

The Conscious Infant

A new study finds a possible brain signature of consciousness in infants as young as five months

BY CHRISTOF KOCH



HOW DO YOU KNOW that your cute five-month-old infant is truly aware, that she is fully sentient, capable of having a phenomenal conscious experience of her mother's face or voice? Let me hasten to add that the question here is not whether or not normal, healthy babies can selectively identify their mom's face or voice; of course, they can turn their head and fixate with their eyes onto the face and eyes of their mother even very soon after birth. The question I am after is whether such visuomotor or audiomotor behavior goes along with the kind of subjective experiences you or I have when we look at our mother or hear her voice. It is a legitimate question for two reasons.

For one, babies can't speak. They can't tell us whether or not they are seeing faces or hearing voices. It is a different matter once they mature enough to be able to talk to us about their inner experiences. So we have to trust our intuitions, which are deeply colored by our biases about when life starts, when consciousness begins, and who is or is not conscious. The second reason the question is valid is that 150 years of psychology experimentation has shown time and again that adults are perfectly capable of carrying out a range of complex tasks unconsciously.

For instance, subjects can distinguish between a face that looks angry or one that has a neutral expression even if those faces are rendered "invisible" by flashing them only very briefly onto a screen and by adding distracting images just before and just after the picture to effectively mask or erase the picture from the mind's eye. People can also unconsciously detect gender, do simple adding problems when "invisible" numbers are flashed onto the screen, or distinguish between depictions of inappropriate and appropriate actions (for example, discerning between an invisible image of an



athlete batting a ball with a baseball bat and an image that has been doctored to show the player swatting at the ball using a flower bouquet). Perhaps babies' behaviors also rely on unconscious, rather than on conscious, processes?

So it becomes critical to find ways to distinguish conscious from unconscious processing in preverbal infants. What is a psychologist to do? One answer is to measure the brain's electrical activity using a common tool we call the electroencephalogram (EEG).

Using such tools, a group in Paris led by cognitive neuroscientist Stanislas Dehaene of the Collège de France has argued for several years that a hallmark of conscious visual perception is a particular type of electric wave, called P300, that occurs whenever an adult subject is attending to a consciously perceived picture

or a sound. These signals start roughly around 300 milliseconds after the onset of the image or sound, can be long-lasting, are depolarizing (positive) relative to a reference electrode, and are particularly prominent above the frontal lobe. Most important, they are not present when, for instance, the image is flashed on the screen but is not consciously seen because it is masked. Looking at an image produces a host of faster electrical responses, which are thought to relate to the processing of the image that occurs prior to conscious recognition. Assuming that the P300 slow wave is one of the brain signatures of conscious perception, can they be found in young children?

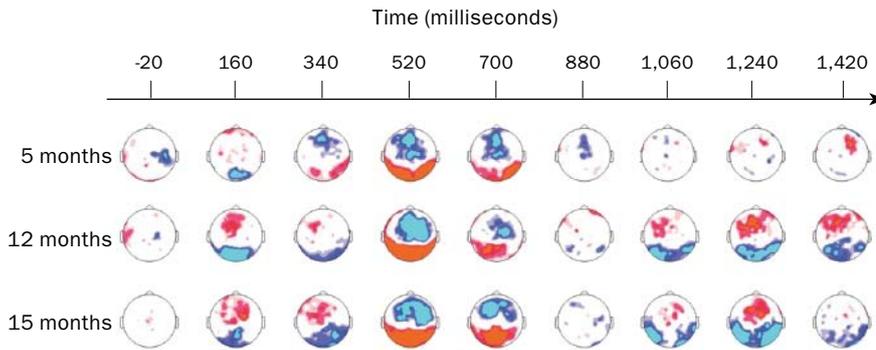
Recording Brain Waves in Infants

Psychologist Sid Kouider of the Laboratory of Cognitive and Psycholinguistics

CHRISTOF KOCH (Koch); EVAN KAFKA/Getty Images (baby)

Thinking Like Adults?

How can you tell whether infants are consciously aware? One way is to see if their brains respond as adult brains do to visible and “invisible” pictures. In an experiment, EEG recordings were made from 80 five- to 15-month-old infants as they looked at photographs flashed briefly (for 17 to 300 milliseconds), either of faces or of random patterns (as a control). These face/random images were preceded and followed by other random patterns. If the face photo is present for longer than 50 milliseconds, adults—who can tell us about their experiences—can report that they briefly saw a face. The EEG recordings of one-year-old children resembled those of the adults consciously seeing something, although they were only a half or a third as fast. In these processed EEG signals, red indicates that the face signal evokes a stronger brain activity than random patterns; blue indicates the opposite.



tic Sciences at the Ecole Normale Supérieure in Paris, together with Dehaene and other French and Danish researchers, undertook the difficult task of measuring brain waves in 80 infants. Difficult because, unlike undergraduate research subjects, very young children (just like puppies) wiggle around, don't pay attention for long and can't easily be instructed. Their head covered by an EEG cap, the infants sat on the lap of their parents, who were blindfolded so that they would not influence their children's responses. They had to look at streams of images, some that contained photographs of a smiling young woman and some that were only random patterns. What varied across experiments was the duration for which the face was exposed, from barely a glimpse—unlikely to be seen at all—to a sizable fraction of a second that, at least in older children, is invariably associated with the conscious sight of a smiling young woman.

The scientists then subtracted the EEG signals taken in response to a face sequence from those of a pattern-only sequence to

extract the unique signature associated with the face stimulus and tracked how this electric signal evolved over time. Segregating these signals according to the age of the infant into groups of five, 12 and 15 months old, and expressed in terms of statistical significance, yields the colored plots, overlaid onto an outline of the head [see box above].

All the kids showed the expected early response that develops in brain regions located at the back of the head, above the visual cortex. This response is proportional to the visual contrast and other image parameters, reflecting neuronal processing of the actual stimulus, whether or not the stimulus was actually consciously perceived. Subsequently, a sustained depolarization (relative to a reference electrode) develops over the front of the brain, in particular in in-

fants 12 months or older. This component of the signal has a more all-or-none character, reflecting the all-or-none character of conscious experience. The data reveal that one-year-old children, at least, do have a brain signature similar to that associated with conscious perception in adults. The electrical signal is perhaps a third of the speed it is in an adult, reflecting the delayed myelination (myelin is the covering of the axon that speeds up transmission of long-distance electrical communication) and immaturity of the young brain.

Of course, the extent to which they truly do have a subjective experience of a smiling face is difficult to ascertain for now. Clever scientists in the future will likely develop some fancy technique to read out the content of these young minds.

The evidence for an even further delayed slow potential is less compelling in very young infants. This finding raises the general question of when does conscious sensation begin? In the infant's first year of life, at birth, in its last trimester in the womb or even earlier? Research on animal and human fetuses suggests that the baby in the womb is partially sedated, even though it can move around, as mothers can certainly attest to [see “When Does Consciousness Arise?” *Consciousness Redux*; *SCIENTIFIC AMERICAN MIND*, September/October 2009].

Indeed, it may well be that the fetus feels as much as we do when we are in a deep, dreamless sleep. It may be that the dramatic events attending birth, including drawing its first breath, are the triggers for its first conscious experience of life. This, too, we shall know one day. **M**

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(Further Reading)

- ◆ **Experimental and Theoretical Approaches to Conscious Processing.** Stanislas Dehaene and Jean-Pierre Changeux in *Neuron*, Vol. 70, pages 200–227; April 28, 2011.
- ◆ **A Neural Marker of Perceptual Consciousness in Infants.** Sid Kouider et al. in *Science*, Vol. 340, pages 376–380; April 19, 2013.