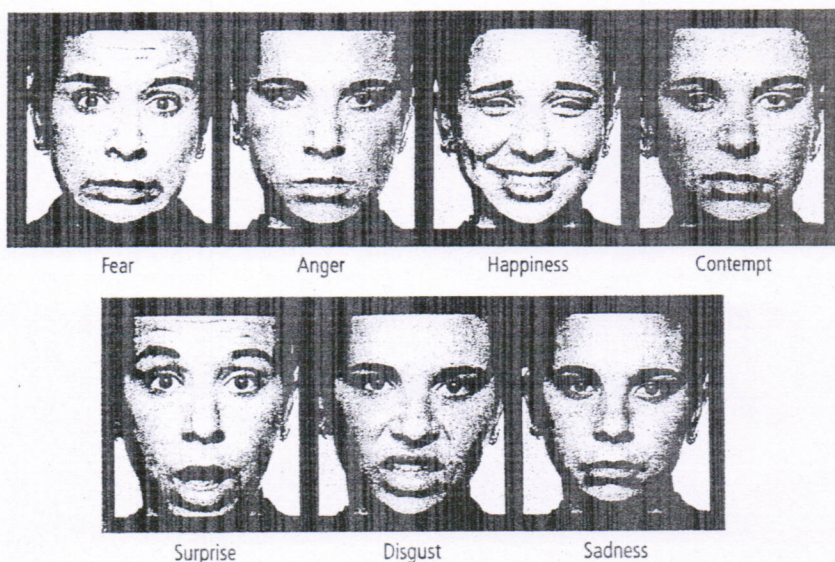


AS SOMEONE INTERESTED IN PSYCHOANALYSIS, I WANTED TO TAKE the Crick-Koch paradigm of comparing unconscious and conscious perception of the same stimulus to the next step: determining how visual perception becomes endowed with emotion. Unlike simple visual perception, emotionally charged visual perception is likely to differ between individuals. Therefore, a further question is, How and where are unconscious emotional perceptions processed?

Amit Etkin, a bold and creative M.D.-Ph.D. student, and I undertook a study in collaboration with Joy Hirsch, a brain imager at Columbia, in which we induced conscious and unconscious perceptions of emotional stimuli. Our approach paralleled in the emotional

sphere that of Crick and Koch in the cognitive sphere. We explored how normal people respond consciously and unconsciously to pictures of people with a clearly neutral expression or an expression of fear on their faces. The pictures were provided by Peter Ekman at the University of California, San Francisco.

- Ekman, who has cataloged more than 100,000 human expressions, was able to show, as did Charles Darwin before him, that irrespective of sex or culture, conscious perceptions of seven facial expressions—happiness, fear, disgust, contempt, anger, surprise, and sadness—have virtually the same meaning to everyone (figure 28-1). We therefore argued that fearful faces should elicit a similar response from the healthy young medical and graduate student volunteers in our study, regardless of whether they perceived the stimulus consciously or unconsciously. We produced a conscious perception of fear by presenting the fearful faces for a long period, so people had time to reflect on them. We produced unconscious perception of fear by presenting the same faces so rapidly that the volunteers were unable to report which type of expression they had seen. Indeed, they were not even sure they had seen a face!



28-1 Ekman's seven universal facial expressions. (Courtesy of Paul Ekman.)

Since even normal people differ in their sensitivity to a threat, we gave all of the volunteers a questionnaire designed to measure background anxiety. In contrast to the momentary anxiety most people feel in a new situation, background anxiety reflects an enduring baseline trait.

- ✓ Not surprisingly, when we showed the volunteers pictures of faces with fearful expressions, we found prominent activity in the amygdala, the structure deep in the brain that mediates fear. What was surprising was that conscious and unconscious stimuli affected different regions of the amygdala, and they did so to differing degrees in different people, depending on their baseline anxiety.

Unconscious perception of fearful faces activated the basolateral nucleus. In people, as in mice, this area of the amygdala receives most of the incoming sensory information and is the primary means by which the amygdala communicates with the cortex. Activation of the basolateral nucleus by unconscious perception of fearful faces occurred in direct proportion to a person's background anxiety: the higher the measure of background anxiety, the greater the person's response. People with low background anxiety had no response at all. Conscious perception of fearful faces, in contrast, activated the dorsal region of the amygdala, which contains the central nucleus, and it did so regardless of a person's background anxiety. The central nucleus of the amygdala sends information to regions of the brain that are part of the autonomic nervous system—concerned with arousal and defensive responses. In sum, unconsciously perceived threats disproportionately affect people with high background anxiety, whereas consciously perceived threats activate the fight-or-flight response in all volunteers.

We also found that unconscious and conscious perception of fearful faces activates different neural networks outside the amygdala. Here again, the networks activated by unconsciously perceived threats were recruited only by the anxious volunteers. Surprisingly, even unconscious perception recruits participation of regions within the cerebral cortex.

Thus viewing frightening stimuli activates two different brain systems, one that involves conscious, presumably top-down attention

and one that involves unconscious, bottom-up attention, or vigilance, much as a signal of salience does in explicit and implicit memory in *Aplysia* and in the mouse.

✓ These are fascinating results. First, they show that in the realm of emotion, as in the realm of perception, a stimulus can be perceived both unconsciously and consciously. They also support Crick and Koch's idea that in perception, distinct areas of the brain are correlated with conscious and unconscious awareness of a stimulus. Second, these studies confirm biologically the importance of the psychoanalytic idea of unconscious emotion. They suggest that the effects of anxiety are exerted most dramatically in the brain when the stimulus is left to the imagination rather than when it is perceived consciously. Once the image of a frightened face is confronted consciously, even anxious people can accurately appraise whether it truly poses a threat.

A century after Freud suggested that psychopathology arises from conflict occurring on an unconscious level and that it can be regulated if the source of the conflict is confronted consciously, our imaging studies suggest ways in which such conflicting processes may be mediated in the brain. Moreover, the discovery of a correlation between volunteers' background anxiety and their unconscious neural processes validates biologically the Freudian idea that unconscious mental processes are part of the brain's system of information processing. While Freud's ideas have existed for more than one hundred years, no previous brain-imaging study had tried to account for how differences in people's behavior and interpretations of the world arise from differences in how they unconsciously process emotion. The finding that unconscious perception of fear lights up the basolateral nucleus of the amygdala in direct proportion to a person's baseline anxiety provides a biological marker for diagnosing an anxiety state and for evaluating the efficacy of various drugs and forms of psychotherapy.

In discerning a correlation between the activity of a neural circuit and the unconscious and conscious perception of a threat, we are beginning to delineate the neural correlate of an emotion—fear. That description might well lead us to a scientific explanation of con-

sciously perceived fear. It might give us an approximation of how neural events give rise to a mental event that enters our awareness. Thus, a half century after I left psychoanalysis for the biology of mind, the new biology of mind is getting ready to tackle some of the issues central to psychoanalysis and consciousness.

One such issue is the nature of free will. Given Freud's discovery of psychic determinism—the fact that much of our cognitive and affective life is unconscious—what is left for personal choice, for freedom of action?

A critical set of experiments on this question was carried out in 1983 by Benjamin Libet at the University of California, San Francisco. Libet used as his starting point a discovery made by the German neuroscientist Hans Kornhuber. In his study, Kornhuber asked volunteers to move their right index finger. He then measured this voluntary movement with a strain gauge while at the same time recording the electrical activity of the brain by means of an electrode on the skull. After hundreds of trials, Kornhuber found that, invariably, each movement was preceded by a little blip in the electrical record from the brain, a spark of free will! He called this potential in the brain the “readiness potential” and found that it occurred 1 second before the voluntary movement.

Libet followed up on Kornhuber's finding with an experiment in which he asked volunteers to lift a finger whenever they felt the urge to do so. He placed an electrode on a volunteer's skull and confirmed a readiness potential about 1 second before the person lifted his or her finger. He then compared the time it took for the person to will the movement with the time of the readiness potential. Amazingly, Libet found that the readiness potential appeared not after, but 200 milliseconds before a person felt the urge to move his or her finger! Thus by merely observing the electrical activity of the brain, Libet could predict what a person would do before the person was actually aware of having decided to do it.

This finding has caused philosophers of mind to ask: If the choice is determined in the brain before we decide to act, where is free will? Is our sense of willing our movements only an illusion, a rationalization after the fact for what has happened? Or is the choice made freely, but

no, it takes
7200
msec.

to predict!

not consciously? If so, choice in action, as in perception, may reflect the importance of unconscious inference. Libet proposes that the process of initiating a voluntary action occurs in an unconscious part of the brain, but that just before the action is initiated, consciousness is recruited to approve or veto the action. In the 200 milliseconds before a finger is lifted, consciousness determines whether it moves or not.

Whatever the reasons for the delay between decision and awareness, Libet's findings also raise the moral question: How can one be held responsible for decisions that are made without conscious awareness? The psychologists Richard Gregory and Vilayanur Ramachandran have drawn strict limits on that argument. They point out that "our conscious mind may not have free will, but it does have free won't." Michael Gazzaniga, one of the pioneers in the development of cognitive neuroscience and a member of the American Council of Bioethics, has added, "Brains are automatic, but people are free." One cannot infer the sum total of neural activity simply by looking at a few neural circuits in the brain.