endorsing creationist beliefs and most of the rest endorsing evolution, the US provides a unique setting in which to examine the cognitive and cultural factors impacting the spread of belief (Evans, 2001). Structured interviews in one Midwest city with 131, 5- to 12-year-olds and their parents from Biblical literalist (God created each species) and theistic evolutionist (evolution is part of God's plan) homes incorporated open- and closed ended questions about the origins of humans, other mammals, and animals that undergo metamorphosis (butterflies, frogs). The evolution measure focused on common descent: That one species is the ancestor of a different kind. There was an age-related increase in children's susceptibility to parental beliefs about the origins of species, with 10- to 12 year-olds' views most likely to reflect those of their parents. Four main factors interacted to influence the emergence of children's origins explanations: (1) acceptance of radical life-cycle change: metamorphosis (2) whether the human is considered an animal (3) the ability to integrate different causal levels (4) parent beliefs and interests. We conclude that creationist belief succeeds to the extent that it links God's intentions to two prevalent cognitive biases, which are part of a folkbiology: that animals are unchanging (essentialism) and purposeful (teleology).

FOLKBIOLOGY, RELIGION, AND IMMANENT JUSTICE EXPLANATIONS OF ILLNESS

Gregg Solomon, National Science Foundation; Sarahn Wheeler, Harvard University

Two studies explored the hypothesis that immanent justice, the notion that good things happen to good people and bad things happen to bad people, might serve as a default form of reasoning for children who have yet to construct biological understandings of illness. In Study 1, kindergartners (5- and 6-year-olds) and adults took part in structured interviews investigating reasoning about two biologically plausible causes of cancer: heritability and contagion. Results show that a minority of kindergartners demonstrated an understanding of biological inheritance. Their judgments of whether a person was likely to develop a cold, cancer, or a scrapped knee were unrelated to whether or not that person's birth parents had the ailment. Most kindergartners knew the fact of contagion, but only in shallow ways, judging scrapped knees or sunburns to be contagious. Consistent with the overall hypothesis, children were more likely to give immanent justice explanations of cancer if they lacked general knowledge of the disease and if they did not show an adult-like biological understanding either of contagion or heritability.

Study 2 is exploring the relation of teleology and religiosity to immanent justice reasoning. Preliminary results indicate that in children the tendency to give immanent justice explanations is associated with the salience of teleological reasoning, but not with religiosity. Among adults, it is associated with religiosity and teleological reasoning, but such adults also give coherent biological explanations as well. These findings are discussed in light of recent work in cognitive development and anthropology on multiple levels of causality.

DISCUSSANT: *Karl Rosengren, University of Illinois*

WHEN KNOWLEDGE LOOKS DIFFERENT DEPENDING ON HOW WE TAP IT

ORGANIZER: Angeline Lillard, University of Virginia

SUMMARY: Sometimes children seem to know something when we tap into their knowledge in one modality (like looking behavior) but seem to lack that same knowledge when we attempt to access it in another modality (like reaching). The symposium will explore this phenomenon in four domains: motor development, gesture, pretend, and object knowledge. Vishton will discuss differences in infant looking and reaching in the context of how different visual information appears to specify object boundaries for each system; Adolph will describe dissociations in infants' motor knowledge across perception-action systems (sitting, crawling, cruising, and walking) and between situations involving variations in surface layout versus surface friction; Ma will present findings that 2-year-olds seem to know who is pretending if one looks to their gustatory behaviors, but seem ignorant when one looks at their reaching in response to an explicit request; and Goldin-Meadow will present research showing that children (and adults) seem to know more with their hands than with their words. Each speaker will present findings, and will comment on the implications for how we define knowledge and for the organization of the mind.

VISUAL INFORMATION SPECIFYING OBJECT BOUNDARIES: CONTRASTING REACHING AND LOOKING BEHAVIORS

Peter M. Vishton, William & Mary; Elizabeth A. Ware, Northwestern University; and Jennie E. Park, Northwestern University

Infants between 6 and 10 months of age were presented with displays that sometimes consisted of a single object and in others consisted of two separate parts. For experiments on looking time behaviors, infants watched an experimenter grasp one end of the display and pull on it. If infants perceived the display as one connected unit, then they should expect the whole display to move together. Alternatively, if infants perceived the display as two separate pieces, then they should expect only the grasped part of the display to move, leaving the disconnected display part behind. Infants looked longer at the events that violated expectations based on shape, color, relative motion, or a small visible gap. For experiments on reaching behaviors, infants were presented with the same displays used in the reaching experiments and allowed to reach for them. Infants reached away from object boundaries and toward the smaller of two display pieces when the boundaries were specified by shape differences and/or relative motion, but not when specified by differences in color and/or a small visible separation. The dissociation of color and visible separation cues for reaching and looking measures suggests that these two behaviors are mediated by somewhat distinct object perception processes.

SPECIFICITY OF INFANTS' KNOWLEDGE FOR ACTION

Karen E. Adolph, Amy S. Joh, Shaziela Ishak, Sharon Lobo, and Sarah Berger, New York University

Previous work revealed specificity in infants' motor knowledge. What infants had learned about affordances for action in earlier developing perception-action systems did not transfer to later developing systems. When tested at the brink of slopes (0°-90°) or gaps (0 cm-90 cm), infants displayed separate learning curves over sitting, crawling, cruising, and walking. Learning was related to the duration of infants' everyday experience maintaining balance in each posture. In a series of new, cross-sectional experiments, we replicated and extended these findings. Increase in age and experience (11-18 months) predicted more finely attuned response curves. With age held constant, adaptive responding depended on infants' experience with each posture. For example, experienced 12-month-old crawlers scaled their attempts to the probability of descending safely, but novice 12-month-old walkers plunged repeatedly over the brink of impossibly steep slopes. At 14 and 18 months of age, walking infants responded adaptively to surface slant, but they appeared oblivious to variations in surface friction. Even when infants could feel their feet slipping on a flat starting platform, they failed to incorporate the tactile information for slip with the visual information about the degree of slant in the ground ahead. Adults fared as poorly as infants under similar testing conditions, where we varied the slip under their feet and indexed their knowledge about possibilities for action on upcoming slopes. We discuss these findings in terms of acquisition of learning sets.

IMPLICIT VERSUS EXPLICIT INDICATORS THAT CHILDREN DISTINGUISH REAL FROM PRETEND

Lili Ma and Angeline Lillard, University of Virginia

To examine 2- to 3-year-old children's ability to make pretend-real distinction in the absence of obvious content cues, we showed children two actors side by side. One was really eating, and the other was pretending to eat, but in neither case was the food (or pretend food) visible. Following the eating displays, the covered bowls from which the actors had eaten were pushed towards the children, who were asked to find the real food (Exp.1) or point to the container with the real food (Exp.2). In experiment 1, over 80% of 3-year-olds chose the correct bowl on the first trial, more than would be expected by chance, but younger children were at chance. However, if one looked instead at their spontaneous behaviors during the displays, 2- and 2.5-year-olds swallowed, smacked their lips, and reached more to the real displays than the pretend ones. In the second study, children were asked to point to the real food instead of actually get it. Under this condition, over 80% of 2.5-year-olds also were above chance in selecting the correct bowl. Two-year-olds, in contrast, were at chance in which bowl they selected, but their spontaneous reactions again suggested that at least an implicit understanding. Thus depending on how the knowledge was tapped—via an explicit bodily reaction to an explicit question, or via observation of behaviors in response to a display, children's knowledge of pretending appears different. How these two systems of knowledge might relate to each other and the implications for the organization of knowledge will be discussed.

GESTURE AS A MEASURE OF HIDDEN KNOWLEDGE

Susan Goldin-Meadow, University of Chicago

When children talk, they gesture and those gestures convey substantive information about the task at hand. Interestingly, children often display knowledge in their gestures that they do not display anywhere in their speech. For example, toddlers who are not yet able to produce two-word sentences produce gesture+word combinations that convey sentence-like meanings ('eat' +

point at cookie). As another example, children who cannot yet conserve number produce one-to-one correspondence conservation strategies in gesture that they are unable to articulate in speech. Gesture thus reveals implicit knowledge that speakers don't seem to know they have.

Moreover, gesture has cognitive significance. Children who reveal implicit knowledge in their gestures on a task turn out to be ready to learn that task. For example, toddlers who are first to produce sentence-like gesture+word combinations are, several months later, first to produce two-word sentences. Children who explain their responses to a conservation task by producing strategies in gesture that differ from the strategies they produce in speech are more likely to profit from instruction in that task than children whose explanations contain the same strategies in gesture and speech.

Gesture is thus an excellent harbinger of a child's next developmental step. The next question, which I will address in this presentation, is whether gesture goes beyond revealing the child's next step to actually play a role in making that step happen. Is gesture an engine of change?

INFLUENCES ON THE ACCURACY AND COMPLETENESS OF CHILDREN'S EVENT REPORTS

ORGANIZER: Claudia Roebers, University of Berne

SUMMARY: The literature on memory development reveals substantial individual differences in the accuracy and completeness of children's reports of their experiences. An analysis of these factors has important implications for discussions of children's legal testimony, but also may serve to elucidate fundamental memory mechanisms. Accordingly, the proposed symposium will focus on explorations of factors, such as narrative skill, parents' construals of events, source monitoring, and conformity to overheard responses, that may be responsible for individual differences in reporting. The first paper examines the relationship between narrative skill and the accuracy of memory reports. The findings indicate that children with increased narrative skill tend to embellish their reports with inaccurate details. The second paper explores how parental encouragement to believe in childhood myths can contaminate memory. The findings show that many preschoolers remember actually interacting with the Tooth Fairy, and that these reports can be more elaborate than those of real experiences. The third paper examines developmental differences in children's vulnerability to an interviewer's correct and incorrect leading questions and to a confederate who gives both correct and incorrect responses. The results demonstrated that the younger children were affected by both sources, whereas the older children were influenced only by the confederate's answers. The final paper explores the relationship between source memory, theory-of-mind-understanding, and suggestibility. The findings reveal that an early awareness of source may hinder children's ability identify the origin of suggestions. The data reported in these presentations will be integrated in a discussion regarding implications for theories of memory and issues concerning children's testimonial reliability.

DO THE FACTS GET IN THE WAY OF A GOOD STORY?: THE RELATIONSHIP BETWEEN NARRATIVE QUALITY AND MEMORY ACCURACY

Sarah Kulkofsky, Cornell University

Many theoretical perspectives on the origins of autobiographical memory place importance on the development of narrative skill. While past research has shown that increased narrative skill leads to increased volume of reporting, little research has looked specifically at the relationship between narrative skill and accuracy of memory reports. The purpose of the present study was to systematically examine whether children who provide longer, more coherent, and more complex memory narratives provide more or less accurate information. Thirty-two preschool aged children participated in a novel event and completed a memory interview one week later. Children's memory interviews were coded for narrative volume, coherence, and breadth, as well as for accuracy. Results indicated that in line with previous studies, as children's narrative skill increased the number of correct statements about the event increased. However, increased narrative skill was also positively correlated with reporting inaccurate information. In other words, children with well formed narratives provided both more accurate and inaccurate information. When proportion of accurate information was considered, children with increased narrative skill provided proportionally more inaccurate information than children with less narrative skill. These results suggest that children at this age may view memory sharing as a social-communicative activity, rather than an activity of accurately reporting the content of past events. While narrative structure may help children retain information from an event, children with increased narrative skill are also willing to embellish or provide false information in order to provide a more elaborate and complete memory report.

THE TOOTH, THE WHOLE TOOTH, AND NOTHING BUT THE TOOTH: HOW CHILDREN'S BELIEFS IN THE TOOTH FAIRY CAN ENGENDER FALSE MEMORIES

Gabrielle Principe, Ursinus College

The memory literature shows that parent-child conversations can affect how children represent, interpret, and remember their experiences. Existing research has not addressed what happens when parents provide children a misleading verbal framework. This question has relevance to legal cases involving abuse if abusive parents provide a misleading framework by calling sexual abuse a special game, or calling physical abuse punishment. In such situations, children may adopt the adult's false construal and formulate memories consistent with it. One ethically permissible way to explore this issue is to examine how children's memories are influenced by parental encouragement to believe in false childhood myths, such as the Tooth Fairy. In this myth, parents are intentionally misconstruing events surrounding their children's loss of primary teeth. Fifty preschoolers were interviewed using a series of open-ended and specific questions about what happens when children lose their baby teeth. Over half of the children recalled seeing the Tooth Fairy, and nearly one-third reported interacting with her. Further, the number of Tooth Fairy rituals in which parents engaged children predicted the number of assents to specific questions about seeing, hearing, and interacting with the Tooth Fairy. To compare the content of narratives about real and fantastic events, children were questioned about what happens when they go to the doctor for a checkup. The children's narratives about the Tooth Fairy were more elaborate and complex than their narratives about the doctor. These data demonstrate that parents' construals of events can contaminate children's memories for their experiences.

DEVELOPMENTAL PROGRESSION IN CONFORMITY AND IN COGNITIVE CONSEQUENCES OF SOCIAL INFLUENCE

Claudia Roebbers and Stefanie Schwarz, University Of Berne

In the to-be-presented study, developmental changes in conformity to social influences and age-dependent long-term effects of prior social influence and suggestions on later memory performance were investigated. Eighty-nine 7- to 10- year olds were three times individually questioned about an observed event. In the first interview, open-ended questions were asked to have a baseline of memory for the to-be-remembered details. In the second interview, leading questions about the same details were asked in the presence of a confederate who answered first and who manipulated social influence through her correct and incorrect answers to the leading questions. On the next day in the third interview, children underwent another leading interview but without the confederate. Analyses were performed for memory accuracy in each of the three interviews as a function of social influence and revealed developmental differences in the extent to which younger and older children were influenced by (a) the leading questions and (b) the answers of the confederate. While there was a significant effect of leading questions and the confederate's answers for the younger children, the older children were influenced only by the confederate's answers. Further analyses revealed that the confederate had a strong influence on the kind of answering changes across interviews children showed, as well as on the total frequencies of change, with the younger children generally being more prone to answering changes, despite correctly reporting the information in the first interview.

THE RELATIONS BETWEEN CHILDREN'S MENTAL-STATE UNDERSTANDING, SOURCE-MONITORING SKILLS, AND SUGGESTIBILITY

Angela Evans and Kim Roberts, Wilfrid Laurier University

Children's ability to resist suggestions is related to both source monitoring and theory-of-mind understanding, yet these skills may not operate independently of each other (Welch-Ross, 2000). Children who lack mental-state understanding may not encode or retrieve source information, resulting in poor resistance to suggestions. In some studies, however (e.g., Welch-Ross, 1999), young children who passed theory-of-mind tests were misled even though they appeared to engage in source monitoring. Thus, we tested children's source-monitoring skills, mental-state understanding, and suggestibility within the same paradigm to allow a direct assessment of the relations between them.

Seventy-two 3- to 5-year-olds watched a video and were interviewed about the video by a Knowledgeable interviewer and a Naïve interviewer. Children were asked non-misleading and misleading recognition questions. After five to seven days, children were asked the same recognition questions by a third interviewer. Children also completed a source-monitoring task to see where they thought the suggestions came from, as well as three theory-of-mind tests. As expected, children who showed 'Awareness of Knowledge Origins' demonstrated a larger suggestibility effect with the Knowledgeable interviewer than children who failed. Interestingly, the children with mental-state understanding seemed to genuinely believe that they had seen suggested items in the video (i.e., had lower source-monitoring scores than children who failed). These data are consistent with those of previous research and suggest that mental-state understanding and source-monitoring skills may need to reach a critical threshold before they can be used to resist suggestions.

DISCUSSANT: *Peter Ornstein, University of North Carolina, Chapel Hill*