THROUGH AN INFANT'S EYES

LEARNING TO INTERPRET THE WORLD VISUALLY IS A KEY DEVELOPMENTAL STEP FOR BABIES. HOW DO THEY DO IT?

by Marilyn Davis

The first time their baby reaches for an object, parents are delighted. Before long, they're entertaining their infant by playing a rudimentary version of hide-and-seek, making a favorite toy disappear and reappear.

That simple activity helps their child in the process of making sense of the world—the ability to perceive things, to focus attention, to realize that an object still exists when it's temporarily hidden, to remember and think about an object when it hasn't been in sight recently. All are connected with learning.

Babies can distinguish colors at two to three months, reach for an object at roughly three months, and track a moving object at about three to four months. By six months, most understand that an object can be temporarily hidden and, given enough information, can anticipate where it will emerge. By two to four years old, a child's short-term visual memory is about as advanced as it will get, although we develop new strategies for remembering information as we get older.

How do babies and toddlers acquire these capacities? Matthew Schlesinger, an associate professor of psychology, studies brain development to find out. "Attention, memory, and perception are linked together," he says, "and I'm studying the brain processes underlying them."

Behavioral psychologists have devised many tests of how babies of various ages interpret visual phenomena. Schlesinger shows me one, usually given at ages two to four months: a simple video of a blue rectangle with two green bars projecting from the top and bottom. The green bars are aligned and they move back and forth along the rectangle in synchrony. Babies will watch this motion for several minutes until they get bored, a state called habituation.

At that point, they're shown two more videos. In both, the blue rectangle is gone. One video shows a solid green rod moving back and forth in its original place. The other shows empty space where the rectangle was, so that the baby sees two green segments moving. As the babies scan these videos, testers track their eye movements. The key questions are where the babies direct their attention in each video and for how long.

> ***DATA FROM SCHLESINGER'S MODELS COMPARED TO THE TESTING RESULTS "CAN HELP YOU SEE A CONNECTION BETWEEN THINGS THAT YOU WOULDN'T HAVE IMAGINED FROM THE TESTING DATA ALONE."***

"A child will generally look longer at something unexpected," says Schlesinger. He terms it a novelty reaction; others call it a violation-of-expectations reaction. The assumption is that babies who look longer and more often at the two separated segments had perceived the original video the way most adults would: as a solid bar moving behind the rectangle. Babies who don't had not mentally "filled in" the bar.

As babies get older, Schlesinger says, "more and more of them will [assume] a solid green rod" in the original test. "How can we explain that change?"

In another video test, a train is shown moving down a track. A small box then appears in front of part of the track, hiding the train for part of its journey. By the age of six months, most babies don't seem

With age, more and more babies interpret the rod-like segments the same way an adult would—as a solid bar moving behind the blue rectangle. Researchers have devised many such video experiments to test babies' visual development and understanding.

Matthew Schlesinger with his research team (from left): master's student Joe Geeseman, senior Catrina Bowen, senior Eric Greenlee, junior Josh Chin, and master's student Jillian Mayer.

surprised to see the train reappear at the edge of the box. But if a subsequent video shows an object on the track before the box comes down over it, and the train still reappears at the edge of the box, most babies—based on their visual tracking and attention span—do seem surprised.

"Experimental work is very descriptive of the process of development over months," Schlesinger says. "But we don't know what makes those changes possible.

"My role is how to figure out what developmental brain mechanisms might be responsible. There are brain development disorders in which this capacity is disrupted. I want to help build a model that explains the normal process of development as well as atypical processes, which might be applicable to attention disorders or learning disabilities."

You'll only occasionally find babies in Schlesinger's lab, however. Instead, you'll find computers equipped with sophisticated software that allows him to simulate how babies learn and develop. Colleagues such as psychologists Dima Amso (Cornell University) and Scott Johnson (UCLA) send Schlesinger their data from behavioral tests with babies. He uses computer models to help interpret what's happening in the brain and to suggest future experiments.

Schlesinger can take a scene shown to a baby, load it into his computer, and—based on what is already known about mammals' visual systems—run software to estimate the attention-getting value of each aspect of the scene. That then allows computer predictions of where a baby is most likely to spend time looking.

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What constitutes "attention-getting"? Certain neurons in the brain are sensitive to line edges and to foreground/background differences, for example. Others are dedicated to detecting color, movement, brightness/contrast, and other visual phenomena. These different sensitivities are called optical filters. They're a function of the occipital lobe, which is the first part of the brain to process the light hitting the retina. Each amounts to a sort of "map" of the scene based on one characteristic.

"There are many different maps of the original scene in the occipital lobe," Schlesinger says, "and these are integrated into a single, unified map in the parietal lobe, which directs attention." Similarly, the computer can combine the maps into a representation of the scene. "We're simulating the view of the world from the infant's perspective," he says.

Schlesinger then runs models to see how well they correspond to infants' actual eye movements—where the babies looked and for how long. The closer the simulation matches those, the better he can pinpoint the brain processes involved. It may sound simple, but it's a complicated mathematical process.

Data from his models compared to the testing results "can help you see a connection between things that you wouldn't have imagined from the testing data alone," he says. Models also can inspire new experiments. "You can use a model with a new stimulus to predict an infant's behavior" before it's tried experimentally, Schlesinger explains. "If it's confirmed, it means the model is doing a good job. If not, I need to refine it. As we learn more, we'll modify the model.

"Models also can provide new behavioral hypotheses and inspire new experiments that wouldn't come about through behavioral studies alone, because many times modeling predictions are counterintuitive. They challenge the popular view."

Over time, the interplay of behavioral testing and modeling gives the researchers a better understanding of how visual attention and expectations develop and become more sophisticated. Which optical filters come into play as a baby gets older? Together, behaviorist and modeler can tease out pathways in the brain and discover how brain structures are maturing. "We talk as a group about what brain pathways or mechanisms we think are developing that make [a particular] capacity emerge," Schlesinger says.

In turn, changes in brain structures give babies the tools to develop new capacities for visual perception, attention, and memory. "Brain structures make [these capacities] possible, but you need experience to activate them. And experience helps those brain structures to grow and mature," Schlesinger says. "It's a feedback loop. Experience—one's expectations and beliefs—can influence where attention is directed, and where you pay attention plays a very important role in how visual perception develops."

Schlesinger and his team of graduate and undergraduate research assistants do behavioral experiments as well—occasionally with babies, but usually with college students. Studies of adolescents and adults, he says, can help researchers understand some of the results from tests with babies. They also allow him and his team to study the developmental process at different points in time and with additional variables.

For example, master's student Joe Geeseman focuses on the relationship between the perception of moving objects and sound. "It's an extension of the idea of vision and attention," Schlesinger says. One of Geeseman's experiments found that students watching a video in which a ball bounces back and forth across a screen misjudge the moment of the bounce if they hear a sound slightly before it—even if they're told to ignore the sound.

In another experiment conducted by master's student Jill Mayer, an object containing a letter passes behind a screen. When the object reappears, students are asked to identify whether the letter is a different one or the same. Interestingly, it takes them longer to do this if the object has changed in color or shape. "The brain seems to prefer context—it makes it easier to perceive or remember," Schlesinger says. The same may be true for babies.

Schlesinger also is teaming with fellow SIUC psychologist Reza Habib to do neuroimaging of adults taking part in such tests. In these functional MRI images, as they're called, different parts of the brain light up under different circumstances.

Imaging can help researchers understand visual perception—"We know the parietal cortex plays an essential role," Schlesinger says—but it isn't sufficient. "An area lights up, but we don't know how the information is being processed," he says.

Rather, imaging provides another tool to solve the cognitive puzzle. Schlesinger believes in a team approach to combine evidence from behavioral testing, computer modeling, and imaging to get the most accurate understanding of how babies perceive the world—and how that shapes our ability to learn and develop.

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Babies' experience with their environment triggers the maturation of brain structures that allow more sophisticated visual interpretation.