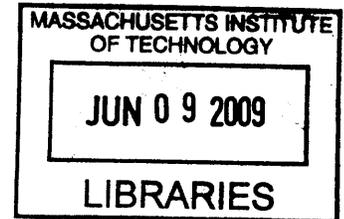


The Clearest Mirror:  
The Science of Laughing and Crying

by

Genevieve M. Wanucha

B.A. Cultural Anthropology  
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SUBMITTED TO THE PROGRAM IN WRITING AND HUMANISTIC STUDIES IN  
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# The Clearest Mirror: The Science of Laughing and Crying

By

Genevieve M. Wanucha

Submitted to the Department of Writing and Humanistic Studies  
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Requirements for the Degree of Master of Science in  
Science Writing

## ABSTRACT:

There are few things as familiar to us as the experience of laughing and crying. Studying the two emotional expressions side by side is a way to see our species anew. A way of linking what we share with other mammals to that which sets us apart from all other species. Pulling laughing and crying onto center stage in all their theatrical glory creates a scene of which philosophers and anthropologists have long dreamt: a vision that is uniquely human.

Laughing and crying are in many ways physiological and psychological opposites, but these complex behaviors are not exact reversals of the same bodily processes. Nor have researchers told me that they are connected in any biologically relevant way. But zooming out of narrow scientific definitions, digging into our evolutionary history, focusing on the disorders of laughing and crying, looking to the stage where actors and actresses come alive through their tears, there emerges a puzzle of psychology, neuroscience, evolutionary theory, and neurology slowly snapping together.

Thesis Advisor: Russ Rymer  
Title: Professor of Science Writing

At 7:15pm, the tiny yellow light bulbs dotting the ceiling of London's Lyttelton Theatre dimmed slowly over the audience. Solid black replaced the waning starlight. Eight hundred and ninety pairs of eyeballs followed the same dark trajectory, looking forward in simultaneous, directed blindness. The play, Tracy Letts's *August: Osage County*, had just won five Tony awards and the 2008 Pulitzer Prize for best drama. The three-hour-and-twenty-minute tragicomedy of a Mid-western family's loud dysfunction spilling addiction, psychological degeneration, incest, suicide, and racism into the theatre was "the first great American play of the 21st century," according to theatre critics. Now it had come to the Lyttelton, tucked into the northwest wing of the National Theatre. Anticipation thickened the air, a silent, collective creation. The man in 6A in the front row cleared his throat and thumbed the velvet fibers of his armrest as the black slats of the metal curtain slowly climbed upward in smooth horizontal folds to expose the interior of a fully-furnished, three-floored Oklahoma house.

Deep within the 2.95-pound rubbery, tightly folded mass inside the head of the man in 6A, a nerve fiber, or neuron, twitched, zapping a connected nerve fiber, and passed an electrical signal down 20 nanometers to the next neuron. Actor Paul Vincent O'Connor sat under the gold glow of the floodlights, swigging whiskey and drunkenly quoting T.S Eliot. "My wife takes pills and I drink," O'Connor said nonchalantly to the new housekeeper. "...That's the bargain we've struck."

The orbicular muscles encircling the eyeballs of the man in 6A received the traveling electric pulses and slowly crunched tight beneath wrinkled skin, pulling inward his cheeks and forehead. Zygomatic muscles, anchored at each cheekbone like leathery

strings attached to a marionette, tugged the corners of his mouth backwards and up.

“Oh God, they’re called Native Americans now, Mom!” actress Amy Morton groaned, scowling.

“Who makes that decision?”

“It’s what they like to be called!”

“They’re not anymore native than me!”

“In fact they are.”

A sudden cough-like 310-millisecond long noise exploded from the throat of the man in 6A, extending to a frequency of 10,000 Hertz. Five smaller pulses beginning with the /h/ sound followed, hovering around 6 Hertz each, lasting 1/15 second and repeating every 1/5 second. The soft tissue lining his upper larynx vibrated 120 times per second. His heart pumped faster, its rate increasing to 115 beats per minute as the words’ impact settled. His lungs expelled air in fast bursts and then violently sucked it back to avoid suffocation. Oxygen level remained constant. Blood vessels relaxed. Some of the one billion neurons in his spinal cord slowly calmed down, softening muscle tone. Endogenous opioids, the body’s natural painkillers, leaked from a spindly protrusion of a neuron to the next, and then trickled into his bloodstream. His abdominal muscles clenched in rhythmic spasms. A sudden decrease in the activity of neurons sending signals to his tibial nerves, fibrous tubes running down the back of the knees to the sole of the feet, temporarily paralyzed muscles of both legs.

“I think you should try to prepare your wife if you can,” the sheriff told Perry.

“Prepare her?...”

Viewers in the front row seats could almost feel the spit popping out of the two men’s mouths.

“What happens to a body,” the thespian sheriff told Perry. “It’s very bloated, an ugly color. And fish have eaten the eyes.”

“Oh Christ. How does a person jump in the water...and choose not to swim?”

“I don’t think you do unless you really mean business.”

Perry stood, face blank, lights dimming, and repeated, “Choose not to swim.”

Hit with the electric signal sent from a bulb at the top of his brainstem, the lacrimal gland of the man in 6A, a puffy packet of cells perched on top on his eyeballs in the bony space behind the eyebrows, began to produce a salty liquid. This warm liquid flowed into small drains called puncta, permanent 0.2 to 0.3 millimeter openings in the papilla lacrimalis, the pink triangle of tissue where his morning eye grit collected. A small amount of this liquid, swimming with globins, glucose, antimicrobial agents, lipids, endorphins, urea, potassium, manganese and sodium, passed through the puncta into another bundle of tissues, the lacrimal sac, then pushed past a membranous flap, the Valve of Hasner. Tiny tubuloalveolar glands secreted streams of phlegm. The thick solution emptied into the nasal passages. The immune enzyme lysozyme in this liquid killed a few of the *Streptococcus* bacteria swarming along the pseudo stratified columnar epithelia lining the inside of his nostrils. He reached for a tissue. The rest of the fluid dripping from the top of the eye quickly expanded in volume as he continued to watch the

expression on Perry's face, and overwhelmed the tiny pink puncta, which could only drain at the rate of a micro-liter and a half per minute. The trembling ledges of eyelids kicked over a drop. He blinked and swallowed. From where I sat in seat 7A, I saw him press a finger hard to the bridge of his nose, and begin to cry.

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"It's really spectacular when you think about it," says William Frey II, biochemist and neuroscientist at the University of Minnesota. "There is this one species who has the ability to shed emotional tears." Spectacular and, as Frey would admit, mysterious. Crying, and its psychological counterpart, laughter, are core human attributes, essential markers of our species. They have been the subject of exploration and exploitation for as long as humans have expressed feelings to one another, and as long as art has wrung emotion out of human drama. But for all of that, they are little understood, one of the darker behavioral mysteries lurking in the light of everyday experience. Arthur Koestler puzzles in the *Act of Creation*, "What is the survival value of the involuntary, simultaneous contraction of fifteen facial muscles associated with certain noises, which are often irrepressible?" Indeed, how would we explain, to any visiting creature unfamiliar with our species, the water dripping from eyeballs, the faces contorted into spasms and creases, the garbled vocal expulsions, the secretions dripping unwanted from the nose, the convulsing rib cages—all induced by no discernable physical stimulus? And how to explain why humans would pay exorbitant London theatre fees to have these involuntary reactions voluntarily induced?

Not surprisingly, considering the depth of the mystery, scientists are paying more and more attention to the phenomena of crying or laughing, trying to tease out the mechanisms behind the complex orchestration of muscular, nervous, endocrine, respiratory, thermoregulatory, and cardiovascular systems. They are asking: why do we do this at all? “There are such enormous claims that crying is healthy and important for making us human. So, for me those are more than sufficient reasons to learn more,” says Ad Vingerhoets, professor of clinical health psychology at Tilburg University in the Netherlands. Psychologists like Vingerhoets focus on how emotional expression arbitrates the relationships of infants and parents, of enemies and lovers. Numerous other fields are taking stabs at the mystery as well. The nature of their endeavors imparts a hint of how many dimensions the prism of laughing and crying has.

Evolutionary biologists and anthropologists have traced the auditory and visual signals back to the pre-dawn of *Homo sapien* culture and nascent social communication. Researchers are measuring the brain waves of adults as they listen to infant vocalizations to determine whether the male and female brain process these loaded sounds differently. Neurologists are investigating diseases that can reveal past secrets about how emotion relates to physical laughs and cries. And most recently, neuroscientists have begun to employ fMRI brain scanning technologies to unravel the neural pathways of emotion.

Their findings have in some ways only deepened our appreciation of the everyday enigma. In 1981, Frey discovered the unique chemical composition of emotional tears; he now says that his effort to investigate crying ended up producing far more questions than it answered. In part this is because of the ineffable nature of emotional response; even

delineating its boundaries can be daunting. “When exactly does someone start crying?” Vingerhoets asks. “And what’s even more difficult—when do they stop crying? It’s nearly impossible to establish the onset and end of crying, and that makes it very complicated to decide the relationship between what’s going on in the brain and the tear glands.”

The questions get deeper still as scientific investigation moves from individual experience to nonlinguistic social exchange: What's going on between groups of people caught up in these emotional expressions? We share tears at a funeral and forge friendships through giggles in the back of a classroom. We feel a prick of empathy in our guts when we watch someone cry, whether it be someone we know, or an actor on a stage or television screen. Do laughing and crying necessarily correspond to an honest emotion at all, as Shakespeare and some cognitive psychologists doubt? What can neurological disorders reveal about the complicated architecture of emotional signaling between people?

And within that neural architecture, what ultimately is the relationship between these two extreme behaviors? Why should both joy and sorrow provoke tears? Crying can so easily slip into laughter. We “hold” back laughter and “hold” back tears. We “burst” into both laughter and sobs, which both produce similar facial expressions. So why do a sob and a guffaw so often sound the same, heard from a room away? And how is it that children will snap from crying to laughing in one blessed instant? Laughing and crying may be estranged relatives, like the weeping angel and cackling devil, but they're also, some say, conjoined twins. “At some point they cross over,” says Randolph

Cornelius, professor of psychology, American culture, and cognitive science at Vassar College. “There’s a well-known observation that we can laugh ourselves into tears or vice versa. So the rapid inhalation and expiration that goes on with both laughing and crying appear to be similar. There are all sorts of complex intersections there that need to be explored.”

Laughing and crying are in many ways physiological and psychological opposites, but these complex behaviors are not exact reversals of the same bodily processes. Nor have researchers told me that they are connected in any biologically relevant way. But zooming out of narrow scientific definitions, digging into our evolutionary history, focusing on the disorders of laughing and crying, looking to the stage where actors and actresses come alive through their tears, there emerges a puzzle of psychology, neuroscience, evolutionary theory, and neurology slowly snapping together. Koestler realizes that “The creative act is not an act of creation in the sense of the Old Testament. It does not create something out of nothing; it uncovers, selects, re-shuffles, combines, synthesises already existing facts, ideas, faculties, skills. The more familiar the parts, the more striking the new whole.” There are few things as familiar to us as the experience of laughing and crying. Studying the two emotional expressions side to side is a way to see our species anew. A way of linking what we share with other mammals to that which sets us apart from all other species. Pulling laughing and crying onto center stage in all their theatrical glory creates a scene of which philosophers and anthropologists have long dreamt: a vision that is uniquely human.

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In 1931, as archaeologist Claude A. Schaeffer was excavating the ancient port city of Ugarit on the north coast of Syria, he uncovered a series of broken clay tablets.

Inscribed in strange symbols on the 14<sup>th</sup> century BC clay was a poem, the first written record of tears. One fragmented bit of the Ras Shamra texts tells the story of the virgin goddess Anat. Distraught at her brother Ba'al's death, she "continued sating herself with weeping, to drink tears like wine."

Greek physicians of the 4<sup>th</sup> century BC, who placed ultimate importance on purging the human body of pathogens, thought tears were the brain's way of eliminating cerebral toxins. These doctors had adopted an Ancient Egyptian physiological idea that sickness sprang from the build-up of bile and phlegm obstructing blood and air from nourishing the brain. Tears were "excess humors" expelled from an overheated and soggy cerebrum. The Hippocratic notion that tears were part of physiological program of bodily catharsis traveled on to Europe, where it showed up in writings of Renaissance doctors like British physician Timothy Bright, who in 1586 called tears "the excrementitious humiditie of the brayne." The French physician Laurent Joubert explained, "When the brain is compressed, it ejects great quantities of tears." Such European doctors acknowledged the common appearance of tears with extreme emotion, Joubert concluding that "it is necessary to know that one weeps of sadness when suffering presses the eyes and the adjacent areas with constraint, squeezing out their humidity. Joy, on the other hand, dilates and opens the pores, from which the humors are able to flow and fall in the form of tears." Tears were brain juice, cranial sweat, up until

the seventeenth century.

Tracing the history of laughter is chasing the ephemeral, akin to searching for the breath expelled with the first joke thousands of years ago. Our world came into being with a particular laugh, according to an ancient papyrus dating back to around the 3<sup>rd</sup> century BC. The supreme, unnamed Egyptian Creator laughed, in seven glorious bursts, the light, the oceans, mind, and soul into physical being. The idea that laughter is a godly possession, bestowed with great creative power, is a common theme in many ancient religious texts. Too much laughter is dangerous, a wicked, destabilizing force impinging on the duties of gods. The 16<sup>th</sup> century Puritan dictum on the activity, a ban on laughter and smiling punished by imprisonment, was far preceded by Plato, who recommended any mention of laughing gods or heroes be deleted from literature. Theater, he felt, should be tightly controlled, as laughter so aroused and freed the spirit that his subjects would riot. He would have surely been horrified at psychoanalyst Sigmund Freud's influential theory that laughter at humor was repressed sexual energy and aggressive tension, released when a joke so mildly crosses the boundary of propriety, that the relief generated from the punch line cracks open the river of dammed up dark energies.

Think of how validated you felt the last time someone laughed knowingly, or how disheartened you felt when your teacher laughed dismissively. Think of how much authority President Barack Obama garners when he succeeds in amusing the press corp. Laughter holds power, the power to create and destroy, affirm and delegitimize.

The tablet dug up from Ugarit, buried under the debris of a ruinous, final earthquake, tells of a time elaborated in the Hebrew Bible. Recorded there is an account

of a pre-Hebrew Canaan ritual practiced around the 14<sup>th</sup> century BC, a springtime ritual in which an entire tribe traveled to the desert and commenced an emotional ritual by moaning and crying in synchrony. Over the course of several days, the group slipped from crying to wailing, to hysteria and laughter dispersed into giggles and a return to daily life. Gliding across the emotional spectrum was the point at which social life began for these ancients. Laughter begins relationships, just as crying begins life. After all, we all enter this world crying.

Even if the cold, new air, and the slimy feel of blue plastic-gloved hands doesn't cause a cry to emerge from the infant larynx, the lives of the new parents will soon move to a grating soundtrack. The infant, who is rapidly assimilating information about his world as blossoming neurons rapidly forge connections and memories, soon learns that crying is useful. "When they're distressed or aroused, crying is the vocalization they can easily produce and can get them what they need in most circumstances. It's a really good way to see how sounds induce feelings in others. People want to turn the crying off," says Jo-Anne Bachorowski, Associate Professor of Psychology at Vanderbilt University, who studies emotional vocalizations. Crying is a powerful infant tool to meld and shape a mother's actions and state of mind. But behind these liquid demands and quick responses, an ancient biological transformation is occurring: the bond. Examples of which, as it turns out, are not hard to find.

"I had a massive panic attack the other day."

"Oh?" My eyes widened, brows raised.

“It started suddenly. And she was right there,” my friend said, gesturing to the front seat. “I just couldn’t stop crying, but I was afraid it would scare her to see me cry, so I hid my face in my hands.”

Meghan<sup>1</sup> is a young mother, living in Red Hook, New York on the Bard College campus where her partner teaches music. Her baby daughter Emma napped in the car seat behind us. A week ago, she had been sitting up here in the front.

“And something very strange happened—Emma interpreted my sound and actions as laughing. She thought I was just laughing really hard and giggled loudly in response. She thought it was so funny that I was laughing. Anyway, she started to tear my hands away from my face, to try and open my closed hands like she would normally do when we play,” Meghan said, mimicking the open-close hand movements. “At that moment I began to laugh while I was crying because I was touched at her utter innocence and assumption of my emotional nature. I began to cry harder, alternating between crying and laughing because I was so touched,” she said.

In the 1950’s, when attachment theory exploded in the field of psychology, the development of this theory pushed infant act of crying front and center. British psychiatrist John Bowlby and social psychologists Mary Ainsworth and Silvia Bell developed this theory, which posited that infant crying and suckling triggered the crucial attentions of their caretakers and cemented the bond between parent and child. Seriously challenged was the Freudian psychoanalytic view that the bond existed primarily for the baby’s nutrition and oral gratification. To Bowlby, the Freudian view did not explain

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<sup>1</sup> Name has been changed for privacy

why a mother figure was necessary. Bowlby and his colleagues turned to ethology, the study of animal behavior, to solve this theoretical dilemma.

The work of American social psychologist Harry Harlow on maternal deprivation in rhesus monkeys interested Bowlby. Harlow had discovered that the isolated but well-fed baby rhesus monkeys craved the attention of and contact with a maternal figure, even if that were only a cloth mother puppet. Maternal deprivation caused permanent neurological damage in these monkeys. Bowlby and his colleagues drew heavily on such research to conclude the instinctual responses that develop in the first half year of life, suckling, cuddling, clinging, crying, laughing, and smiling, were part of an evolutionary heritage, in which strong mother-infant bonds promoted species survival. Suddenly, infant vocalizations were not just a signal from a helpless or spoiled infant, but a preprogrammed, biologically based repertoire of attachment behaviors.

It wasn't until a neuroscientist attempted to explain this attachment theory through brain anatomy that the mysteries of laughing and crying inched further out of the dark.

“Walking in a cathedral” is how the behavioral neuroscientist Paul D. MacLean often described the arches and vaults of brain tissue he saw through the microscope. But the cell-level constituents and molecular interactions of this elaborate structure, in his opinion, were exclusively the purview of neuroscientists attempting to study emotion. They were missing the forest for the molecular trees. His colleague, psychologist Kelly Lambert of Randolph-Macon College recalls that MacLean was a “big-picture” neuroscientist who proposed that without bringing an evolutionary perspective into

affective neuroscience, the real answers as to how the brain circuits control behavior would be abandoned for a narrow biochemical vision. MacLean surrounded himself with peacocks, squirrel monkeys, rats, hamsters, anolis lizards, komodo dragons, and their respective brains, and in 1952, after peeling through layer after literal layer of cerebral matter, he named what he found the “triune brain.”

This theory of the ‘triune brain’, an idea that some researchers see as outdated and simplistic, lies behind many of the tenets of neuropsychiatry and child development psychology. ‘Triune’ refers to MacLean’s contention, after painstaking observation of reptilian, mammalian, and human brains, that the human brain contains the markers of its evolution and is composed of three brains. In his model, our cranial trinity is made up of interconnected structures: the protoreptilian complex (controlling automatic motor and behavioral routines), the paleomammalian formation (he named this the limbic system, or the program of emotions), and the mammalian formation (recently evolved cognitive functions), all layered like tree rings betraying the process of millions of years of evolution. The limbic lobe of the mammalian brain contains the emotional instructions crucial to mammal life, such as inborn nurturing behaviors like play and separation cries. “The history of the evolution of the limbic system is the history of the evolution of mammals, while the history of the evolution of mammals is the history of the evolution of the family,” he writes. Our brains, he suggested, contains specific wiring for maternal-infant relations.

Emotions and their expression are “inherited tools for living from our ancestral past,” says neuroscientist Jaak Panksepp at Washington State University, agreeing with MacLean’s idea. Panksepp makes this “big-picture” affective neuroscience his life’s

work. Like MacLean, he thinks that studying the animal equivalent of emotion will reveal volumes about how our minds work, because of the shared ancient neural circuits. “We know from human work that the basic circuitry for laughter and crying is well represented in very primitive brainstem regions—brain areas that are quite homologous in all mammals. Such social urges were built into the brain long before humans, even though they obviously take unique species-typical expressions in humans, as they do in every species,” he explains. His work with rats has, like MacLean’s, undermined the traditional assumption of behavioral neuroscience that emotional processes and vocalizations were the prized possession of humans alone.

In the early 1990s, he and his colleagues hooked up ultrasonic recording equipment and listened while juvenile rats engaged in rough-and-tumble play. They heard a cacophony of 50 kHz ultrasonic “chirping” type vocalizations. These rambunctious rodents also chirped in anticipation of play. It wasn’t until years later that Panksepp made the connection between these chirps and human laughter. Having completed a study in which he concluded that laughter was an integral part of human children’s physical play, he suddenly decided to look to rats to confirm a rising suspicion. Walking into his lab the morning after this realization, he approached his undergraduate assistant. “Come tickle some rats with me,” he remembers saying.

And so they “tickled” the rats. Or, in scientific language, they engaged in “Heterospecific Hand Play.” They stuck their fingers in the cage, and tickled the young rats on the nape of their necks, where they usually target their own play grabs. The rats chirped wildly. When the rat’s necks were anesthetized, the tickling ceased to cause chirping. He thinks that these delighted rodent chirpings, as do tickled chimpanzee

panting, have some kind of ancestral relationship to the laughter of human child play. Though human laughter is hardly identical to rat vocalizations, the reward systems and the purpose of the vocalizations seem to have similar evolutionary roots.

Around the same time, MacLean expounded his theory that the mammal limbic system functioned to secure relationships through animal cries and calls, and that those sounds were the evolutionary precursors to human laughing and crying. In 1990, he published his hypothesis in *The Triune Brain in Evolution* that laughing and crying were maternal-infant attachment behaviors forged deep in the ancient brain stem and limbic lobe. These noises and corresponding nurturing and social behaviors, he wrote, made possible group communication and family relations. Long-term social contracts, in turn, paved the way for the development of empathy and a moral conscience. The capacity for art and ritual appeared soon after, judging from one of the oldest known cave paintings, hunted animals etched in the Ardèche River valley Chauvet cavern in southwestern France 32,410 (give or take 720) years ago. Abbé Breuil, the pioneer interpreter of Palaeolithic art, first proposed this connection between drawn animals and hunting rituals in the early 1900s.

MacLean dwelled on the evolutionary origins of laughing and crying, imagining their sounds traveling through the smoking fire pits illuminating the Palaeolithic cavern walls. “As for a connection between laughter and smoke and tears,” he wrote, “one might suggest that guffawing amusement around a hearth fire in a cave might be conducive to increased smoke inhalation and an aggravation of tearing.” This conjecture has been criticized as fanciful Lamarckian evolutionary theory—the idea that certain

individuals can develop traits to adapt to an environment and pass those traits directly to their offspring—and incompatible with Darwin’s theory of natural selection. Though MacLean’s scenario is creative, he did reason with Darwinian logic that a mutation favoring tear production in the face of campfire smoke would have bestowed the evolutionary advantage of self-healing eyes to creatures playing with the undiscovered dangers of the life promoting crackling flames.

The field of zoology contributed another idea to this evolutionary connection of human laughing and crying. Zoologist Desmond Morris, in his 1967 book *The Naked Ape*, reasons that because humans are born twelve months earlier than expected for a primate brain of our size, we come into the world as especially helpless creatures. For months, human babies depend solely on adults for food, navigation, and care. So, the infant capacities to cry, scream, and gurgle serve as important tools to secure this parent-infant relationship of survival. Morris reasoned millions of years of parenting practice converted crying into laughter. He imagined this scene of emotional transition like this: a prehistoric infant nestled in his mother’s arms is suddenly startled by a loud noise. The immediate reaction is to cry in distress, but just as fast, the youngster hears his mother’s voice and realizes that he is safe. The danger can be ignored. “The outcome of this,” Morris writes, “is that the child gives a response that is half crying reaction and half parental-recognition gurgle.... It is as though the long wail of the crying infant has become segmented, chopped up into little pieces, and at the same time has grown smoother and lower.”

Recent neuroscientific research involving human mothers, fathers, babies, laughing,

and crying offers contemporary evidence of this innate connection between laughing and crying and mothers and babies. In 2004, behavioral neuroscientist Henning Scheich, director of the Leibniz Institute for Neurobiology Center for Learning and Memory Research in Magdeburg, Germany, ran a study in which he and his colleagues lugged recording equipment to the homes of new parents. They wanted to collect the data in the most natural of settings. They recorded hours upon hours of infant laughing and crying, later combing through the data and isolating samples. They then assembled nine women and nine men, all who had never been parents, and exposed them to the sounds of infant laughing and crying and, as a control, time-reversed laughing and crying. They found that the authentic infant laughing and crying, more than adult laughing and crying, strongly activated the adults' amygdala, a two-pronged almond shaped brain area devoted to emotional processing and attention to the environment (part of MacLean's limbic lobe). But most interesting, said Scheich, is that the sounds activated women's amygdala many times more than they did the men's. "This points to the fact that laughing and crying are inborn components" he said. Our brains have been engineered to respond to emotion.

In 2003, a group out of the University of Basel, Switzerland performed a similar experiment for a slightly different purpose. They, too, analyzed the brains of adults as they listened to tape recordings of infant laughing and crying. And women, not men, no matter their parental status, showed a decrease in the activity of a brain area in the prefrontal cortex called the anterior cingulate, a sort of relay station integrating emotional and cognitive processes, as well as social decision-making. A decrease in this area, suggests Erich Seifritz, Professor of Psychiatry and Director of the Clinic for

Affective Disorders and General Psychiatry at the University of Zurich in Switzerland, reveals that an infant's call may momentarily disable this area, suppressing less relevant sensory information, and leaving the mother's brain uninterrupted access to her infant's yammering. These data hint that women, mothers or not, inherit brains wired to respond emotionally to infant cries, just as MacLean had thought. It's as though infant laughing and crying activate private infant communication lines in the female brain.

The University of Basel researchers found that other brain areas responded differently in parents and non-parents, independent of the listeners' gender. In other words, a mother or father hears more of an emotional tug in a cry than does a non-parent. Seifritz thinks these automatic parent brain responses to infant crying reveals that audio emotional signals are adaptive behaviors. "Giving highest attention to a crying baby is an adaptive advantage because this helps support survival of the offspring," he said. Though everyone's brain registers a baby's vocalizations, the parent brain has unique activation patterns. Nature has placed these caregivers, it seems, at the mercy of a baby's cry.

Neuroscientific studies like these acoustic analyses have bolstered evolutionary theories that the origins of laughing and crying are deeply entwined with the roles and rigors of ancient family matters. Clearly, these auditory and visual social cues are built into the human brains at a mechanistic, biological level. But the quest to more deeply understand these communication signals has led researchers on ventures requiring electrical probes, rodent tickling, even medical therapies—and ultimately, the insights of artistic expression.

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Her glassy eyes wobbled to the right, tracking the three traveling fingers. The hand stopped and then rose up towards the ceiling. Auburn hair, splayed with static charge, fell back as her eyes resumed the task. With her glasses removed, her face was naked, surprised.

“Try and keep your head still,” a soft voice murmured. “Just follow my fingers with your eyes.” She couldn’t. At each attempted ascent, her eyes fell to center, unable to find visual anchor.

“How are you doing with your MS?”

“It’s fine,” the woman voiced over the course of eight seconds, her eyes calm and accepting. “I’m de-al-ing with i-t.” An array of wrinkles, right then, grew from her crunched eyelids. Rivulets of tears washed into the creases, bathing her cheeks with a saran wrap coating. “Don’t mi-nd me,” she blurted.

Then, the doctor’s voice: “Give me a big laugh.”

Like a knee jerking at the hammer’s tap, her jaw dropped to send an attack of laughter into the boxy beige examination room at the Stanford University Neurology Clinic.

Dr. Josef Parvizi was unfazed. He sat on a short stool, his scarlet tie dangling as he leaned into her wheelchair, softly grasping her shoulder and stroking her hand. At his slight provocation, she would immediately change from crying tearfully to laughing

strongly. It was as if there was an invisible, maniacal puppeteer behind her. Parvizi told the woman that she was doing fine in a voice tinged with an unplaceable accent. “Dr. Gross is a world expert in this kind of thing,” Parvizi assured her, gesturing to a tall blonde man, psychophysicologist Dr. James Gross of Stanford University, who leaned in from four feet over. “He’s here to give some insight.” She nodded vigorously.

Dr. Parvizi, a neurologist and professor of neurological sciences at the Stanford Medical School, has a calm oval face and a frequently dawning smile. He flits down the narrow sea-green corridors of the busy Neurology Clinic, perpetually in that blood churning space between a walk and a run. I had to break into a trot to stay at his heels. He works in a small, warm office smelling of the tart sliced dried persimmons and sour black cherries on his desk. Out of the corner of his eye, he can see a \$95,000 stack of Tucker Davis Technologies equipment, whose dials and knobs measure the brain waves of his epilepsy patients 30,000 times per second to detect minute electrical abnormalities buzzing deep in the brain. The walls are tiled with framed neurology degrees, completed residencies, awards. An espresso machine sits next to his keyboard. Many nights he is in the office past eight. If he keeps his door open a crack, heads will constantly emerge from the hall, students to show him their work, other doctors reporting a plaque on a patient’s brain or informing him of a scheduled meeting. “Josef is a wonderful doctor. He develops really creative solutions to patients’ complex problems,” Gross tells me later, referring to Parvizi’s current work.

Parvizi is planning a systematic study on the rare disorder called pathological laughing and crying. PLC is not one disorder on its own, but the result of a lesion or

tumor encroaching upon structures in the brain that govern emotional expression. The unpredictable and uncontrollable episodes of laughing and/or crying that sometimes develop after a traumatic brain injury, stroke, epileptic seizure, or during the course of a neurodegenerative disorder such as Parkinson's syndrome emerge uninvited and inappropriately into social exchanges. The muscular contractions and vocalizations of laughter and crying are torn from the normal hinges of happiness and sadness so that a patient may erupt into raucous laughter during a somber meal or tax session, free of the mirth that usually triggers laughter.

Earlier, Gross had walked over from his psychophysiology lab on the other side of campus, through the late morning Palo Alto sun and flame-shaped evergreens that line the hospital courtyard, through the doctors hurrying by in their forest green scrubs. Gross's research into emotional regulation in the healthy brain allows him to immediately sense any minute hand movement, eye twitch, or comment suggestive of emotional dysfunction, abilities crucial to helping Parvizi gather participants for his study. Today, in the boxy beige examination room, these doctors will make a diagnosis.

Leila<sup>2</sup> stopped rocking the wheelchair, calmed down, and tried once again to answer the doctors' questions. Her sister, a rusty-haired woman clutching a leather bag sat outside the huddled group next to the wall and spoke for her. "So many things seem to upset her. There's no rhyme or reason for an outburst," she said.

"It sounds like there are no brakes, like in a car. The brakes aren't working so well for her emotion," Gross offered.

“Uh, huh.”

Her sister mentioned the trouble Leila was having with the aides who dressed her. Leila’s oddly-timed crying started again, as though a memory triggered the corresponding emotional reaction that would normally be kept inside, like a filter between private thought and public expression was missing. Parvizi and Gross shot each other a private, knowing glance.

For the past twelve years, Leila, 51, has lived with a progressing case of multiple sclerosis, a disorder in which the immune system attacks cells of the central nervous system, slowly nibbling away at the ability of brain and spinal cord to send signals and coordinate muscle movements and cognition. Her MS has taken away her ability to walk and has obstructed a waterfall of words behind an uncooperative tongue. Her usual physical and cognitive symptoms have recently eaten into her emotional life, affecting her ability to control the expression of sadness, anger, and frustration. Her doctor referred her to Parvizi soon after he observed an abnormal increase in crying spells and a few instances of seemingly out-of-place laughter. If Parvizi and Gross diagnose PLC today, she could become part of a study now in the works.

Parvizi asked her to once again remove her glasses and held up her arm for a few seconds. Her arm shivered back and forth like a broken compass. The doctors looked at each other and spoke in their fast abbreviations. “Cerebellar ataxia!” Parvizi mouthed to Gross. Cerebellar ataxia, a hallmark sign of multiple sclerosis, is the loss of muscle coordination. The cerebellum, a fist-sized 1/3-pound chunk layered with 50% of all the

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<sup>2</sup> Name of patient has been changed for privacy

neurons in the brain, is squeezed between the bottom of the brain and the top of the spinal cord. It usually controls fine-tuned management of moment-to-moment actions. When compromised by the lack of communication from the brain and the spinal cord, the cerebellum, or “miniature brain” in Latin, can’t relay proper instructions to the brain stem, the part of the brain that executes many prepackaged muscle movements, like the diaphragm and facial contractions of laughing and crying.

Recognition flashed in Parvizi’s eyes as he watched Leila’s uncontrolled movements. He recognized this as cerebellar dysfunction because one of his past major findings suggested that this “mini-brain” is a leading antagonist in the wrenching drama of PLC. A decade ago, Parvizi was a graduate student at University of Iowa College of Medicine. He and his colleagues challenged the old neurological explanation for this rare disorder. This old explanation, that pathological laughing and crying was caused by damage to parts of the brain that voluntarily controlled emotional expression, dates back to 1924, when the anatomical and neurological data that doctors had to work with was extremely limited. Disruption of voluntary pathways could not explain why PLC patients often have no problem performing voluntary muscle movements, even mimic laughing and crying. At the same time, the patients would start laughing at a dime dropping. Parvizi and his team knew that there had to be something going on with the involuntary behavior patterns.

They studied a middle-aged landscaper who had suffered a stroke the year before. Right after his stroke, C.B. had started breaking into uncontrollable episodes of laughing and crying. A CAT scan revealed some dead tissue on his cerebellum. When the Iowa

team examined him, C.B. was still regularly experiencing these episodes. He would cry in response to a joke and laugh after a frustrating test. So, Parvizi and others scanned the patient again with Magnetic Resonance Imaging to secure a more revealing image of the brain. Damage to his cerebellum and brain stem appeared as black spots on the scan. The cause of C.B.'s PLC had something to do with a broken interplay between these brain regions.

A new schema of laughing and crying was gleaned, in part, from this study. Parvizi says that the brain can be seen as a complex looping network made up of nodes and sites of action that are in constant communication. There are induction sites, such as the amygdala or ventral striatum, which pair a stimulus with an emotion. "You can think of an induction site like a switchboard deciding when A comes, what would be the best deal for B," explains Parvizi. "Like how, for most people, snakes trigger a sense of fear." Effector sites, like parts of the brain stem, execute the actual physical expression of that emotion. "Effector sites are the warehouses producing the actual act of laughing or crying: moving the facial muscles up, moving your lips, producing lacrimation, or some pharyngeal contractions," he says. The PLC study showed that these sites did not operate in a linear step-by-step fashion; there was another site intercepting these signals, making sure that all is well. In C.B.'s brain, it was broken.

The cerebellum, Parvizi and his colleagues suggest, normally makes sure our behavior plays appropriately in our social surroundings, deploying our lifetime of memories and learned social cues. Making sure that what would have been a shriek of laughter in the café is a soft giggle in a classroom is the cerebellum's constant chore. But

when this disciplinarian is ailing, as in some cases of PLC, behaviors can swing wild. “Here’s one example,” says Parvizi. “Normally, somebody calls the switchboard and says their name is Anderson and the switchboard knows that when Anderson calls it has to connect Anderson to Mrs. Anderson. Now in PLC, the switchboard signals to Mrs. Anderson, but unfortunately, the signal goes to Mrs. Jackson’s room. So you’re not supposed to laugh there, but you start laughing because there is this short fusing or disconnect. That switchboard glitch is happening, we think, between the inductor sites and the cerebellum.”

The evaluation in the Stanford Neurology Clinic ended. Diagnosis: Pathological Laughing and Crying because of Multiple Sclerosis. Leila was wheeled out with a prescription for a medication that will raise her brain’s emotional threshold and hopefully dampen her haphazard emotional outbursts. Parvizi and Gross leaned in on their stools, looking at each other across the space where the patient and wheelchair sat seconds ago.

“I feel for her sister, wow,” sighed Gross.

“Yeah,” agreed Parvizi, observing how the problem afflicted the family member more than the patients themselves. “She denied many times that she was sad or depressed; she actually didn’t think the outbursts were a big deal. Where as you can see on the sisters face—she’s, like, tortured anytime she sees any of this.” Gross nodded.

“She’s a severe case, severe in every sense.”

“And this is something we see over and over—,” Parvizi said, turning to me. “These patients have no problem with voluntary control of facial muscles. So the

problem isn't a lack of voluntarism. It's something much more."

"Yes. When you get these reports of PLC, its not one thing is it?" Gross remarked.

Not all patients with PLC experience the same thing, because PLC is not a disease in itself, but rather a spectrum of symptoms stemming from many possible primary disorders or accidents. Parvizi thinks that the only way to come up with better treatments and a more thorough understanding is to invent a completely new diagnostic system. He thinks that this study will be able to establish norms for these evaluations, a system for recording the patients' self-reports and those of their observers. He will interview more patients to assess their eligibility. He has begun video recording interview sessions and studying the tapes afterwards. "PLC is so hard to study because the symptoms are so fleeting. They are just lost to us forever if they aren't recorded." The videos of patients having laughing and crying attacks during seizures or other neurological disorder have become vital to his planning. They allow him to catch the subtleties in the patient's emotion and muscle control that can easily be forgotten after the patient leaves the room.

Years of studying laughing and crying and the moments our emotional reactions become derailed has led him to a knowledge that emotions are not consciously controlled cognitive tools, but rather spontaneous reactions that rely on other built-in mechanisms to be properly regulated and projected into the world. "The lesson from this is a philosophical and ethical one," Parvizi says. "It's an old notion that we regulate our behavior through a very conscious process, through an hierarchical top down process—'we shall do what is right.' By bringing in the cerebellum, what we see is that we don't

have as much conscious control over behaviors as we think.” We do not have ultimate control over how we act. Rather, we depend on the proper functioning of our involuntary brain systems so that we can make decisions, choose actions, and hide our feelings.

A nurse poked her head in the room. The doctors had run over their scheduled time.

“There are two more waiting to be seen,” Parvizi said. “By then we’ll have IRB approval for diary charting.”

“Then we’ll think about drafting...” Parvizi and Gross were checking their watches, about to get up.

“You have a lovely manner, I should say, always, with patients and their families,” Gross said.

“Ha! That’s why I like to be with you, James, you know? We always give each other compliments!” The sound of both men’s laughter cooled the air.

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And then there are individuals who, unlike those patients with PLC, are so in control of emotional expression that they can willingly propel their bodies into the involuntary displays of laughing and crying. Intimate understanding of their own emotional physiology allows them trigger or squelch emotional phenomena. As Hamlet puzzled, “Is it not monstrous that this player here, but in a fiction, in a dream of passion, could

force his soul so to his own conceit, that from her working all his visage waned, tears in his eyes, distraction in his aspect, a broken voice, and his whole form suiting with forms to his own conceit?" The exhibition of profound, genuinely tearful emotion when one really has no personal reason to feel it is the prerogative of the performer, or the "player" in Shakespeare's day. The talented performer spends hours refining and practicing the ability to laugh and cry in a matter of seconds in front of a sea of onlookers. For the actress, mastering the emotional is artistry; for the neuroscientist it is elusive science.

Antonio Damasio, neuroscientist at the University of California at Santa Barbara and Josef Parvizi's former professor, has long been determined to understand the neurobiology of emotion. He investigates how circumstances trigger emotions and how emotions then become feelings, "a privileged view into mind and body," as he calls it. He authors today's leading theory of emotion, which builds on those of the giants before him, such as Carl Lange and William James, the scholars who first noted that bodily phenomena came before the feeling of sadness or happiness, that feelings were perceptions of our body state. "Common sense says," James hypothesized in the 1890s, "we lose our fortune, are sorry and weep; we meet a bear, are frightened and run ... This order of sequence is incorrect ... the more rational statement is that we feel sorry because we cry, angry because we strike, afraid because we tremble." You do not cry because you are sad, but you feel sad because you are crying. Of course, as Damasio's more sophisticated research methods have revealed, it is a bit more complicated than that.

To distinguish between human emotion and feeling, Damasio starts at the beginning. He sees emotion as a package of survival tools that originally evolved to help

living beings navigate their environment safely, providing bodily warnings of dangerous situations. These responses later evolved to cause positive and negative feelings, which extended the impact of emotions by leaving a permanent stamp on memory. Over millions of years, this feedback process between organism and environment birthed foresight, and eventually, the human ability to respond to situations creatively.

Emotions familiar to us, such as happiness or anger, in the same way, require an initial stimulus, one that corresponds to a visual or auditory memory. These stimuli are like keys, he says, that unlock the mechanisms in the brain that trigger such behaviors as crying. Crying, laughing, trembling, or fleeing then causes the feeling of sadness, happiness, or fear. (Unless, as Parvizi's patients have illustrated, the steps in the emotional process are somehow interrupted.) "Psychologically unmotivated and "acted" emotional expressions have the power to cause feeling," Damasio writes.

"Oh yes," J.J. El-Far, a graduate student in directing at the New School for Drama in New York City told me, "That's why we call it acting."

Sheila Donio's first attempted to cry onstage was as Rizzo in *Grease* in 2001. She has acted since childhood and settled into professional acting career as a teenager in Sao Paulo, Brazil. "As I knew I wanted to cry on a specific scene," she explained, "I started to work on Rizzo's emotions at home, listening to the song used during the change from the previous scene to the crying scene. Studying Rizzo's emotions with that specific soundtrack made my brain connect one thing with the other." Method acting, techniques devised in the 1930s by Constantin Stanislavski, and later adapted by director Lee Strasberg, emphasize this kind of manipulation of sense memory. Students of this

method learn to use personal memories of sensory details to trigger authentic physiological reactions. Teaching herself, Sheila used this process to tap into the pathways of her brain responsible for the generation of emotional expression. Crying on command became second nature. “Every time I heard that song, I would start to feel her anxieties and frustrations and the buttons for crying would show up in my body, ready to be pressed.”

In 2000, Damasio and his colleagues published the results of a landmark study in the field of emotion and feeling. The research team had started the study with the goal of confirming the hypothesis that the brain only begins to process feeling after certain regions detect a shift in physiological state (emotion). The team asked forty-one participating individuals to recall a particularly vivid emotional episode of their lives, memories charged with happiness, sadness, anger, or fear. In a Positron -Emission Tomography scanner, which detects the activity in brain regions by measuring the blood flow to or away from those regions, the participant re-lived the chosen experience. As instructed, they each made a small hand movement when they began to feel the emotional impact of the personal memory.

The researchers found that brain regions dedicated to mapping bodily phenomena, like the somatosensory cortex located on the top of the brain, came on-line as soon as the person reported feeling the memory’s impact. More interestingly, the electrical monitors measuring physiological changes like sweat levels in skin, revealed drastic changes before the feeling was felt. In other words, Damasio’s team found that people raised their hand only after the emotion erupted within their bodies. It was evidence that emotional

states come before the conscious waterfall of feeling. It was also scientific confirmation of a trademark acting technique. Of course, only tears give Sheila confirmation that conjuring the emotionally tinted memory of Rizzo's song, or "pushing her buttons for crying," can activate her somatosensory cortex and trigger an emotional cascade.

Today, Sheila works for the Brandeis University theater department and performs with Playback Theatre, an international improvisational acting group. To say the least, she's matured her crying talent. "I can cry on stage in five seconds now," she said. A turning point came in 2004 when she earned the role of Norma Desmond in *Sunset Boulevard*. This time, she had to cry for pain, sadness, and happiness. Without a soundtrack this time, she switched technique. "I started to study how my body reacts when I am crying for real, in real life," Sheila told me. "It's all about breathing, for me. Try this," she instructed. "Inhale normally. Hold you breath for 2 seconds and start exhaling veeeeery slowly. Check if you feel something different, some type of energy, in your stomach. Somehow that energy comes from my stomach and gets all around me. I feel myself on the highway that leads me to cry. If I go on with the exercise, forcing a very slow exhale, I do cry. I feel sad. When I do improv theatre, this is how I find my emotions in 30 seconds," she said.

Sheila's method of manipulating her body's physiology is a living demonstration of Damasio's theory of emotion. He suggests, in a technology-age tweaking of the 1894 James-Lange theory of emotion, that feelings are not simply the perception of any body state, but rather, feelings arise from "maps" continually forming in body-sensing regions of the brain. In 2006, Damasio published another study in which he had found that for

each basic emotion, happiness, sadness, anger, and fear, there was a distinct cardio-respiratory pattern. As Sheila tailored her inhalations and exhalations, her body mapping somatosensory cortex detected the body map for crying. The feeling of sadness followed the tears. The tears amplified the feelings, creating a feedback loop. What Sheila describes as a “highway,” Damasio, who has been sketching a map of human emotion for decades, thinks of it more as a two-lane rotary.

J.J El-Far sprang from behind the director’s table, slicing a pencil into a swath of maple curls. “We are like ninety percent there, people!” she said, her wild hands accentuating every syllable. “The final thing I want to do is kind of put this last gloss on the piece, a last layer.” The eyes of the performers followed her body as she duplicated “gloss” and “layer” with a sweeping, circular gesture. “And that last layer is the paradox. It’s lifting the piece out of the sadness and playing the happiness, especially you guys. Especially you guys,” El-Far repeated slowly, using two arms to point at two actresses. Her big brown eyes traveled between the two women. “It falls a lot onto your shoulders. Also, we see it at the end, when we have this very sad song and a very, very happy dance, a joyful dance. So that’s what I am going to be looking for today, pulling out those moments, lifting the piece up with that. O.k.?”

The New School for Drama is a shiny, clean, calm-colored modern building, jutting orange flags onto a quiet side street in New York City’s West Village. Most of the practice rooms at 10:00 PM are dark, empty mirrored boxes. Except for the one from which raised, laughing voices vibrate down the hall, through the rows of lockers hanging

open, spilling binders, crumpled scripts, costume garments out onto the tiled floor. Inside, El-Far looked over the performers, some lounging in chairs, and some standing by the mirror playing with the unlit prop cigarettes. They seemed tired, but filled with residual spirit from her energized delivery.

The performance of *Smoke*, a student production about post-WWII guilt and romance, a “burnt valentine,” El-Far calls it, was three nights away and the emotional edge in a few scenes wasn’t sharp enough yet. “As a director,” El-Far told me later that night, “My job is to take the whole story and to break it down. And with an emotional thermometer, understand what temperature each of those scenes is at. What’s the hottest scene, the coldest scene? And I need to be able to get the actors there.” To gauge the emotional accessibility of the performance, she must become “the ultimate audience member” and see and feel as an audience member, over and over again, multiple times a day. This enormous ability originates from a tiny sliver of her brain. Whether she’s heard of it or not, her ‘mirror’ neuron system and those of her performers, is the mechanism enabling her nightly theatrical exchange with her performers.

For the past decade the buzz in neuroscience has been about the discovery that the visual brain enables us to experience what we see other people doing and experiencing. It all started when a macaque monkey grabbed a peanut in Parma, Italy. Vittorio Gallese and his colleagues at the University of Parma had surgically implanted electrodes into the brains of two monkeys to study the neurons that were active when monkeys grabbed and reached for food. In 1995, they accidentally discovered that neurons in the F5 area, or inferior frontal gyrus, and the inferior parietal lobule fired in the same way, not only

when the monkey picked up the nut himself, but also when he watched the researcher grabbing and eating. The monkey's brain appeared to register the movement of self and other in the exact same way. Immediately, the researchers named these active neurons 'mirror' neurons and hypothesized that the human brain might experience movement in a similar way.

The performers were taking a short break. The two women who play the mothers stood with El-Far practicing the song through which they are supposed to cry. I approached a group and broached the subject. "We're actually working on that in our Mask class," said actor Jonathan Ziese. Masking is a technique that performers practice to train their bodies to be able to express an emotional state without displaying the stereotypical response. "It's showing through your body what it is like instead of actually doing it. For example, you can't make a lip purse to show kissing. It's very much the emotion of it. Crying? It was different for each of us." He took a step back and suddenly grasped his sweater over his heart, and twisting his wrist, the fabric is dragged into a swirl. Eyes dead as stones, he slowly, slowly, slowly lowered his head until it hung limp.

"And laughing?" I plead. Ziese widened his mouth into a wide O and grabbed the hair on top of head, and in quick succession, dropped to knees, looked and pointed intensely straight ahead, slapped his leg, and squeezed his eyes closed. I could feel the muscles in my body predicting his movements. Everyone around him laughed. Emotion in acting is not all about conjuring tears through physiological manipulations and intense memories. The audience in the back row needs to recognize the crying or joyous body

just as intensely the people in the front row. That's why the performer must play to the visual brain, or the mirrors reflecting within it.

Since the discovery of the human mirror neuron network, the visual brain and its power to shape our experiences has become less of a mystery. "Mirror neurons" as units still only technically exist in macaque monkeys because it is nearly impossible to record the activity of single neurons in the human brain. But many studies have revealed that swaths of neurons in the human premotor cortex activate both when we are performing an action and watching someone else perform an action, so we have a mirror system, not single mirror neurons as of yet. Our brains can "mirror" the actions of those we watch. We have the ability to exist for a moment in others' bodies. We feel our muscles clench when we watch a figure skater twist in the air or grab our stomachs when the ball punches the goalie into the net. And our mirror neuron system could explain why we leave theater seats feeling rejuvenated, why I felt like laughing when Ziese mimicked the actions of hilarity. "That's why I say it's a living breathing thing," El-Far said. "You're never passively observing. You're part of it, you're there."

In his continuous mirror neuron system research since 1995, Gallese has found strong connections between acting and mirror neuron systems. Through working with actors, he recently illustrated the contagious nature of movement, and sound. He had a professional actor and actress perform sorrow and joy without uttering words—laughing and crying. He showed other participants silent versions of the actors' performance and recorded the movement of their facial muscles. In a second condition, the participants just heard the sound of laughing or crying. "The results are pretty interesting," he

reported at a mirror neuron conference in 2007. “If you see someone laughing, you have strong activation of your zygomatic muscle, which is active when you laugh. If you see someone crying, you have an activation of the corrugator supercili. The same results are obtained with sound.” So, whether we hear laughing or crying, or watch the actions in silence, our smiling and frowning muscles automatically begin to respond. In essence, our emotions betray us as we sit in the theater.

Sophie Scott, neuroscientist at University College of London, also studies laughter and motor neuron systems. “Running in front of that cortex is this triangle called the premotor cortex,” Scott showed me, tracing her finger along fluorescently colored image of a brain on her computer screen. “The premotor cortex has cells that are functionally responsible for complex movements, so if you stimulate that you might get something like a vocalization or a complex movement of the arm.” She was rehashing the results of a 2006 study where she and other researchers tested to see if the sound of nonverbal positive emotional sounds, like laughing, would activate the region of the premotor cortex that controls the facial expression muscles of smiling or laughing, the bright green sliver of brain on her screen.

Scott pressed ‘Play’ on her iTunes and a cacophony of laughter and shrieks, as well as gagging and groans attacked the air, causing both our faces to cringe and smile. A few years ago, these were the sound samples used in this study. Twenty subjects listened to the samples, both positive and negative emotional vocalizations, while their brains were scanned with fMRI. They were told not to move their faces. The research team analyzed the areas of brain activation, concentrating on effects of the amused

sounds. The disgust samples were only controls. A specific part of their brains, the premotor cortex that controls the muscle movements for positive facial expressions, became active when the subjects heard the delight noises, even though they were not actually smiling or laughing. These participants were experiencing other people's apparent happiness through sound alone. In essence, their brains were starting to share a laugh. "When we have social interactions we tend to mirror positive emotions," Scott explained. "Laughter is a social link. It's a very good signal that we're all in a safe environment." The team suggests that this laughter-activated mechanism in our brain helps us establish cohesive social groups. It's part of the reason why, researchers say, humans evolved into such a group-oriented species.

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Evidently, part of the reason the man in 6A started to laugh in the Lyttelton Theatre is that the cells in his supplementary motor cortex, the ones governing his zygomatic muscles, activated as he watched the characters on stage laugh and smile. But the mirror neuron system can't explain why humans *do*, at times, laugh and cry at art. That's moving into the territory of human nature, and to the everlasting question of 'what does it mean to be human?' "Such primitive social urges were built into the brain long before humans walked the face of the earth," said Panksepp. "But in humans, they also link up with much higher mental processes, thoughts and deliberations, so we can cry simply for symbolic reasons, as highlighted by much great art. We can laugh and cry based on what is happening on celluloid simulacra. No other animal does that." Celluloid simulacra, or,

material likenesses of our own lives, and the particular human response to such art, mark a separation between animal and man.

The Chauvet cavern paintings, the immortal prints of lions hunting bison and horses bowing their heads, are reflections of a primal human desire to reproduce and create meaning from the environment. These carvings may be the oldest celluloid simulacra archaeologists have found yet, but even the newest productions such as *Smoke* at the New School for Drama or *August: Osage County* are examples of that division between beings whose place in the universe goes unpondered, and beings who, around fifty thousand years ago, long before mirrors were made from glass, gained the intelligence to self reflect and an awareness of personal mortality. Somewhere along the way, we met that recognition of self with tears.

Sociobiologist Edward O. Wilson, contemplating the evolutionary origins of art and culture wrote, “Works of art communicate feeling directly from mind to mind, with no intent to explain why this occurs.” Art theorists acknowledge art’s unique power to instantaneously transmit the emotion potency of human experience. Likewise, the emotionally laden social messages transcribed in the visuals and audio of laughs and cries travel directly mind to human mind, mirror neuron to mirror neuron. Laughing and crying are a kind of living art. Involuntary emotional expression is a response to celluloid simulacra, and in the case of theatre, it is also a vehicle of mind-to-mind transmission of emotion. If there is any possibility of translating neuroscience into the language of art, this is a fluent start.

Laughing and crying share limited space in scientific literature, and only

discipline-crossing researchers like Paul MacLean draw connections between them. But bringing studies of laughing and crying side to side in a multi-disciplinary mosaic exposes a way new of thinking about ‘humanness.’ Over these past two million years, the functions of laughing and crying have changed. All prior thought suggests that separation cries and squeaks slowly evolved to carry messages of human emotion, up all the way through the evolution of language, until now, when laughing and crying pick up where words cease to be adequate. Those changing functions trace ‘humanness’ from its origins in mammal utterance and chimpanzee play panting all the way to appreciation of spiritual transcendence. Through laughter and crying, we become human.

What has stayed constant is the power of these phenomena to forge social bonds. These innate behavioral repertoires demolish racial and language boundaries, even if for a passing second. The audience member shares an emotional experience with hundreds of other people and connects, on a personal level, with reverberations of an ancient human nature. It is not a stretch to connect the laughs and cries in a theatre to the physiological expressions evolved millennia ago.

Paradoxically, blurring the physiology, evolution, and neuroscience of laughing and crying results in the clearest of mirrors. Exposed are not only the minuscule mirrors in our motor cortex, but also the mirroring that happens between performers on stage or between two people smiling as they pass on the sidewalk. Exposed is the fact that humans are wired with neurological machinery, involuntary brainstem responses that can go awry, to mediate social lives. This machinery operates without our permission, shoving our emotional natures in our faces, forcing us to reflect, and revealing our

feelings to others. Most of the time, we do not think about how any of it happens—because it is perpetually happening all around us, leaping from our throats and eyes, traveling between us, through us. There are times when angry tears permanently dissolve a relationship, or when a spiteful laugh drives mile long spikes between people. But more often, a tearful episode erases the need to apologize. A well-aimed joke sets a room on fire. And the walls come down.

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