LOOK AND LEARN

Prevailing wisdom says the adult brain cannot learn to see if it had no visual stimulation during childhood, but blind people in India seem to be breaking all the rules. **Apoorva Mandavilli** reports.

Doctors gave SK his first pair of glasses in July 2004. He had been too poor to afford a pair before — but then he was a 29-year-old blind man, what use were glasses to him? Had he been given glasses as a child they might have helped him overcome his congenital aphakia — an extremely rare condition in which the eyeball develops without a lens. Yet his chances of being diagnosed, let alone treated, in the poor Indian village in which he was born were slim. As a result, SK was living in a 'hostel for the blind' with no running water when the doctors arrived from New Delhi.

SK's doctors weren't sure how much sight he would gain, or if he would comprehend what he saw. For the first year, he had only the most basic visual skills. He could recognize simple two-dimensional objects but anything three-dimensional, even an everyday object such as a ball, was beyond him. All this was consistent with the idea of a 'critical period' in vision: that if you haven't learned to see by a certain age, you never will.

But 18 months after getting his glasses, SK surprised everyone. He had begun to make sense of his world, building his visual vocabulary through experience and recognizing more complex objects with varying colours and brightness. In doing so, he turned one of the most fundamental concepts in neuroscience on its head.

"Twenty-nine years without any normal vision? I would have said that's a life sentence," says Ron Kalil, a visual neuroscientist at the University of Wisconsin in Madison. For Kalil and other experts, the impossible now seems possible. And while the scientists might be amazed by the brain's adaptability, the real winners are the countless blind people — both children and adults — who had been considered untreatable.

Light work

SK is the first success of Project Prakash (Sanskrit for 'light') launched in 2003 and run by Pawan Sinha, a neuroscientist at the Massachusetts Institute of Technology. Originally a humanitarian effort to help blind children in India, under Sinha's guidance Project Prakash has blossomed into a chance to investigate how we learn to see.

The idea of a critical period for vision grew out of research in animals. In the 1970s, Torsten Wiesel and David Hubel at Harvard Medical School famously shut one eye of a week-old kitten. They found that closing the eye for only a few weeks caused the kitten's visual cortex, the part of the brain that deals with sight, to develop abnormally. But similar experiments had little effect on adult cats.

P. SINHA

After 29 years of being officially blind, SK is learning to see — and defying neuroscience in the process.

After further work in monkeys, Wiesel and Hubel suggested that there is a critical period during the first few months of life when normal vision must develop. In 1981, they shared the Nobel Prize in Physiology or Medicine for this and other work.

> "The work in India challenges the clinical notion that treating a blind child beyond the age of eight is hopeless."

The notion of a fixed critical period has been crumbling steadily for the past few decades, and the brain is now seen as much more flexible — able to grow new nerve cells and to adapt long after childhood. For instance, Uri Polat and his colleagues at Tel Aviv University in Israel showed in 2004 that adults with a lazy eye can be trained to improve their vision[1] — contrary to conventional expectations.

In the strictest sense, SK's case does not contradict Wiesel and Hubel's finding. Without glasses, his visual acuity was 20/900, far worse than the standard 20/20 for normal vision or even the World Health Organization's definition of legal blindness at 20/400. Like others with aphakia, SK could sense light and movement, which arguably allowed his visual cortex to develop normally.

With his glasses, SK's acuity jumped to 20/120, although he still saw objects as separate regions of colour and brightness, and struggled to put them together as a whole. He saw a cow, for example, as patches of black and white, each a separate object, until the cow moved. As soon as there was movement, SK was able to recognize that the set of objects made up a cow. Over the next 18 months, his acuity remained stuck at 20/120, but he was able to stop relying on motion to integrate objects and learned to recognize them even when they were still.

Critical point

Under conventional dogma, SK shouldn't be able to do this, but where scientists went wrong, says Sinha, is in applying the notion of critical period too broadly. They assumed, incorrectly, that if the eye's vision doesn't improve, neither does the ability to interpret what you see. "What is so exciting about Sinha's work is that he is showing that's not the case," says Lynne Kiorpes, a neuroscientist at New York University. "People can learn to use the vision they have."

As well as being Sinha's native home, India is a natural choice for studying blind children. One-third of the world's 45 million blind people live in India, according to the non-profit organization Orbis International. Caught early, half of the cases of childhood blindness could be treated or prevented — but they aren't.

Some parents see blindness as punishment for sins in a previous life. Most can't afford the treatment. Born poor, and neglected in the broader struggle for survival, more than 60% of blind children in India die before reaching adulthood, according to Orbis. Those who survive tend to be shipped off to special schools or hostels, where they resign themselves to making candles or weaving baskets.

"The first thing that prompted me was seeing these numbers, the humanitarian goal was just so evident," says Sinha. After touring villages in the summer of 2002, Sinha joined forces with Dr Shroff's Charitable Eye Hospital on the outskirts of New Delhi. By Western standards the hospital is unassuming, but it is among the best equipped in the country.

With funding from international organizations, volunteers from Dr Shroff's hospital

head into under-served communities and screen hundreds of children for sight problems. In many cases, the children are beyond help. But if the condition seems reversible, the hospital offers to treat them, often for free. Many suffer from cataracts and, with only minor interventions, could well have normal vision.

With Project Prakash, volunteers from Dr Shroff's hospital have begun visiting schools for the blind for the first time. The project aims to treat 15 'hopeless' cases from these schools each year, and to enrol them in further experiments. SK is the oldest by far: most are aged 7 to 11. Sinha plans to measure the children's visual abilities before and after treatment to learn how much vision is needed for recovery to be possible.

W. LEVENBERG

Pawan Sinha (left) gauges the progress of an Indian child who gained his sight later in life than usual.

Alternative view

SK's case has already provided new ideas about how vision develops. Studies on individuals who recover sight late in life are rare, and researchers who have measured acuity found that, as with SK, it did not improve over time[2]. Those scientists did not ask, as Sinha did, whether other visual skills might eventually improve.

"If they'd looked at it that way, then they probably would have found all sorts of things they weren't looking for," says Nigel Daw, a neurobiologist at Yale University. "This will lead people to do more experiments along those lines. It's ground-breaking work in that sense."

Sinha's work suggests that different visual abilities might have different critical periods. For example, detection of motion is one of the first abilities to develop, perhaps even hard-wired at birth; understanding of colour and full stereo vision develop later, and visual integration — the process that allows SK to resolve separate objects into a cow — might take even longer. "This project allows us to refine the very broad and vague idea of a critical period," Sinha says.

And it challenges the clinical notion that treating a blind child beyond the age of around eight is hopeless. Most children with reversible causes of blindness can sense light, and so may be able to recover. In fact, says Sinha, the complete blindness created in animal experiments is rarely, if ever, found.

Wiesel himself maintains that a critical period still exists, but that scientists should be more open-minded about how they interpret it for clinical use. "There is a critical period and we should try to help kids as soon as possible," Wiesel says. "But if for some reason that's not possible, and there's some vision left, certainly recovery is possible."

SK's case has led Sinha to some interesting tangents. For example, children with autism also have trouble integrating different parts of an object into a whole — they literally can't see the forest for the trees. It turns out that these children also have trouble with motion perception[3,4], which bolsters Sinha's hypothesis. He is now studying visual skills in autistic children.

For Project Prakash, this is just the start. Soon after the project began visiting schools for the blind, Dr Shroff's hospital petitioned the Indian Supreme Court, demanding that at least those children who can be helped are given a chance. As a result, India's Supreme Court has ruled that before being admitted to a blind school, every child must be examined by an ophthalmologist.

On the research front, Sinha plans to use imaging techniques — primarily functional magnetic resonance imaging — to study the brains of children and adults whose sight is restored later in life. He wants to see how much of the visual cortex in these people can be stimulated by light. Sinha also hopes to discover how much of the cortex has been taken over by other functions such as hearing or touch, and whether this change is reversible. "I think that is a very, very fundamental question," he says.

Presumably, the children might also recover different skills to varying degrees. Such information might help doctors design rehabilitation programmes and may offer clues to which visual abilities come prewired at birth and which develop over time. "Slowly but surely, the evidence is coming forward to indicate that the brain is much more adaptable than we suspected," says Kalil. "Work such as Pawan's should tell us to go looking for more." ■

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Staff at Dr Shroff's Charitable Eye Hospital are trying to reduce the levels of blindness in India.

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