THE SCIENCE AND ART OF SILHOUETTES:

WHAT SQUIGGLY LINES TEACH US ABOUT FACE RECOGNITION, FINE ART, AND ASTRONOMY

by

Raphael Philip Rosen

A Thesis Presented to the
FACULTY OF THE USC GRADUATE SCHOOL
UNIVERSITY OF SOUTHERN CALIFORNIA
In Partial Fulfillment of the
Requirements for the Degree
MASTER OF ARTS
(SPECIALIZED JOURNALISM)

December 2011

Table of Contents

Abstract

Silhouettes have mesmerized people for centuries, appearing in 18th-century art as well as contemporary advertisements for mp3 players and basketball shoes. Silhouettes have also become a cultural force, appearing on Disneyland's Main Street and the fine art created by Kara Walker. But until recently, no one has figured out how the brain can identify a human face in a bare line. Recent studies at Stanford University, the University of California Los Angeles, and Vanderbilt University, however, have begun to unlock the mystery of silhouettes and face recognition.

The Science and Art of Silhouettes: What Squiggly Lines Teach Us About Face Recognition, Fine Art, and Astronomy

Human beings excel at perceiving patterns, decoding patterns, even seeing patterns where none exist. Dark splotches in the moon become an old man's face; a haphazard collection of stars in the sky becomes a water dipper; ink blots on a sheet of paper look like a tree. Listening to someone else's cell phone call drives one to insanity because the brain cannot help trying to figure out the pattern of the conversation. Numerology rests on the supposition that random occurrences of numbers hold ominous meaning. Where there is chaos, humans impose their own kind of order, even if that order exists only within a person's mind.

Patterns may not always accurately reflect what is happening in the world, but they help us immensely. Piecing together sights, sounds, and smells into coherent wholes helps people live their lives, navigate dangers, find their way home. A round object hanging on the wall with moving hands and inscribed marks becomes a clock, indicating the hour of the day. Lines drawn on paper become a map, communicating directions from the grocery store to the gas station. A few notes of music heard on the radio become a song, unlocking memories. The patterns that we create inside our minds become our world.

Patterns are crucial to human life, but only recently have people begun to figure out exactly how the brain stitches together individual sensations into a single quilt. One pattern – faces – has especially attracted the interest of neuroscientists. After all, when we think carefully about what we really see when we look at someone, we realize that a face is simply a round blotch of colors and lines. How is it that one can look at this blotch and recognize celebrities like Tom Cruise, or the bus driver who takes us to work every day? How can a person look at two similar blotches and tell that one is a man's face and another the face of a woman?

Usually, people do not think about patterns and faces. Most of us go about our daily routines without questioning how the brain translates colors and shapes into the familiar mugs of friends and neighbors. On rare occasions, though, we *are* confronted with the miracle of face perception, and the brain's remarkable ability to pull meaning out of nonsense.

One situation when we pull up short and marvel at face recognition is when we see a silhouette. Silhouettes appear in advertising, film, art, and neuroscience; they pervade our society. In fact, silhouettes have appeared in popular culture off and on throughout the past 100 years century. In the 1950s and '60s, the television show *Alfred Hitchcock Presents* showed the paunchy director walking toward the left of the screen until his round face lined up with a correspondingly round silhouette. More recently, Nike based its Jumpman logo on a silhouette of Michael Jordan soaring toward a dunk. Silhouettes have also infiltrated the world of technology: Apple's original iPod ads featured silhouettes of joyful customers holding silhouettes of their new mp3 devices. They have even made their way into art: contemporary artist Kara Walker has become known for her life-size silhouettes exploring race and gender on the plantations of the pre-Civil War South.

In essence, silhouettes inspire wonder because they showcase the distilling power of the human brain. Whether in art, marketing, or entertainment, silhouettes force people to confront the brain's remarkable ability to quickly digest perceptual data and make sense of it. Yet, only now is science beginning to understand how the brain pulls information out of such a paucity of information.

* * *

The story of silhouettes and face recognition begins in the 1700s, when the practice of cutting silhouettes had its heyday. Silhouette portraits became popular in a time before cheap photography had made accurate portraits affordable. The word "silhouette" derives from the name of a French minister of finance, Etienne de Silhouette, who became known for imposing severe economic measures on the French public. "Silhouette" became linked to cost-cutting, and because silhouettes were one of the least expensive ways to capture a person's likeness, the name stuck.[1]

Helping to promote the art form of profile cutting was Auguste Amant Constant Fidele Edouart. Born in France in 1789, Edouart toured both England and America throughout the 1800s, showcasing his skills. In these far-flung locations, he cut the silhouettes of thousands of luminaries, including Sir Walter Scott, the famous playwright; Henry Clay, the Kentucky statesman known for his powerful oratory; and Henry Wadsworth Longfellow, one of the 19th century's preeminent poets. Anyone who was anyone had his likeness cut out of black paper by Auguste Edouart. If silhouette-cutting had had a professional organization, Edouart would have been its president.[2]

---

[1] "Silhouettes," Wikipedia, accessed March 2011

[2] "Auguste Amant Constant Fidele Edouart," Wikipedia, accessed March 2011

Like Edourt and others before them, today's silhouette artists continue the tradition of putting scissors to paper. But, unlike Edouart, they don't cut the portraits of famous politicians and literary stars. More often, contemporary scissor artists are hired for special occasions, like weddings or birthday parties.

Some, like veteran silhouette artist Sylvia Fellows, work in Disneyland. On most days, she can be found sitting in her studio on Main Street, as she has for the past thirty years, asking the wriggling child sitting next to her to be still. With one hand, she picks up a pair of shining steel scissors; with the other, she grasps a square of black paper. She begins cutting, and in two minutes, she has cut the child's silhouette portrait, accurate down to the cowlicks and distinctive nose. She smiles and hands the portrait to her assistant, who then pastes it into a traditional oval frame, as if it were meant for the drawing room of a large Victorian mansion. Fellows waits for the next customer to wander in from the bustling street outside her door.[3]

In this age of iPads and Wi-Fi, multimedia boardroom presentations and e-mail, Sylvia Fellows and her fellow scissor artists seem like throwbacks to the 18th century, coelacanths in an ocean of modern, swift-swimming tuna. In Fellows's Disneyland studio, bathed in Anaheim sunshine surrounded by tourists carrying digital cameras and cell phones, technology has stood still.

As if they were heirs to the Dutch guilds of the Early Modern era, silhouette artists learn their craft at the feet of masters. Fellows began her training as a silhouette artist in 1979 as an assistant to Harry Brice, a master silhouette-cutter with 28 years of

---

[3] Sylvia Fellows, interview with author, January 2011

experience. For eight months, Fellows was a paster, gluing silhouette portraits onto hard backings for tourists to take home. In the meantime, Brice taught her basic silhouette-cutting techniques. She also learned how to add important details that brought the portrait to life. For instance, Brice taught her that silhouette artists should always add eyelashes: the portraits don't look finished without them. Without eyelashes, the nose transitions seamlessly into the forehead, creating an unnatural curve that makes the face look more alien than human.[4]

Throughout the history of silhouettes, though, no one has figured out what makes them so captivating. No one has deciphered the mystery of how the brain can recognize a face from an intricately cut piece of paper. Until recently, scientists knew that after light struck the eye, processes in the brain led to the recognition of a face, but what *exactly* happened within the brain remained hidden from observers. The skull was a black box.

Now, silhouettes have allowed neuroscientists to open that box and peer inside the brain's secret workings. Silhouettes have become both a muse and a tool, both inspiring neuroscience questions and simultaneously helping to answer them. At Stanford University, for instance, psychologist Nicholas Davidenko studies whether people can look at silhouettes and determine whether the portrayed face is male or female, young or old, attractive or ugly. In a word, silhouettes have become – forgive the pun – cutting-edge.

Like all bodily processes, face recognition relies on electrical bursts happening inside one's brain. At its most basic level, then, face recognition is governed by the same

---

[4] Sylvia Fellows, interview with author, January 2011

forces that guide lightning bolts from thunderheads to North Dakota plains, and that are responsible for the flow of power from vast nuclear power plants to the lamp on one's desk. Complex phenomena often have simple roots.

Neuroscientists have linked face recognition to a region known as the visual cortex; specifically, to a place called the fusiform face area (FFA). (An object that is fusiform is tapered at both ends.) When this area does not function properly – whether because of a birth defect or an accident – a person loses the ability to recognize faces. The resulting condition, called face blindness, or "prosopagnosia," means that the afflicted person will not be able to recognize himself in the mirror. (Well-known people with face blindness include neuroscientist Oliver Sacks and artist Chuck Close.) People with face blindness cannot recognize neighbors, co-workers, even their own parents and children. They can look at a face and point out the nose, eyes, and mouth. But they cannot tell *whose* face it is. A damaged FFA interferes with the brain's ability to bring coherence to incoherence.

On the other hand, some evidence suggests that face recognition dwells within individual cells. Neuroscientists have found that some neurons will fire only when a specific person comes into view. One cell, for instance, fires whenever a person looks at Bill Clinton, whether depicted in a photograph, painting, or line drawing. Another cell responds only to Halle Berry. These baffling properties were discovered by Itzhak Fried, a neurosurgeon at UCLA's David Geffen School of Medicine who implants electric probes into the brains of patients with epilepsy to learn which parts of the brain are responsible for seizures.[5] The electrodes allow Fried and his colleagues to eavesdrop on individual brain cells, pinpointing the exact moments when the cells flash their electric pulses. Another UCLA neuroscientist, Indre Viskontas, published a paper in 2009 hinting that neurons are more likely to fire if you look at relatives than at celebrities. "That's the cool part," says Viskontas. "Our individual neurons can tell that your grandmother is more important to you than Jennifer Aniston is."[6]

In other words, individual cells somehow seem to be "comprehending" or "thinking." Christof Koch, a Caltech neuroscientist who works with Fried's research group, posits that each neuron might function as a small computer. Rather than seeing neurons as cogs in a giant machine, Koch hypothesizes that each brain cell might process information on its own.

Other neuroscientists have performed experiments suggesting that face perception stems from *experience* with faces, not from inborn parts of the brain. In a 2010 experiment, Vanderbilt University psychologists Isabel Gauthier and Rankin McGugin divided two images of a face into a matrix of squares, and then numbered each square. Next, they removed the even-numbered squares from one image, and the odd-numbered squares from the other. (The resulting faces resembled collections of square-shaped pockmarks.) They then asked the test subjects to match the two versions. Gauthier and McGugin found that their subjects were less able to match these two modified faces with the original face than they were to match two identical faces that had not been modified

---

[5] John Horgan, "Can a Single Cell Recognize Your Face?", Discover Magazine, June 2005.

[6] Indre Viskontas, e-mail messages to author, August 8, 2011

at all. They also found that this difficulty extended to *any* object a person is familiar with. When they performed the experiment with people who were car experts, for instance, they found that the experts experienced the same difficulties as the people in the face experiment. Whether an object is a face, chair, door, or table, a person will have a hard time identifying it with its complement if the person knows the object well. "The expertise hypothesis," says McGugin, "argues that the FFA is not exclusively responsive to faces. Rather, the FFA responds to faces because we – as normal human adults – are exposed to many faces all the time and thus develop a specialized brain region for the type of perceptual encoding required to process facial stimuli." "Objects of expertise," McGugin concludes, "can be treated like faces."[7]

Whether face recognition stems from experience or inborn ability eludes an easy explanation. How much more complex, therefore, must recognizing a face in a *silhouette* be? Compared to recognizing a face, recognizing silhouettes seems impossible. Silhouettes lack internal detail: there are no eyeballs, no teeth, no wrinkles, no skin tone, and no shading, nothing for the brain to latch onto when determining the silhouette's owner. In essence, a silhouette is a single line.

But even though a silhouette can be thought of as merely a boundary separating light from darkness, the brain can pull a large amount of information from it. This ability has been established by Nicholas Davidenko, a psychologist at Stanford University.

Davidenko's interests in silhouettes began early. Years ago, Davidenko's younger brother returned from school with a silhouette of himself that the teacher had

---

[7] Rankin McGugin, e-mail messages to author, February 3, 2011

made by tracing his shadow. "It intrigued me," says Davidenko, "that I could recognize his face just from the outline of his profile."[8] Later, when he was in graduate school, Davidenko wondered whether he could write an algorithm – a set of instructions for a computer – that would be able to differentiate a male from a female face.

Davidenko conducted a series of experiments on Stanford undergraduates showing that silhouettes were more than dark blotches. In all, Davidenko performed five studies, using 48 face silhouettes. Of those 48, half were silhouettes of male faces and half were silhouettes of female faces. The ages of the faces ranged from 18-65.

The studies established that the brain can mine silhouettes for information about age, gender, and attractiveness. In the first study, 156 Stanford undergraduates were asked to determine the gender of 16 silhouettes, and rate their level of confidence on a scale from 1-7. Not only did the ratings agree with each other, but also "the proportion of correct classifications was 69.5%, significantly above chance." The second study involved 51 Stanford undergraduates, who were asked to determine the age of 48 silhouette faces. (They could choose among the following age categories: "teens," "20s," "30s," "40s," "50s," and "60s.") Again, there was high agreement among the test subjects, and 68% of the age evaluations were correct. The results demonstrated that silhouettes convey a lot of "age information," even though they lacked "internal features that normally contribute to age perception." A third study evaluated how well three groups of Stanford undergraduates could rate the attractiveness of silhouette faces. One group evaluated 16 silhouettes; another group evaluated 16 face profiles shown only in

---

[8] Nicholas Davidenko, e-mail messages to author, March 20, 2011

shades of gray; and the third group evaluated 16 front-view face images, also shown in gray shades. (The set of images in each group depicted the same faces.) The attractiveness ratings of the silhouette faces matched the ratings of the gray-scale and front-view faces, and the ratings of all three groups agreed highly. Apparently, "silhouettes contain much of the information necessary to determine the attractiveness of a face."

Yet, despite its sophistication, the brain makes mistakes. For instance, Davidenko found that the Stanford students in his gender experiment identified a higher proportion of male silhouettes as male than female silhouettes as female. In fact, the test participants correctly identified 88.3% of the male silhouettes as male, but only 55.7% of the female faces as female. In other words, test subjects tended to identify female faces as male. Why? Davidenko posited two possible reasons. First, because silhouettes lack hair, they could be perceived as being bald, "which in turn could be a cue to maleness." Second, anthropological studies have shown that male faces tend to be more "variable" than female faces. In other words, a male face can be changed in many ways and still be identified as male. Take any male face, and make the chin longer, or make the brow higher: that face would still look male to an observer. But, female faces cannot be changed in the same way and still look female. And, since some male faces are bound to look more feminine than others, a feminine face can be mistaken for a man's face.

Silhouettes have proved their worth in both psychology laboratories and on Disneyland's Main Street. At home in the worlds of both the left and right brain, they aid in scientific discoveries and amuse tourists in amusement parks. But, silhouettes also feature in fine art, in the world of galas and galleries.

Most notably, the power of silhouettes has recently been harnessed by visual artist Kara Walker. Walker began experimenting with silhouettes in her art in the early 1990s, and in 1997, she became the youngest person ever to win a MacArthur Genius Award.[9] Walker's art consists of dream-like scenes from the antebellum South. She cuts out full-sized silhouette figures of slaves and plantation owners, and then pastes them on stark white walls. In *Slavery! Slavery!*, for instance, Spanish moss drips heavily from thick tree branches while a woman is raped on a roof-top and a large crescent moon hovers above the horizon. On one side of the piece, a man in tattered clothing kneels in front of a fountain while farting on to a prim woman in petticoats and high heels. Walker has found that the silhouette is an ideal form to express the racially charged atmosphere of pre-Civil War America. "The silhouette says a lot with a little information," she says in the catalog from one of her shows, "but that's also what the stereotype does." For Walker, a silhouette is the physical manifestation of a stereotype. "While the stereotype, or the emblem, can communicate with a lot of people," Walkers says, "and a lot of people can understand it, the other side is that it also reduces differences, reduces diversity to that stereotype." Walker also relies on the cultural associations linked to silhouettes. By juxtaposing the staid history of silhouettes as parlor-room décor with the graphic rapes and lynchings of the antebellum South, Walker highlights the graphic violence of that age.

---

[9] Lynell George, "Artworks That Cut Deeply," Los Angeles Times, March 9, 2008

Though they inspire wonder, Walker's silhouettes have also elicited controversy. Her images of pickaninnies and slaves have touched a nerve with many people, including artist Betye Saar, who feel that the stereotypes resuscitate thoughts and feelings best left to another time.[10] Silhouettes can reduce complex things – people, faces – to easily digested morsels. But, they can also evoke times of pain.

Silhouettes can do more, however, than indicate the gender of a face or the feeling of a historical age. They can also reveal the presence of planets, stars, and moons. Think of a solar eclipse: a silhouette marks the passage of the moon in front of the sun. Or, think of the search for planets outside our solar system. Astronomers discover these planets by detecting their silhouettes as they pass in front of their stars, which cause a dip in the stars' light. Silhouettes also reveal the presence of black holes, the dense objects that remain when a large star explodes in a supernova. Because black holes possess enormously strong gravitational fields, neither light nor heat nor any other kind of radiation can escape from them. Theoretically, then, black holes cannot be observed directly at all. But, silhouettes might be one of the only phenomena that can reveal these bizarre things to us. After all, a silhouette is a shadow whose outline hints powerfully at what cannot be seen.

In the past few years, astronomers have proposed using silhouettes to observe black holes directly. "The challenge is to take a snapshot of a black hole with sufficient resolution to clearly see its horizon silhouetted against the luminous accreting plasma in its vicinity," says Avery Broderick, an astrophysicist at the Canadian Institute for

[10] Karen Rosenberg, "Darkness and Light," New York Magazine, August 24, 2007.

Theoretical Astrophysics, in Toronto.[11] And, because astronomers rely on telescopes – really just buckets that catch the steady rain of photons from across the universe – black holes have remained perpetually out of sight. As a result, astronomers have had to rely on inference to establish the existence of these light-gobbling monsters. By closely observing the motion of stars circling in space, astronomers can calculate the existence of something in the center of that orbit with a strong gravitational pull.

Black holes are also hard to observe because they are tremendously far away and therefore look very small to us. The black hole thought to reside in the center of our Milky Way galaxy, for instance, "appears roughly as large as a poppy seed in NY seen from LA," says Broderick. And, that poppy seed happens to be surrounded by the combined light of thousands and thousands of stars. "What we are trying to do," says Broderick, "is see the silhouette of that poppy seed in front of a neon sign."[12]

Observing the silhouette of a black hole would allow astronomers to study the hole in unprecedented detail. The proposed Event Horizon Telescope – maintained by the MIT Haystack Observatory, Arizona Radio Observatory, and Harvard-Smithsonian Center for Astrophysics, among other astronomical institutions – would try to detect the ring of photons and heated gas swirling around the black hole like water circles a drain. As cosmic matter orbits a black hole, it collides and rubs and jostles, creating intense heat. This accretion disk, as it is known to astronomers, gives off radiation that people on Earth can see. The Event Horizon Telescope would, in theory, zero in on this radiation,

---

[11]Avery Broderick, e-mail messages to author, May 24, 2011

[12] Avery Broderick, e-mail messages to author, May 24, 2011

and in the process show darkness in the middle where the black hole would be. The black hole would be revealed by its silhouette, its existence betrayed by a shadow.

The Event Horizon Telescope would consist of many land-based telescopes scattered across the face of the Earth. Some would be individual devices 50 meters wide. Others would be combinations of smaller telescopes: one of them, the Atacama Large Millimeter Array, located in an arid part of Chile, comprises 64 dishes, each one 12 meters across. Other telescopes pressed into service would include a 10-meter dish at the U.S. South Pole Station, a 30-meter dish in Spain, and a collection of 15-meter dishes in the French Alps. If needed, more telescopes would be installed in Africa and the Himalayas. In essence, the entire planet would become a telescope, searching the skies for the shade cast by an object strong enough to warp space and time.[13]

From Disneyland to neuroscience labs, from art galleries to astronomy, silhouettes have proved to be reliable guides into the thickets of the universe. They illuminate the workings of the brain, helping neuroscientists understand how the mind pulls meaning out of squiggly lines. They help artists distill complex emotions into simple paper cuttings. They help astronomers detect the existence of black holes light-years from planet Earth. In short, they help people understand the mysteries of face recognition, but they have also become a force in our culture. Silhouettes have become both objects of art and tools of science, a means of conveying information while simultaneously helping scientists unlock the secrets of that conveyance. Though silhouettes are only lines, holes in the universe, black blobs, they hold sway over our minds and imaginations.

---

[13] Event Horizon Telescope, http://www.haystack.mit.edu/ast/uvlbi/mm/eht.html, accessed April 2011

Bibliography

Broderick, Avery. E-mail messages to author, May 24, 2011

Davidenko, Nicholas. E-mail messages to author, March 20, 2011

Dawson, Jessica. "Standing in the Shadow of the Silhouette Figure." The Washington Post. June 20, 2008.

Event Horizon Telescope. Accessed April 2011. http://www.haystack.mit.edu/ast/uvlbi/mm/eht.html.

Fellows, Sylvia. Interview with author, January 2011

George, Lynell. "Artworks That Cut Deeply." Los Angeles Times. March 9, 2008.

Horgan, John. "Can a Single Cell Recognize Your Face?" Discover Magazine. June 2005.

McGugin, Rankin. E-mail messages to author, February 3, 2011.

Rosenberg, Karen. "Darkness and Light." New York Magazine. August 24, 2007.

Viskontas, Indre. E-mail messages to author, August 8, 2011.

Wikipedia. "Auguste Amant Constant Fidele Edouart." Accessed March 2011. http://en.wikipedia.org/wiki/Auguste_Amant_Constant_Fidèle_Edouart.

Wikipedia. "Silhouettes." Accessed March 2011. http://en.wikipedia.org/wiki/Silhouettes.