Babies' brains to be monitored using light scans

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Researchers hoping to better understand the development of the infant brain have long been stymied by a formidable obstacle: babies just don't want to sit still for brain scans.

"There have been some studies that obtained brain scans of infants while they were napping or sedated, but what we'd really like to do is to scan their brains when they're sitting on a parent's lap, seeing new things, hearing new words and interacting with the environment," says Joseph Culver, Ph.D., assistant professor of radiology at Washington University School of Medicine in St. Louis.

In a paper published by the *Proceedings of the National Academy of Sciences* in July, Culver and his colleagues report that they've improved a recently developed brain imaging technique to the point where it will allow such scans. In addition to aiding basic research, the technology, known as high-density diffuse optical tomography (DOT), should help clinicians treating infant brain injury by making it possible to monitor brain function at infants' incubators.

Using scans to determine what parts of the brain become active during a mental task, an approach known as functional brain imaging, has been the source of many of neuroscience's most important recent insights into how the human brain works. But until now, it's been very difficult to apply this approach to infants. One such brain imaging technique, functional magnetic resonance imaging (fMRI), inserts volunteers into a tightly confined passage through a huge, noisy magnet, an environment that even adults find unnerving and difficult to sit still in. Similarly, computed tomography (CT) scans involve large, loud equipment, and also expose patients and volunteers to radiation exposure levels generally considered unacceptable for research studies of infants.

The DOT scanner, in contrast, uses harmless light from the near-infrared region of the spectrum and is a much smaller and quieter unit. "It's about the size of a small refrigerator, and it doesn't make any noise," Culver says. Diffuse optical brain imaging was originally developed in the 1990s by research groups in the United States, Europe and Japan. To scan a patient or volunteer with high-density DOT, scientists attach a flexible cap that covers the exterior of the head above the brain region of interest. Inside the cap are fiber optic cables, some of which shine light on the surface of the head, and some of which detect that light as it diffuses through tissue.

"The fact that light will diffuse through tissue may seem surprising at first, but almost everyone has held a flashlight up to his or her hand and watched the light shine through the other side," Culver notes. "The flashlight's white light becomes visibly reddened, because there's a window in the near infrared region of the spectrum where human tissue absorbs relatively little of the light."

Unlike X-rays or ultrasound, near-infrared light passes through bone with relatively little attenuation. Scientists can use the diffusing light to determine blood flow and oxygenation in blood vessels of the brain. When these characteristics increase, researchers assume that the area of the brain they are scanning is contributing to a mental task.

Most previous studies have not used diffuse optical imaging in conjunction with tomography, a computerized approach to data analysis that allows depth sectioning and is more commonly applied to X-ray and positron emission scans. Adding tomography became possible because of the greater density of fiber optic cables in the new scanning unit. With 54 fiber optic cables, high-density DOT has four times the density of previous scanners.

To prove that they achieved sufficient resolution for functional brain imaging, scientists used high-density DOT on human volunteers to link stimulation of parts of the visual field to activation of corresponding areas in the brain's visual cortex.

"This is called retinotopic mapping of the visual cortex, and it's a classic functional brain imaging task that was used to establish the validity of earlier neuroimaging techniques like fMRI and PET," Culver says. "Before the development of our high-density DOT system, detailed retinotopic maps like this weren't possible with non-invasive optical imaging."

In addition to enabling infant brain scans, high-density DOT should make it possible for neuroscientists to scan adults engaging in complex tasks that are difficult in the tight confines of an fMRI scanner, such as playing a game or engaging in conversation.

Culver is currently collaborating with pediatricians to adapt the technology for use in neonatal and pediatric intensive care units. Scientists hope to use the technology to assess the effectiveness of therapies for brain injury in infants.

They are also working to shrink the size of the unit further, hoping to develop clinical systems "with a footprint similar to a microwave."

Source: Washington University in St. Louis