Mirror Neurons

How We Become What We See

Perhaps the most important finding of the last decade in neuroscience, mirror neurons pave the way for understanding such diverse phenomena as the evolution of language, emotional empathy in interpersonal communication, and personal social identity and coherence. Because all communication theory and all assumptions about the way we process images and the impact they have on us must be compatible with neurological research, the impact of mirror neuron research goes far beyond simply furthering our understanding of the brain. Mirror neurons reveal some relatively direct biological functions that underlie many complex theories of how we are affected by visual culture, why and how we imitate media, and ultimately, how we become what we see. This article introduces what mirror neurons are, how they function within the context of human development and the culture as a whole, and the related efficacy of strategic persuasive communication in relation to such significant cultural forces as advertising and video gaming.

Ann Marie Barry

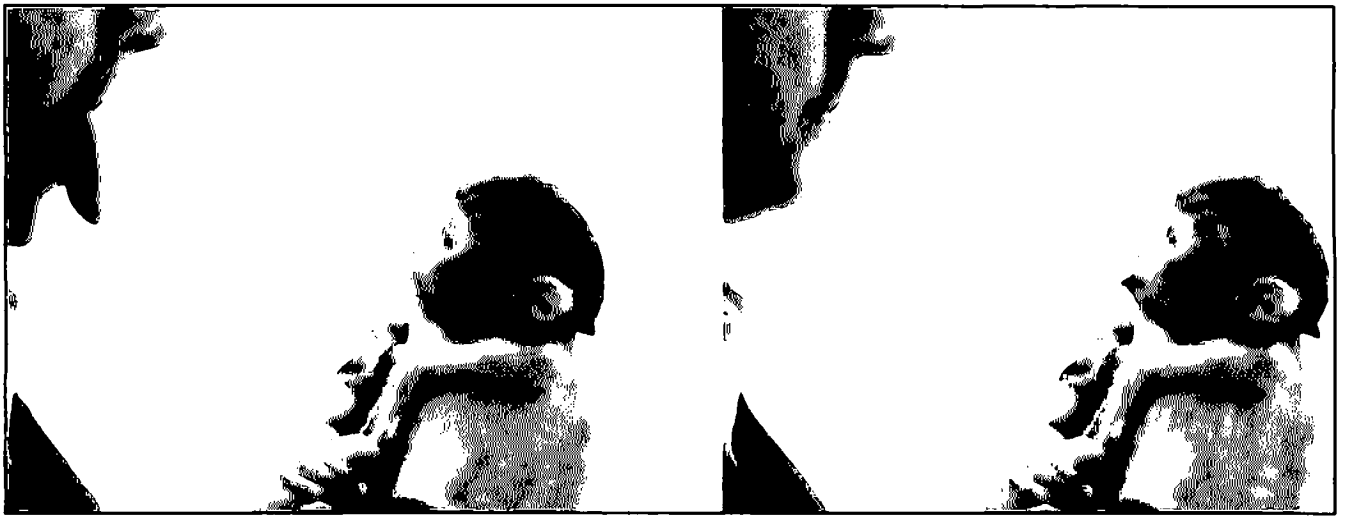
What are mirror neurons, and why are they are so important to visual communication and learning? Well, to begin with, they are the reason happy people make others smile, and tense and anxious people make us nervous. They're the reason yawning is contagious.

The presence of mirror neurons in Macaque monkeys by researchers at the University of Parma just over a decade ago first opened the door to understanding the human mirror system and its significance in imitative learning, language development, and even the "big bang" in human evolution in mental ability and culture. What they discovered was a specific class of visuomotor neurons in the brain that enable us to understand through direct observation (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallesa, & Fogassi, 1996; Gallese 2000, 2001, 2003a, 2003b, 2004a; Gallese, Keysers, & Rizzolatti, 2004; Rizzolatti, Fogassi, & Gallese, 2001; Rizzolatti and Craighero, 2004).

Mirror neurons in effect break down the barrier between ourselves and others: as the actions or expressions of others resonate within us, we empathize and recognize the other as us. The discovery was serendipitous and unexpected. As the researchers were monitoring motor neurons in Macaque monkeys, they found that not only did the monkey's motor neurons light up when the monkey moved, but also when the monkey saw a student come into the lab eating an ice cream cone. As the monkey watched the event, researchers saw his brain respond in exactly the same way it would if he were eating the cone. Mirror neurons in area F5 of the Macaque inferior frontal cortex fired both when the monkey grasped the food and when it observed the experimenter grasping the food (Rizzolatti et al., Fadiga, Fogassi, & Rizzolatti, 2001; Gallese et al. 2002; Blakeslee, 2006).

In people, mirror neurons have been found to be more flexible and more highly evolved. Because as Rizzolatti observes, "Our survival depends on understanding the actions, intentions and emotions of others, mirror neurons allow us to grasp the minds of others not through conceptual reasoning but through direct simulation—by feeling not thinking" (Blakeslee, 2006). Unlike our Macaque cousins, we also have the ability to infer intentions of others. The same part of our brain becomes activated whether performing or observing an action, but activity increases when the context of an observed action reveals intention. Extra spiking reveals detection of the intention (Gallese, 2004b).

This ability for intentional attunement not only allows for sophisticated social communication between individuals (Goleman, 2006; Ramachandran, 2000) but also provides a neural platform for establishing language (Ramachandran, 2000), altruism (Gintis,



Previous Page: Golgi-stained neuron with cell body, axon, and dendrites. **Source:** ***Robert Huber, http://commons.wikimedia.org. Above: Macaque Neonatal Imitation.*** **Source:** ***Evolution of Neonatal Imitation. Gross L,*** **PLoS Biology** ***Vol. 4/9/2006, e311. doi: 10.1371/journal.pbio.0040311.***

Bowles, Boyd, & Fehr, 2004; *New Scientist*, 2007; Warneken & Tomasello, 2006), and advancing culture as well (Goldschmidt, 1999; de Waal, 1996, 2006; Decety & Lamm, 2006). Our brain tracks experience through chemical codes, and after every interaction, we update a built-in neurochemical profile of the world (Niehof, 1999; Niehof & Rhodes, 2000). At the heart of the concept of culture lies the necessity of registering what others are doing and subsequently imitating without fully understanding why. Through mirror neurons we absorb culture without explicitly being taught it. We are hardwired for imitation.

There are different types and layers of mirror neurons in humans. The top area activates motor empathy; the middle, context recognition; and the bottom, recognition of intention. These processes, which are automatic and outside of our conscious control, are what allow for empathy, understanding, and culture-building (Allot, 1992; Arbib, 2004; Decety, 2006; Ganguli, 2006; Jackson, Meltzoff, & Decety, 2004, Jackson, Rainville, & Decety, 2006; May, 2006; Mogil, 2006; Preston & de Waal, 2002, Preston et al., 2007; Rizzolatti & Craighero, 2006).

That is why since their discovery by Giacomo Rizzolatti and his colleagues, mirror neurons have captivated the interest and imagination of neuroscientists. Neurologist V.S. Ramachandran has even gone so far as to predict that "mirror neurons will do for psychology what DNA did for biology" and has credited them as the driving force behind the great leap forward in human evolution (Ramachandran, 2000, 2006).

Part of this great leap was the development of language, and Ramachandran believes that the mirror system enabled the primitive gestural system already in place to develop into a vocal language. Mirror neurons begin working at birth. Stick your tongue out at a newborn and he'll stick his tongue out, too. Humans are hardwired for imitation, and this capability becomes the basis for language acquisition. Research by Rizzolatti has shown, for example, that mirror neurons enable one to mime and therefore understand the lip and tongue movements of others—a vital step in the evolution of language (Rizzolatti & Arbib, 1998; Rizzolatti et al., 2001; Rizzolatti & Craighero, 2004). Research by Michael Arbib (2004) has shown that the same systems are tapped for both physical gesture and spoken language, with overlapping circuitry for both spoken and sign language. He and other neurologists believe that this overlap provides the means of human evolution from a "gesture-performance-understanding" system into human language.

An increase in the sophistication of the mirror neuron system not only expanded our propensity to imitate, but also expanded our visual learning potential in general—providing the basis for culture as a stabilizing source of identity and learning. The social ripple effect of mirror neurons explain our ability to learn through seeing; how culture is established by imitation through observation; and how cultural forces bias normative behavior, allowing for the rapid dissemination of ideas. Ramachandran (2000, 2006) also suggests that our capacity for creative thought through metaphor also has its basis in mirror neurons. This, of course, is speculation on Ramachandran's part, but his ideas continue to spur more in-depth research along these precise lines.

One the areas that neuron research would inevitably encompass is advertising (Senior & Rippon, 2007). Because the essence of target marketing is the ability to read the consumer's mind, it will not be long before functional magnetic resonance imaging (FMRI) becomes a standard part of advertising research.

Of course the idea of using images to titillate the mirror neurons and sneak under the conscious rational radar of potential consumers is nothing new. The great advertising genius Leo Burnett , who created the Marlboro man, the Jolly Green Giant, and Tony the Tiger expressed it this way: "The most powerful advertising ideas are non-verbal and take the form of statements with visual qualities made by archetypes. Their true meanings lie too deep for words ... A strong man on horseback, a benevolent giant, a playful tiger. The richest source of these archetypes is to be found at the roots of our culture—in history, mythology, and folklore" (Broadbent, 1984). Burnett understood the power of the visual image and advised his creative

teams to mine the archetypal power within the image to appeal to the deepest part of the consumer psyche.

Because mirror neurons also work to expand the social understanding of images, giving them true archtypicality, advertising images then become part of the cultural lore themselves. James Blake Miller, for example, was dubbed the "Marlboro Marine" after he appeared on the front page of more than 150 newspapers. Dan Rather talked about the photo on the evening news. President Bush sent cigars, candy, and memorabilia from the White House. A year and a half later, Miller ended up with post-traumatic stress disorder (PTSD), was given a "personality disorder" discharge from the marines, and eventually ended up divorced and broken in mental health in his home mining town of Jonancy, Kentucky. James Miller the man shows us both the bright and the dark, invisible sides of the power of images. About 650,000 sites on the worldwide web carry his story.

UCLA neurologist Marco Iacoboni, a leader in mirror neuron research, was the first to tackle this deepest part of the human psyche using FMRI to scan the mirror neurons in the brain to determine the impact of advertisements. During the Super Bowl in 2006, Iacoboni's volunteers viewed Super Bowl ads through special goggles equipped with high resolution LCD monitors. Brain scans of viewers showed a high response for Doritos, while the Emerald Nuts ad got little response. Budweiser's "Secret Fridge" ad received high ratings in the Best TV Commericials category on the internet's TVCB. But it scored low on response in Iacoboni's "instant science" experiment—unlike Budweiser's "office" commercial. Disney's NFL/"Going to Disneyland" commercial was one of the highest scoring ads (Iacoboni, 2006).

Iacoboni's research also revealed discrepancies between what people say they feel and what they really respond to. A Burger King Whopperettes ad featuring women as condiments piled onto a burger consciously offended the sensibilities of many women, but FMRI showed a deep empathic response. Iacoboni's subject came out of the scanner after the ad and said she didn't like commercials in which females are treated as objects of sexual desire. "But guess what?" Iacoboni comments, "Her mirror neural regions were firing out like crazy when she saw those." Conversely, the same subject did not show a response to Dove's campaign for self-esteem, even though she said she loved it (Wittlin, 2006).

Although it is possible that her contradictory responses reveal that women do respond better to sexist commercials, the results probably better illustrate just how deep cultural conditioning goes in the mirror neuron system. When *Seed Magazine's* writer Maggie Wittlin summarized the findings of Iacoboni's research, she titled her article "Instant Study Hints that Advertisers Should Objectify Women" (America's Army, 2009). In doing so, she both reinforced the cultural norm and did her small part to continue the social injustice.

Another area where mirror neurons have sparked renewed interest is learning violence through observation and then imitation in real life.

Learning Violence through Mirror Neurons

Because mirror neurons let us grasp the minds of others through direct simulation rather than conceptual reasoning, video games are the perfect medium for teaching through feeling, not thinking (Iacoboni, 2007).

Although most video gamers will insist that they know the difference between a video game and reality, they would be more neurologically correct to say that they consciously register the difference. On the unconscious level, the brain registers everything that it sees as reality. Since every thought and action is emotionally primed automatically in the brain, video games become one of the best methods of teaching through direct simulation. It seems that "We have in our brains some mechanism that may induce some form of immediate behavior, and so whenever you expose kids to any form of violence through media, through video games or through films, then you put these kids at risk of expressing violence with their own acts because they're going to imitate that" (Iacoboni, 2007).

This fact has not been lost on those who have vested interests in tapping into the teen market of emotional learners for financial or political gain. Among today's top video games, for example, is a game called "America's Army." Produced by the U.S. Army and downloaded for free from the Internet, "America's Army" is a first-person tactical shooter games that realistically simulates combat. A joint project of the U.S. Army and U.S. Navy, the project cost thousands of man hours and $7 million to create under the supervision of a top Navy experimental psychologist. It features double Dolby digital sound and the highest level graphics, which the images from the game do not do justice (America's Army, 2009).

Players must go through training before they can proceed to operations. In training, they gain experience in standard and advanced weaponry, including the M16A2 rifle, the M9 pistol, the M24 and M82 sniper rifles, and the M249 machine gun. They also get medical instruction, parachute training, escape-and-evade training, and practice driving a Humvee. After training, they go into battle alongside indigenous forces to fight terrorists who have been created to be of vague nationality. All the play action is stored in a U.S. Army database, and outstanding players receive e-mails from the Army giving them information on how to transform from gamer to actual soldier (U.S. Army).

The success of the video game on a global scale, with well over 7 million users as of October 2007 has naturally inspired spin-offs. The U.S. Marines, Air Force, and Navy are developing their own video games, and other militaries including those of Palestine and Hezbollah have developed their own versions.

So successful has this approach to visual learning been, that the Army has produced a game station for placement in arcades and bars that features eight training video games using authentic training exercises and a drill sergeant to "bring out the best in each player." (West Point Army News, 2007).

The response from video game players has been ecstatic. As one player poetically expressed his feelings on geekologie.com: "I can hardly wait. The shooting game at the local bar now sucks, and this thing is supposed to be bad ass. It's allegedly going to be using the latest version of the Unreal Engine, so the graphics should be straight. I've already got a moderately stiff boner just thinking about all the beer I'm going to swig and the terrorists I'm going to kill" (DeLappe, 2007).

Needless to say, the video game has caused some protest, ranging from anti-Iraq War veterans chanting that war is not a game at the August 2007 Black Expo recruitment station in St. Louis, MO, to various individual efforts. One such effort by Joseph DeLappe, a University of Nevada professor, attempts to counteract the emotional training designed in the game with statistics that are

Advanced Marksman, America's Army
Source: *U.S. Army.*

Field Training, America's Army.
Source: *U.S. Army.*

designed to bring the person back to a higher level of conscious cognitive engagement. In his own words taken from a Canadian Broadcasting Corp. interview:

This work commenced in March of 2006, to roughly coincide with the 3rd anniversary of the start of the Iraq conflict. I enter the online U.S. Army recruiting game, "America's Army," in order to manually type the name, age, service branch, and date of death of each service person who has died to date in Iraq. The work is essentially a fleeting, online memorial to those military personnel who have been killed in this ongoing conflict. My actions are also intended as a cautionary gesture.

I enter the game using as my login name, "dead-in-iraq" and proceed to type the names using the game's text messaging system. As is my usual practice when creating such an intervention, I am a neutral visitor as I do not participate in the proscribed mayhem. Rather, I stand in position and type until I am killed. After death, I hover over my dead avatar's body and continue to type. Upon being reincarnated in the next round, I continue the cycle. (DeLappe, 2007)

But are Such Protests Truly Warranted?

If mirror neurons are so effective at visual training and transfering emotions of thrill and excitement at killing other human beings, why then don't all video game players end up repeating what they have seen? More specifically, why do some do and some don't? (see Carlisle, 2007; Grossman, 1996).

To answer this, we must first look at the differences between the imitative behavior of primates and humans. First of all, the power of imitative learning is stronger in humans than in other animals, even our nearest ancestors. Humans will imitate others' motions even when they know it is not the most efficient means to accomplish a task. Secondly, our tendency to model others' behavior is strengthened both by repetitive observation and internalized visualization. Thirdly, while our tendency to imitate remains strong, the empathy enabled by mirror neurons can easily fail, leaving us to see others not as ourselves but as merely an instrumental "other." Injury to the brain, emotional abuse, or brain dysfunction due to genetic or developmental defect—all these can cause problems with the mirror neuron system and allow for a predisposition to imitate observed violence. In all of these, one of the key variables in determining who imitates violence and who does not is the presence of super mirrors.

One ingenious experiment by Victoria Horner and Andrew Whiten of the University of St. Andrews in Scotland shows the first phenomenon. The researchers prepared two boxes that contained a reward in a bottom chamber. They showed both monkeys and children a ritualistic way of getting the prize, by first tapping and inserting a stick into the top unconnected chamber, and then inserting the same stick through an opening in the bottom chamber.

When chimps could not see inside the box, they followed the ritual to retrieve the reward. The children did the same. But when a clear box was substituted, and they could see inside it, the chimps bypassed the useless steps in the ritual and went right for the reward. The children didn't. Instead they overimitated, following the ritual for its own sake, and faithfully repeated what they were shown—even though they could easily recognize it was not at all efficient. The advantage of this phenomenon lies in its enabling our brains to absorb culture directly (Horner & Whiten, 2005, 2007).

Because our mirror neurons provide for the rapid dissemination of knowledge and culture among those similar to us, we have been able to evolve well beyond our nearest primal relations. The reason chimpanzees have not evolved to the same level of culture and language is a direct result of mirror neurons. According to Horner, "imitation and copying accurately is a huge part of our development as humans. It's how we learn language. It's how we learn to interact with objects and acquire cultural behaviors.... It's a default for us to copy accurately ... Humans focus on repeating process, something that has served us well in building a complex society" (Horner & Whiten, 2005).

Acculturation involves both a preference for imitation and also for social empathy. By means of mirroring

and intentional attunement, "others" become persons rather than simply illustrations modeling behavior. A direct experiential link is created between the observer and observed, according to pioneering neurologist Vittorio Gallese, which "enables the observer to use his/her own resources to experientially penetrate the world of the other by means of a direct, automatic and unconscious process of simulation.... The other's emotion is constituted, experienced and therefore directly understood by means of an embodied simulation producing a shared body state." The embodied simulation enabled by mirror neurons acts as an emotional scaffold upon which all further conceptual reasoning is based (Gallese, 2004b).

Who and how much we internalize from what we see involves a variety of factors ranging from personal motivation to cultural differences, from dysfunctional mirror systems to prior experience and skill development. Other major factors include practice and expertise, cultural bias, and gender.

In one experiment by Daniel Glaser, for example, ballet dancers, capoeira experts, and nondancers watched a performance both of ballet and capoeira. What he found was that the more alike our skills are the more we respond to the performance. When we see others performing acts within our own capabilities, we resonate more with them (Glaser, 2007).

These newer studies also tie in with older studies in modeling theory in which it is asserted that watching excellent form not only educates as but also increases the speed of learning. Pioneered by Karl Pribram at Stanford, modeling theory took off in its applied form in the 1980s through the work of Steve DeVore who used it to teach athletic skills through what he called "Sybervision." In one illustrative event, DeVore, not a bowler himself, watched professional bowlers on television and then went to a bowling alley where he threw nine strikes in a row (DeVore, 2008).

Gender empathy is another area of different mirror neuron response. One study by Tania Singer at University College London involved men and women observing a game in which some people cheated while others did not. Although both men and women responded equally when bad things happened to good people, only the women responded with empathy when bad things happened to bad people. Not only did the men show less empathy, but they also showed positive delight, as the reward center in the left nucleus accumbens lit up the brain scans (Singer et al., 2006).

Broken Mirrors

One of the key areas of research involving mirror neurons is in the study of autism. Because autistics are typically impaired in social interaction, neurologists have theorized that mirror neurons may be the key to understanding the disability and to developing effective therapies for it as well (Wittlin, 2005).

Autistic children, for example, appear to have fewer "mirror neurons" to govern empathy and learning by observation. In one study, 10 autistic children and 10 normally developing children were first shown emotions and were then asked to imitate them. While both groups could successfully imitate the expressions, the children with autism showed no significant activity in brain regions with mirror neurons. The more impaired the child was, the less activity appeared in the key mirror area; the less impaired the child, the greater the activity (Fecteau, Lepage, & Théoret, 2006). Functional magnetic resonance imagings (Fmris) quickly reveal the difference in activity between normally developing children and children with autism.

This research has led to innovative teaching techniques for autistic children which are visually based and interactively imitative (Cassell & Tartaro, 2008). Virtual peer Sam is a virtual character designed to look around 8-years-old and be gender ambiguous. In the child's learning environment, Sam's image is projected on a large screen. A dollhouse with movable furniture and figurines sits between the child with autism and Sam. Sam engages the child with autism in conversation and play while a researcher observes their interaction. Such efforts, it is hoped, will engage the mirror neuron system in such a way that autistic children can learn both instructional content and social interactivity (Cassell & Tartaro, 2008).

Neural disorders and frontal lobe damage can also cause the same level of disconnect between ourselves and others as like ourselves, causing a lack of empathy and therefore socially appropriate action. In

the case of perpetrators of violence, for example, we also see a parallel lack of compassion for victims. Ten years ago, no brain imaging studies existed to show the brain differences in violent criminals. Adrian Raine, a neuropsychiatrist and criminologist performed some of the first positron emission tomography (PET) scans on violent criminals. He found that although excessive subcortical activity predisposes to aggressive behavior in both impulsive and predatory murderers, predatory murderers have sufficiently good prefrontal functioning to regulate these aggressive impulses, while affective murderers lack such prefrontal control over emotion regulation (Raine, 1998). In 2006, researchers Strueber, Luek and Roth (2006/2007) reviewed studies in violent behavior from all over the world and concluded that violent behavior never erupts from a single cause.

In a combination of factors, however, it is likely that mirror neurons play a key role in lack of empathic emotional, interpersonal cognition. Susan Hurley explains that like other social animals we learn through observed body movements and we emulate actions that lead to attractive goals others have obtained, and in this tendency, violence and aggression have no special exemption. Observing aggression, therefore, should tend to prime similar behavior, which may or may not be inhibited. When the results of observed aggression are attractive, emulation of goals should be expected (Hurley, 2004).

For autistics, the mirror neuron system seems to be broken, while for those who imitate media violence, either the socializing pull toward empathy is lacking in development, or the subculture has created an overriding value that blocks empathy. Because social emotions such as guilt, shame, pride, and embarrassment are dependent upon active mirror neuron systems, we can expect that damaged or inhibited mirror systems will result in either their absence or inhibition (Wicker et al., 2003; Keysers, 2004). Super mirrors may hold the answer to the kind of inhibition of empathy associated with both imitative media violence and predatory violence.

Super Mirrors

Super mirrors, it is theorized, govern lower-level mirror neurons by inhibiting mirror neuron activity. Because of individual exposure and cultural values, we can and do build up cognitive resistance to our empathetic neurophysiological responses. Differences in cultures and subcultures, as well as individual experiences, cause the system to work differently in different people, although it is not yet fully clear how they affect behavioral patterns. According to a UCLA team of researchers, "Super mirror mechanisms may provide a fairly detailed explanation of imitative violence after being exposed to media violence" (Iacoboni, 2007).

Addressing imitative violence and media, writer Katharine Ramsland (2008) puts it succinctly: "It's safe to say that in cultures that tolerate violent images and even encourage them, there will likely be a greater propensity among young people and the mentally disturbed to be influenced toward acting out what they see. If their options for dealing with conflict are limited to violence as a resolution, they will generally turn to violence themselves."

Such research, backed by more than 50 years of behavioral data, support the idea that media violence induces violent behavior in observers. Yet we still cling to the idea that we are always in conscious control of how our minds work, even though this assumption has been disproven by neurological research.

As neuroscientist Antonio Damasio explains, we are not thinking beings who feel, but feeling beings who also think. Unconscious learning through the emotional system is the basis of all perception, with our conscious minds not only informed after the fact of emotional processing, but also without access to the emotional processes which form our thoughts and attitudes (Damasio, 1994, 2000). "Mirror neurons," Iacoboni observes, are not rational, free-acting agents in the world. Mirror neurons in our brains produce automatic imitative influences of which we are often unaware and that limit our autonomy by means of powerful social influences" (Iacoboni, 2008).

Mirror neuron research is clear. The likelihood of our imitating the violence we see may depend on the individual strength or weakness of the action-governing super mirrors which mediate cognitive resistance to imitation as well as on the adequate

functioning of the neural systems and the culture we live in. There can be little doubt that the overriding cultural value we exist in is antithetic to empathy. And because cultural influence and mirror functions lie outside of our conscious control, the only real control we have over how we respond to what we see may lie simply in carefully choosing what we see and in attempting to build a visual world that prizes empathy instead of aggression.

Recognizing that "our brains are capable of mirroring the deepest aspects of the minds of others at the fine-grained level of a single brain cell," Iacoboni hypothesizes that mirror neurons are not only important in imitative violence induced by media violence, but also in various forms of social identification such as "branding" and political affiliation. In the decades to come, he anticipates, mirror neurons will be determined to be the foundation of neuroethics (see also Gazzaniga, 2006), neuromarketing (see also Senior & Rippon, 2007), and neuropolitics (see also Connolly, 2002; Olson, 2007), and in fact, everything in neuroscience. He states that "Our knowledge of the powerful neurobiological mechanisms underlying human sociality provides an invaluable resource for helping us determine how to reduce violent behavior, increase empathy, and open ourselves to other cultures without forgetting our own. We have evolved to connect deeply with other human beings" (Iacoboni, 2008).

But before we can achieve a society based on a natural empathy, the first step must be to recognize that we ultimately become what we see.

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Ann Marie Barry teaches courses in visual communication theory and aesthetics at Boston College.

Correspondence should be addressed to Anne Marie Barry, Boston College, Department of Communication, 140 Commonwealth Avenue, Chestnut Hill, MA 02467-3804. E-mail: barrya@bc.edu