The Man behind the Curtain: What Cognitive Science Reveals about Drawing

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I believe that in the indeterminacy of drawing, the contingent way that images arrive in the work, lies some kind of model of how we live our lives. The activity of drawing is a way of trying to understand who we are or how we operate in the world.

—William Kentridge

Hands play with torn scraps of paper. Somehow they come together to form a horse. As the thick fingers keep moving, shifting bits and pieces around, the horse is momentarily lost but reappears, again and again. We see its mane, then a leg, a tail. “I am not me, the horse is not mine,” the artist tells us. It doesn’t matter. We are made to find meaning in what we see. Now almost all the bits of paper are gone, only a few shards remain. We still see a horse. We can’t help ourselves.

The artist pulls larger torn pieces of paper out of the air. He presses them onto the wall, where they seem to meld into one another. He moves an eraser back and forth across the now whole paper as a self-portrait appears beneath his hand. It’s clear the tape is simply running backwards. The artist has first erased, then torn up, a drawing, and now he’s showing this in reverse. It doesn’t matter that we know how the trick is done. If anything our understanding seems to add to its wondrous magic: the artist has pulled his own image out of thin air. In this film, “Invisible Mending,” he has satisfied our deep desire to see something broken made whole.

William Kentridge is a magician who wants us to see the man behind the curtain. He welcomes us in. The very crudeness of his materials—torn paper, thick charcoal, and blunt eraser—exposes his tricks while at the same time providing us with a mirror to our own actions. We are made to find meaning in what we see.
time intensifying our pleasure. The catalog to a recent retrospective of his work includes a DVD with raw source material from his animated films, paired with excerpts from those films. It shows live footage of the actual hotels, cabanas, people, and cattle on the beach near Capetown, South Africa, that inspired the poetic elegy “Tide Table.”

“Tide Table” was unscripted, Kentridge tells us. He felt his way through the images as they emerged in the process of drawing. The diverse characters “wandered onto the scene in quite a blind way, and the hope is there are meetings and recognitions once they are there.” And we, his audience, feel our way along with the artist. We recognize in his work the ways we all grope in the dark for shards of meaning in our own lives, finding patterns within partial and fragmented experiences of the world around us.

Cognitive scientists explain that everything we know, we know through our bodies, which were designed by evolution to enable us to survive under an enormous range of conditions. Analogy—comparing current situations with past experiences—is a primary tool we use to navigate the environments in which we find ourselves. We explore the possible intentions and emotions of others by imagining ourselves in their place, literally simulating their actions in our own minds. Kentridge is able to engage this visceral response through his work. We feel for the old man in the beach chair in “Tide Table,” recalling his youth on that same beach. We share his pleasure when he finally gets up to pick up a stone and skip it over the waves.

Functional magnetic resonance imaging (fMRI) studies have revealed that visually perceiving a thing in the world, or simply imagining that thing lights up the same part of the brain. Harvard neuroscientist Stephen Kosslyn explains that the brain doesn’t care whether what we see is “real” or “imagined.” As we watch Kentridge perform and reveal his tricks in front of our eyes, we experience a deep sense of empathy with smudges of charcoal and eraser marks. We don’t care whether we are simply looking at charcoal smudges: we see and feel the waves. In fact, we take pleasure in our knowledge that it is only marks on paper, seeing and feeling our own minds at work.

Drawing and the New Science of Cognition

Over the past ten to fifteen years the twin fields of neuroscience and cognitive psychology have exploded. Through a number of new imaging technologies, such as fMRI and positron emission tomography (PET) scans, scientists have been able to look into the living brain in ways never before possible. What they have discovered, some of which is discussed below, may help to inspire new approaches to the practice and teaching of drawing.

The process of thinking through drawing shares characteristics common to many domains in the arts and sciences. Improvisation, analogy and metaphor, exploration and invention all have their place in a variety of creative pursuits. Yet the simplicity of marks on paper as a direct externalization
of thought makes drawing a particularly good case study of the human imagination at work. The act of drawing can be understood as the creation of a physical space to play with our thoughts outside the confines of our minds, to see and manipulate our ideas and perceptions in visible form.

During much of the past century, the brain/mind was thought of as a computation machine. The notion of mind as computer was appealing as a subject of science, especially to those in the relatively young science of cognitive psychology, which was eager to rid itself of the messy taint of human emotion. We do compute and calculate all the time. We calculate so well that we have been able to build computers that are infinitely faster and more precise than ourselves. Yet, as cognitive linguists Mark Turner and Giles Fauconnier have pointed out, certain problems in artificial intelligence have remained surprisingly recalcitrant. We figured out how to get to the moon over forty years ago, but to teach a robot to find the door in an unfamiliar room has proved surprisingly difficult.

The human mind and a computer solve problems very differently. Take your average word jumble: HICAR, for example. Can you unscramble these letters to form a common word? If so, how did you do it? A computer (if a person had written the software to make this possible) would very quickly assemble a list of the 120 possible combinations of letters. It would then compare these combinations with a list of all known words and choose as the correct answer the combination that matched a known word. Chances are, that’s not what you did. The human mind constantly approximates, invents, and imagines in ways we take for granted but that are not less miraculous for their ordinariness.

Grounded Cognition

Over the past twenty years academics and researchers from fields as diverse as linguistics, behavioral economics, art history, evolutionary biology, cognitive psychology, and neuroscience have converged on an understanding of human thought as grounded in our physical interactions with our environment. Even the most lofty and abstract concepts—such as balancing the scales of justice, or the journey of life—have their origin in bodily experience. In the film “Tide Table,” William Kentridge captures the sensation of the waves on sand in charcoal on paper and draws us into his world. The ebb and flow of the waves become the embodiment of the relationship between Europe and Africa, youth and age, life and death, played out upon the sands of time. Cognitive scientists have come to define this quality of mind as “grounded cognition.” I challenge the reader to come up with a metaphor not rooted in the body.

There are three main components of grounded cognition: modes of perception, movement, and introspection. We know the world through our modes of perception: vision, audition, smell, taste, and touch. We also
get information from the movement of our bodies in space, through direct action, and through propriaception—that is, the awareness of different parts of our bodies in relation to each other as we move. Our third source of knowledge comes from introspection, our inner awareness of bodily states and feelings. Our brains, through mechanisms still quite opaque, somehow manage to knit together a functional and unified illusion of a stable external reality through a multitude of tiny acts of attention to these three sources of information.

When we draw, we engage all three components of grounded cognition. We see, we move our hand, as we feel our way across the paper. The partial, provisional nature of our sense of reality, the “sketchiness” of much of human thought, visibly emerges beneath our hand as we struggle to make form out of experience. Anyone who has ever tried to draw from observation can attest to the difficulties of capturing a solid and convincing sense of external reality. Observational drawing can be frustrating for exactly this reason: the process itself reveals how little we really understand of what we think we see. Cognitive scientists have demonstrated what magicians (and politicians) have known for millennia: we perceive much less than we realize, and much of what we do perceive is inaccurate.

Change Blindness Blindness and the Unknown

As we know, there are known knowns. There are things we know we know. We also know there are known unknowns. That is to say we know there are some things we do not know. But there are also unknown unknowns, the ones we don’t know we don’t know. (Donald Rumsfeld, February 12, 2002)

You are walking across a college campus and someone stops and asks you for directions. In the middle of your explanation, two workmen carrying a door rudely push between you and the stranger. You may be annoyed, but after they pass, you continue with the directions. You then find out you were an unwitting participant in a psychology experiment. If you are like most people, you will be dumbfounded to learn that the person you finished giving directions to was not the person who first stopped you. In fact, differences in age and race and even gender might have slipped by unnoticed. An impressive body of experimental research on change blindness has been conducted over the past ten years or so. The phenomena of “change blindness blindness” demonstrates the metacognitive error we consistently make by overestimating our grasp on reality.

We see and remember much less than we think we do. And as Rumsfeld revealed, the “unknown unknowns” can sometimes have catastrophic consequences. Yet fortunately, most of the time the world and our bodies help us fill in the gaps. Our cognitive abilities did not evolve to provide a full and complete representation of the world around us at each moment of our
lives. Rather, they evolved from our need, as autonomous organisms, to survive and reproduce in a constantly shifting and uncertain environment. We pay attention to that which appears most salient at any given moment, constantly redirecting our attention as we figure out our next move.14 The world itself remains out there, to refer to on a “need to know” basis.

Language reflects the “need to know” economy of human cognition. Words denote categories, eliminating particular details in order to emphasize common characteristics. We understand the word “dog” on the basis of a multitude of experiences with a variety of four-legged creatures, whose commonalities of appearance and behavior (wagging tail, hanging tongue, distinctive teeth) stand out to us as salient. This kind of categorical thinking influences how we attend—or fail to attend—to certain unfamiliar aspects of a situation. Unfortunately, inattention to these “unknown unknowns” (such as an unkempt appearance that might have provided clues to an animal’s abuse or neglect) can be a problem.

Feeling Our Way: The Unknown Knowns

As Rumsfeld perhaps unwittingly (?) revealed, we are sometimes woefully blind to our own ignorance. Yet most days, we survive and thrive. There is another epistemological classification that Rumsfeld left out: the unknown knowns—those things that we know without even realizing we know them. Neuroscience has revealed dimensions of pre- and nonverbal cognition not previously considered significant. Although controversy remains, more and more research shows that much of human thought relies on mental imagery rather than words.15

What cognitive psychologists Barbara Tversky and Masaki Suwa have termed “constructive perception” enables us to see meaning in patterns, compare what we perceive at the moment to prior experience, and create complex simulations that are action oriented.16 When we draw, we construct meaning from marks and smudges on a two-dimensional surface. Through the coordinated movement of eye and hand, spatial relationships are discovered and described. We look, we make a mark, we look again. Underlying structures and configurations emerge beneath our hands. Examining the external traces of our own thoughts and perceptions, we see them anew. The physical act of drawing makes us more aware of the intricacies of our own minds, the complex interdependencies and recursive loops of perception and cognition. We learn to see the world around us with fresh eyes.

Kimon Nicolaides, an influential drawing teacher of the 1920s and 1930s (his book is still in print and in wide use today), intuited from his teaching experience what neuroscience has recently revealed: we come to understand the world through imaginatively projecting ourselves into what we see. He wrote, “you should draw, not what the thing looks like, not even what it is, but what it is doing. Feel how the figure lifts or droops . . . A drawing of
prize fighters should show the push, from foot to fist, behind their blows that makes them hurt.”

Traditionally, artists have paid a great deal of attention to capturing gesture: it makes their work vivid and alive. Gesture studies, a specific type of fast, scribbled drawing, have a long history in the quick sketches and preparatory drawings artists have used to explore ideas and solve problems for larger works. In gesture drawing the artist mimics the movements of the figures with the movement of the hand. Nicolaides reported that his beginning students were often surprised at the success of their gesture studies, that somehow they were able to capture more than they were actively conscious of noticing. This happens frequently when drawing quickly (it’s those unknown knowns). By learning to trust their hands, artists make new discoveries and inventions. As Nicolaides observed of his students’ drawings, “the gesture is a feeler which reaches out and guides them to knowledge.”

Nicolaides’s observation strikingly coincides with the latest scientific understanding of the role of the hand gestures that accompany speech. Susan Goldin-Meadow’s groundbreaking work demonstrates how gesture not only helps others understand the spoken word but helps the speaker extend his or her own conceptual reach. Goldin-Meadow first used Piaget’s conservation of volume task to look at the relationship between speech and accompanying gestures. Young children will say the same amount of water poured into two containers is different when the water level is higher in a tall container rather than a short container, even if the short container is wider. When a child conveys the same information in gesture (he indicates the height of the water in each container)—he has produced a gesture-speech match. Another child conveys the next stage of understanding through gesture (by indicating awareness of width of each container) even though she still says there is more water in the tall container. She has produced a gesture-speech mismatch. When there is a mismatch between the level of understanding expressed in speech and gesture, it is almost invariably the gesture that reflects more advanced understanding.

Goldin-Meadow proposes that gestures, which externalize thinking in a less-structured form than words, can assist a learner to “feel” her way through a difficult problem or concept. Regardless of any response from others, the gesture itself helps to form new understandings for the learner; hands sometimes know what words may not yet be able to articulate. Goldin-Meadow contends that our gestures help us imagine and invent and may open new possibilities ahead of our conscious verbalizations.

Drawing requires instantaneous coordinated movement of mind, eye, and hand. There are relatively strict rules (grammar, definitions, categories) governing the ways in which words may be used. This contrasts with the relatively unstructured improvisational nature of gesture. This may be why hand gestures and gestural sketches can exhibit more advanced understandings than the words that might accompany them. Drawings,
however, can capture the fleeting gesture, to be examined later, in the visible trace left behind.

The relationship between hand gestures (and other bodily gestures), as a rich form of expression, and drawing (the record of these gestures) is a promising area of inquiry yet to be fully explored. In his 2007 video “Taking a Line for a Walk” (a reference to Paul Klee’s 1925 Pedagogical Sketchbook), we see William Kentridge in front of what looks like a studio wall pacing back and forth, making odd and cryptic gestures, and perhaps conversing with an unseen companion. Then it becomes clear. The same video is shown again, this time overlaid by a gracefully looping and sweeping line, which seems to be formed by the artist’s previously incomprehensible gestures. Yet it obscures the image of the artist himself, who becomes less and less visible behind the swirls and smudges. The gesture questions. The questioner himself slowly vanishes. The question remains.21

The “Inarticulated Dialogue”

About twenty years ago, in Parma, Italy, scientists investigating the neural basis of hand movements, such as grasping, made a discovery that led to one of the most heralded breakthroughs in recent neuroscience. Researchers were amazed when they noticed that when a macaque monkey saw another monkey, or even a human researcher, reach for a banana, a pattern of neurons fired in its brain as if he were reaching for that same banana, even though his hands remained still. These neurons within the motor system have come to be called mirror neurons.

Although claims about human correlates to the macaque’s mirror neuron system have not been without controversy, the evidence is mounting.22 They seem to be at the root of our ability to communicate with others and understand ourselves.23 When someone tells you he feels your pain, he may indeed literally feel it. This neurological activation is strongest when we have had similar experiences to those we are observing. It has been shown that the mirror neurons of a spectator at the U.S. Open will be activated to a greater degree if she actually plays tennis herself.

We come to understand the world through imaginatively projecting ourselves onto what we see. Seventy years before Rizzolatti and colleagues discovered mirror neurons, Kimon Nicolaides exhorted, “it is necessary to participate in what the model is doing, to identify yourself with it. Without a sympathetic emotional reaction in the artist there can be no real, no penetrating understanding.”24 The macaque, like Nicolaides’s art student, understands the actions of others by imagining himself in their place. Recent evidence shows we understand the feelings of others through the mental simulation of facial expressions activated through the mirror system.25

We are hardwired to be extremely sensitive to the smallest details of the human face. The gaze of a newborn is drawn to anything that resembles a
face, and once caught, we are mesmerized by her gaze. Humans see faces everywhere: in an electric plug or a piece of toast. Once a face is perceived, we will mimic an expression unconsciously in order to comprehend it. By smiling ourselves at the sight of someone else’s smile, we stimulate that emotion in ourselves: we literally share their joy. The tail wags the dog. We smile upon seeing another person’s smile not because we are initially joyful, but because our mirror neurons urge us to do so. It is the triggering of the neurons that brings about our mirrored smile, which then causes our mood to become a happy one.

Our brains detect the significance of the most subtle nuances of shape and line in the momentary gesture of lip or eyebrow. The meanings of the myriad involuntary movements of the human face cross cultures and centuries (and perhaps even species). Making meaning from our observations of others, in order to comprehend their goals and motivations, has always been an important survival tool. Early in human evolution it was vital to distinguish whether another’s expressions and gestures signified an imminent attack or a friendly offer of food. In employing the capacity to decipher intentions, we gain insight into the inner lives of others. This may be the evolutionary basis for our own self-awareness.

Drawing seems to engage the mirror neuron system. As artist and writer John Berger describes, “to draw is not only to measure and put down, it is also to receive. When the intensity of looking reaches a certain degree, one becomes aware of an equally intense energy coming towards one, through the appearance of whatever it is one is scrutinizing . . . It is a ferocious and inarticulated dialogue.” The visceral nature of the “dialogue” experienced when drawing may reflect its primitive origins and may underlie our tendency to anthropomorphize inanimate objects. It can make even a still life or “nature morte” come alive.

Language itself may have emerged from the mirror neuron system. Animals began to use gesture as a means of communication when they developed the capacity to observe the response of other animals to their own actions. Dialogue seems to be grounded in an awareness of the other looking at us and trying to understand what we are doing and thinking. When I grimace, I understand (at some primitive level) that the person at whom I direct my expression will involuntarily mimic my grimace and come to understand I am displeased. I am communicating that I do not like what he is doing and wish him to stop. Intentional gestures, including facial expressions, signify actions, prefiguring the spoken word.

Can Words Get in the Way?

Words are abstractions based on past experiences, and as such, they can distort our current experiences in surprising ways. Would you think that the
process of verbally describing a face would help you remember it? Police, after all, routinely ask the crime victim to describe the perpetrator. Yet facial recognition can actually be impaired by verbal description. In a study by Schooler and Engstler-Schooler, subjects were shown a video of a robbery, and some of the participants were asked to describe the perpetrator while others were not. Later, those who did not provide verbal descriptions were more successful at picking out the robber in a line-up. The results have been replicated extensively across a broad range of phenomena. Visual imagery, color recognition, sound perception, and wine tasting accuracy all suffered when subjects were asked to talk through their observations too soon.

Abstract tasks, such as decision making, problem solving, and analogic thinking, might be disrupted by verbalization. In one study people were asked to read groups of stories. Some were asked to verbally discuss each story as soon as they finished it. Others read all the stories without verbally discussing them. Those who waited were better able to uncover the deeper structural similarities and relationships between the stories. Those who verbalized as they read seemed to have been distracted by incidental detail at the expense of global and analogic reasoning. Over time, through both training and experience, the effects of verbal overshadowing do tend to fade; however, meta-analysis has demonstrated the overall reliability of results showing verbal overshadowing.

One possibility may be that a novice in a particular domain will use words to focus on specific elements, or parts of the whole, rather than the relationships between the parts. Domain-specific vocabulary may help to overcome these kinds of biases as deeper levels of conceptual understanding are gained through experience. While it’s easy to say someone has a large nose, it’s more difficult to describe in words the position of the nose in relation to other facial features. This might make sense of the surprising result that verbalization can sometimes impair analogic thinking. Situations are analogous when the relations between the elements, rather than the elements themselves, are similar. Configural, rather than featural, awareness is the kind of thinking needed for analogic reasoning and successful transfer of knowledge from one domain to another.

Cognitive Error and Metacognition

The good news about verbal overshadowing is that it can be overcome through reflective practice. We can learn to think smarter. Developing metacognitive skills—the ability to detect and analyze our own thinking processes—can help us overcome many common cognitive errors. Intelligence can also be cultivated through “distributed cognition,” in other words, through the use of external supports, which can be social, symbolic, or physical.
Drawing is exactly the kind of external cognitive support that can enhance metacognition. It is a powerful tool for nonverbal inquiry, for thinking through problems and analyzing experiences. Beginning to draw, you immediately discover that you understand far less about what you see than you had assumed and that there is much more there than you had imagined. Drawing enables the drawer to see and comprehend that which is beyond words.

**Sketching as Discovery**

Unlike diagrams, drafting systems, and natural language, which differentiate phenomena into discrete categories, human thought is often continuous. Quick, gestural drawing—that is, sketching—unlike these other symbol systems, is also continuous. It emphasizes configural rather than featural information. As neuroscientist Vinod Goel explains, sketching is replete and dense. Its indeterminacies and gaps reflect the way we actually think through problems and provide openings for the new and unforeseen.36

Ambiguity is not only tolerated but cultivated by expert practitioners in order to make room for the draftsman to be surprised by her own work. Cognitive scientists have studied the drawing practices of experts who use rough sketches to inspire new design solutions. More than a mere aid to short-term memory, sketches are not just about lightening cognitive load, or even making new combinations. Sketches support radical restructuring of percepts and concepts, stimulating new analogies and leading the way to innovation and invention. Through disassembling and making new combinations, old sketches may generate new ideas.37

Psychologists often look at differences between the behavior of novices and experts in order to understand what is learned through education and experience. Gabriela Goldschmidt studied how experienced architects sketch and describes how they use an oscillating dialectic between “seeing that”—seeing what is already there—with “seeing as”—using analogic reasoning to imagine what could be.38 Suwa and Tversky define “constructive perception” as a metacognitive skill that can be honed through practice. Experts can generate new interpretations of ambiguous figures, reorganizing parts to form new wholes, and find new meanings through alternative associations or frames of reference. Openness and fluency of analogical thought seems to be gained through experience.39

Architect Marc Trieb writes, “at some point—and this is one of the miracles of drawing—the image begins to tell us more than we have projected into it; new or unrecognized relationships or ideas emerge that stimulate further creativity.”40 Experts are able to maintain an overview, resist fixation on the depiction of specific detail, and keep things open in order to wait for the surprise. Unlike the romantic ideal of the born genius, cognitive scientists are learning that it takes hard work and patience to become truly free.
Analogic Thinking and Transfer

Analogic thinking is a skill found in experts of all kinds that allows them to make connections between one domain and another. These kinds of connections are known as “transfer,” which has long been a holy grail of education and is key in teaching intelligence. Transfer is also notoriously difficult to achieve. Configural understanding distinguishes expert from novice across a range of domains: the expert visualizes the deep structures underlying his domain of expertise, whereas the novice sees only the surface details. Learning to see and visually describe configural relationships rather than superficial features is a key milestone in learning how to draw.

A promising new approach to transfer in the sciences may have important implications for the teaching of drawing. Goldstone and Wilensky have demonstrated that by emphasizing the deep structures underlying superficially different phenomena, and reducing emphasis on the superficial details, they were able to significantly improve students’ ability to transfer prior knowledge and understanding to new situations. They focused students’ attention on intrinsic complex system principles that naturally cross domains, such as positive feedback loops (affecting microphone and speaker sound production, wealth accumulation, and journal citations) and diffusion-limited aggregation (found in frost, human lungs, and cities), which occur when individual particles, moving randomly, bump into others and attach themselves, creating branch-like structures.

Goldstone and Wilensky describe complex systems researchers in terms that will sound very familiar to artists: “researchers study how relationships between elements within a system give rise to emergent properties of the system, and how the system interacts and forms relationships with its environment.” The “systems-level” perspective emphasizes configural understanding: the system as a whole has properties and organization that cannot be deduced from a consideration of the parts in isolation. The act of drawing is all about relating one mark to the next, noticing and responding to relationships as they emerge, and, through this process, developing configural awareness and exploring alternatives.

Why Draw?

Drawing as an activity gets close to being a visible external equivalent of an invisible internal process. Drawing (and all art making) is about negotiating the space between what we know and what we see.

“The Long Conscious Look: Toward a Pedagogy of Attentiveness” is the title of a 2008 lecture by Barbara Stafford, a historian of the relationship between art and science. She makes a case for “slow looking,” an antidote to the increasing automaticity of our information overloaded society. In other words, we must attend to the “unknown unknowns,” becoming more
conscious of the gaps between what we see and what we know. By slowing down, we can learn to look at what is around and outside ourselves.

As neuroscience has shown, cognition is grounded in sensory experience. Our understanding and knowledge, no matter how certain we may feel at the moment, is always partial and provisional. Through metacognition, developing an awareness of the ways we feel our way through this world, we may also learn to attend more closely to the inner workings of our own minds, our tacit knowledge, the “unknown knowns.”

Drawing helps us to “escape automaticity” and combats the “deskilling of the hand” that Stafford describes in her talk. Through drawing, we can free ourselves of preconceived notions of the world around us and correct innate perceptual distortions as we learn to see what is usually ignored. We have the opportunity to develop metacognition: the ability to notice, question, and direct our thought processes. Training the brain to draw, to engage with eye and hand, is to learn to be open to surprise, to perceive underlying structures and make unexpected connections and discoveries. In moving beyond automatic, superficial, and stereotyped responses and developing metacognitive skills like constructive perception, it is possible for those who draw to become deeper and more creative thinkers who are better equipped to solve problems across disciplines and make the leaps forward that advance all of us.

NOTES

3. Ibid.
10. The solution is CHAIR.
11. See, for example, George Lakoff and Mark Johnson, Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought (New York: Basic Books, 1999), 16–44; Dan Ariely, Predictably Irrational I: The Hidden Forces That Shape Our Decisions (New York: HarperCollins, 2008); and David Freedberg and Vittorio


18. Ibid., 14.


20. Ibid., 27.


27. Some neuroscientists, such as V. S. Ramachandran, now hypothesize that the biological origins not only of empathy but of human consciousness itself, are born from the need to decode the intentions of others. See V. S. Ramachandran, *Reith Lectures 2003: The Emerging Mind* (London: BBC, 2003), http://www.bbc.co.uk/radio4/reith2003/lecturer.shtml; also in Jean-Pierre Changeux and Antonio Damasio et al. eds., *Neurobiology of Human Values* (Heidelberg: Springer-Verlag, 2005).


32. Chin and Schooler, “Why Do Words Hurt?”


42. Perkins and Grotzer, “Teaching Intelligence.”
46. Goldstone and Wilensky, “Promoting Transfer by Grounding Complex Systems Principles.”
47. Qtd. in Rosenthal, *William Kentridge*, 244.
49. Ibid.