The contemporary artist Chuck Close (1940– ) is well known for his large portraits of faces that are composites made from multiple small geometric forms. The individual elements of the images are very visible when viewed close up, but merge when seen at a distance. Close suffered from a collapsed spinal artery in the neck in 1988, which left him partially quadriplegic, but he is still able to paint vigorously.

*Arch Ophthalmol.* 2008;126(8):1148-1151

Chuck Close (1940– ) is one of the most famous American artists working today. His distinctive paintings are huge canvases that depict faces, often his own. He works in a nontraditional manner by combining many small geometric forms, usually squares or rectangles, to create a portrait. The individual elements he uses in making an image may be termed *pixels.* The word *pixel* is a neologism used in computer technology to mean the smallest form in a digitized image and is a combination of the words *picture* and *element.*

Chuck Close is a compelling individual who has endured a great physical misfortune. In 1988 he experienced an occlusion of a spinal artery in the neck, which left him quadriplegic. The occlusion has affected the way he paints, but not his style of painting. Many experts have found it difficult to differentiate work done before the onset of his quadriplegia from that done afterward.

The paintings lead to important questions concerning visual perception and the possibility of artificial vision. What determines our ability to combine many small geometric units into a coherent image? How many different elements are needed to create an image? What are the effects of changing colors within the elements?

**THE IMAGES**

When first confronted with a massive 2- to 3-m face (Figure 1 and Figure 2), a typical viewer is astonished by the magnification of the image and its details, which may or may not be complimentary or may reveal little emotion. After the initial response, the observer may note that the head is given little context and may become fascinated by the technique. Close has chosen his subjects from the challenge that their facial details represent. He does little to model or round forms. His compositions are usually based on photographs taken with a large-format camera. He will retain the distortions induced by his subject’s proximity to the camera and may even enhance the distortions. To cite one example, the artist Alex Katz (Figure 2) has complained that the camera exaggerated the size of his small nose in portraits Close made of him.1

The number of elements in a Close portrait has varied from a few hundred to more than 100,000. The individual pixels may range widely in size. Close or an assistant will usually mark a grid pattern on a photograph and then onto a canvas, maintaining the same proportions. To transfer the image to the canvas, he uses a set of coordinates, as though the photograph were a map, with numbers on one axis and letters on the other. Comparison of the photographs and the painted images reveals that he has often subdivided the grid so
that a single square in the photograph may be represented by several squares on the canvas. More recently, he has been placing irregular forms within each pixel. Sometimes he has united 2 or more pixels when he has wanted to emphasize particular features, such as portions of the nose or glasses frames.

Close’s technique has affinities to the work of other artists. The late 20th century American artist Roy Lichtenstein (1923-1997) used multiple small circles of variable size to mimic the elements of cartoon art. The pointillist artists who painted in France during the late 19th and early 20th centuries, such as Georges Seurat (1859-1891), also worked with small geometric forms. They were trying to find an alternative style but also sought a scientific means of mixing light rather than pigment. The early 20th century Austrian artist Gustav Klimt (1862-1918) incorporated geometric elements into many of his paintings. Brilliant irregular shapes, usually rectangles, cover much of the canvas in some of his portraits, most notably his masterpiece, the portrait Adele Bloch-Bauer I of 1907, which recently entered the collection of the Neue Galerie in New York. There is an even earlier precedent. Mosaics from Greek and Roman antiquity were made of stone, metal, and glass fragments, and their regularly spaced, colored elements are comparable with Close’s technique. However, when we asked Close if any of these earlier approaches influenced him, he replied that he was not thinking of any of them when developing his style. Certainly, he knew of these predecessors. He explained that he was working from photographs and was aware of the small, regular elements that are visible in photomechanical reproductions of magazine and newspaper illustration. Initially, his goal was to recreate an enlargement of a photographic image on canvas, which evolved into his current, pixelated format.

BIOGRAPHY
Chuck Close was born in Monroe, Washington, in 1940. Although he had been dyslexic as a child, he adapted well enough to receive an undergraduate degree from the University of Washington and a master of fine arts degree from Yale University. A Fulbright grant enabled him to study in Vienna at the Akademie der Bildenden Kunste, which, he notes ironically, was the same school Hitler attended. He then taught at the University of Massachusetts and worked in the abstract expressionist style typical of that era. One of his students, Leslie Rose, became his wife in 1967. Following their marriage, they moved to New York City and Close taught drawing, painting, and design at the School of Visual Arts. Thinking that abstraction had been stretched to its limits, he turned in a different direction, toward realism.

He began to work from photographs, in essence reproducing the reproduction. He created large-scale, dramatic portraits that magnified facial details, whether or not they were flattering. As a result of these oversized works, critics described him as a “photo-realist.” He experimented with an airbrush, fin-
Close's great catastrophe occurred in 1988, when one of his anterior cervical arteries became occluded, leaving him partially quadriplegic. He has become a distinctive figure in New York, where he ambulates in a motorized wheelchair and has a specially equipped van with a driver to facilitate his travel. In retrospect, he dates his symptoms back 11 years before the occlusion. In 1978, at age 37 years, he and his wife were living in Soho, a district of New York where many artists lived and worked. He developed chest pain and was examined medically. A myocardial infarction was ruled out, but the cause of his symptoms was not apparent. He had no health insurance at the time, which limited further testing. Acting on the suggestion of friend and fellow artist Jack Beal, he consulted a physician–art collector in Chicago, but no specific diagnosis was made. Close returned home and underwent further examination at the New York University Medical Center and at the Hospital for Special Surgery. A definitive diagnosis, however, remained elusive. When chest pains recurred, cardiac evaluations continued to be normal. Close says he was prescribed nitroglycerine or digitalis. While working in Japan in 1986, another attack resulted in hospitalization there, but the language barrier hampered his assessment. After his return to New York, testing continued to be inconclusive.

On a December evening in 1988, the then 48-year-old Close was a guest of Mayor Ed Koch, who was hosting a dinner to honor achievements in the arts at the mayoral residence, Gracie Mansion. During the presentations, Close suddenly experienced back, chest, and arm pain. A policeman assisted him across the street to the emergency department at Doctors Hospital. A recent biography describes what occurred:

His wife, Leslie, was waiting for an elevator in their apartment building when she heard the phone ring. “As soon as I got to the hospital,” she remembers, “he had some kind of episode—chest pains. He said he couldn’t move—he couldn’t feel anything. The nurses were kind of dismissing it, thinking it might be the result of whatever they had given him intravenously. By the end of that night he was paralyzed. The seizure went on for about twenty minutes, until he finally lapsed into a calm state. By then, he was almost totally paralyzed from the shoulders down. He could barely move his head and neck; breathing was almost impossible because only the upper part of his lungs was working, the lower having filled with fluid. After extensive tests, his seizure was diagnosed as the result of an occluded spinal artery. Close was transferred to New York University Medical Center, where he spent a month in an intensive care unit because of poor pulmonary function, another month in critical care, and then 6 months at the Rusk Institute of Rehabilitation Medicine.

Close’s quadriplegia is incomplete. Although he has no function of the lower extremities, he has enough strength in his arms and hands to paint without assistance. He has a mechanism for raising and lowering his huge canvases from the floor beneath his studio. When he began to paint again in 1989, he briefly used a wrist support. Atrophy is visible in his hand muscles and his handshake is weak. Close has moderately high myopia and with corrective lenses has a visual acuity of 20/20 for both distance and near (P.M.O. has been his ophthalmologist for many years). A convergence insufficiency exophoria was successfully treated with orthoptic therapy in 1974. He has a 10-diopter vertical phoria, which is controlled with prisms. The motility findings predate his quadriplegia. His stereocuity is excellent, with a fusional visual angle of 50°.

Close has an international reputation and he and his wife are well-known fixtures in the New York social and art scene. He is a strong-willed, determined individual who attempts to minimize the limitations placed on him by his disability. He is very generous with his time and energy and supports many charitable causes.

**SCIENTIFIC CORRELATIONS**

Close first exhibited a pixelated portrait in the fall of 1973. Just after that show opened, he was amazed to see the November 1973 issue of *Scientific American* at a newsstand, because the cover contained a pixelated, computer-generated color portrait of George Washington. The convergence of methodology astonished him. Evidently, computer scientists were experimenting with portraits in a manner very comparable with his own. The computer images were made of multiple small rectangles, and the colors could be manipulated just as his could. The father of our country was depicted in low resolution, using 624 pixels. Close did not work from computer-generated images then and still does not.

Also in 1973, a pixelated image of Abraham Lincoln was published on the cover of the journal *Science*, accompanying a paper by Harmon and Julesz. Julesz, the pioneer of random-dot stereocuity imagery, first described random-dot technology in 1960. The story in *Science* showed that Lincoln’s facial features could be recognized from a very low-resolution computer-generated image consisting of only 216 black and white squares. Harmon reported that the minimum number of squares required to allow facial identification was 108. Lincoln’s face is so distinctive that he is recognizable from fewer pixels than is Washington. In comparison, the 2.5-m–high portrait Close made of the artist Alex Katz in 1987, just before Close’s vascular accident (Figure 2), consists of 14 896 squares, each less than 2 cm across.

Viewers of Seurat’s masterpiece *A Sunday on la Grande Jatte* at the Art Institute of Chicago have long been aware of seeing individual spots of color, which disappear when the viewer moves farther away from the canvas. Mosaics from Greek and Roman antiquity give similar effects. Salvador Dali enjoyed experimenting with the technique. Three years after the pixelated image of Abra-
ham Lincoln was published, Dali incorporated it into a painting, *Gala Contemplating the Mediterranean Sea which at 20 Meters becomes the Portrait of Abraham Lincoln (Homage to Rothko)* (oil on canvas, 1976; Salvador Dalí Museum, St Petersburg, Florida). Dali consciously made the pixels far too large for the edges of the separate elements to blur out at any reasonable viewing distance. Not the pointillist painters, ancient mosaic makers, or Dali exploited these techniques to the extent that Close has. If the observer moves closer to the image, he is well aware that it is made up of multiple elements. The individual pieces dominate and the figure disappears into a mass of geometric forms. One must step back or consciously unfocus the image to make it coherent and recognize that features such as the eyes and nose exist. Close began with small pixelated forms, just a few millimeters wide, and has been steadily increasing their size, which can reach 10 cm. He has been enlarging the paintings as well as the pixels, though not necessarily proportionately. Pixel size is only meaningful relative to the size of the image and the viewing distance. The evolution in his style toward larger elements makes it harder to avoid the complex effects of his image fragmentation simply by moving farther away from the canvas.

Close’s work has intrigued Dennis Pelli, one of the inventors of the Pelli-Robson letter chart to measure contrast sensitivity. Pelli has been interested in identifying the critical size of the pictorial elements in Close’s works necessary for the image to take on an overall structure rather than to appear as an abstraction. He found the threshold for distinguishing facial features is a visual angle of 0.3° (18 minutes of arc) for the individual elements. This size measured in degrees is the width of the mark relative to the distance of the viewer from the work. If the visual angle of the separate elements is larger than this amount, the facial features are not recognized. If the observer moves closer to the image, the visual angle is increased, and moving away does the opposite. In slightly different words, Pelli notes that the threshold for seeing the painted elements as a portrait is the “visual mark size, which is simply the width of the mark relative to the viewer’s distance from the painting.”

The marks make sense as a viewer’s distance from the painted elements as a portrait is the “visual mark size, which is simply the width of the mark relative to the viewer’s distance from the painting.” The marks make sense as a portrait when seen from more than 200 mark-widths away. This is a critical size of perception, not of optics. (This critical size assumes the viewer has normal visual acuity. If the spectator normally wears glasses to improve distant vision and does not use his glasses to see the image, the individual elements become indistinct and the picture becomes recognizable as a face at a nearer viewing distance.)

Close takes advantage of another aspect of visual perception: luminance (brightness). The neurophysiologist Margaret Livingstone explains that colors that blend in some areas of his portraits are very similar in luminance. “Also, in many places, there are strong, luminance-defined local patterns that compete with—and are in a dynamic equilibrium with—the global face pattern. It is the dynamic tension between local and global patterns that is so interesting in Close’s paintings, just as in the earlier Pointillist paintings.”

Pixelation is being studied to determine how faces can be recognized for artificial vision. Silicon chips have been implanted above and below the retina, and some visual recognition results. This is a major work in progress that cuts across many disciplines, including ophthalmology, neurobiology, psychology, and art. Chuck Close’s imagery may be a provocative step on the way to artificial vision.

Submitted for Publication: May 29, 2007; final revision received October 23, 2007; accepted October 25, 2007.

Correspondence: James G. Ravin, MD, 3000 Regency Ct, Toledo, OH 43623 (jamesravin@bex.net).

Financial Disclosure: None reported.

Previous Presentation: Presented at the American Academy of Ophthalmology Annual Meeting; November 12, 2006; Las Vegas, Nevada; and the Cogan Ophthalmic History Society Annual Meeting; April 1, 2006; Hershey, Pennsylvania.

Additional Contribution: We thank Chuck Close for giving permission to describe aspects of his health.

REFERENCES