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NEUROHYPE
A Field Guide to Exaggerated Brain-Based Claims

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On November 11, 2007, as the 2008 U.S. presidential election was kicking into high gear, the *New York Times* ran a now infamous op-ed column "This is your brain on politics" (Iacoboni et al., 2007). The author team was led by Marco Iacoboni, a professor of psychiatry at the University of California at Los Angeles. Iacoboni and his coinvestigators hoped to harness the power of brain-imaging technology, functional magnetic resonance imaging (fMRI) in particular, to ascertain the political preferences of a sample of undecided voters. Like many proponents of the use of fMRI for real-world applications, they began with the assumption that brain-imaging data could help them discern preferences that prospective voters are either unable or unwilling to acknowledge.

"Our results reveal some voter impressions on which this election may well turn," the scientists proclaimed. As revealed by fMRI, voters' brains ostensibly displayed marked ambivalence toward Hillary Clinton; while viewing her, their anterior cingulates—which play a key role in mediating conflict—suggested that "they were battling unacknowledged impulses to like Mrs. Clinton." Mitt Romney, the team concluded, "shows potential." Participants' amygdalae—brain areas integrally involved in fear processing—became activated upon first glimpsing him but seemed to calm down upon further viewing, suggesting that voters might become more comfortable with him over time. Images of John Edwards seemed to activate voters' insulas, pointing to feelings of disgust toward him.

Of all presidential candidates, two stood out as having "work to do." These two individuals failed to provoke pronounced brain activity in most voters. Who were these two decidedly unremarkable politicians? Barack Obama and John McCain, who were soon to become their parties' candidates for president (see Satel and Lilienfeld, 2013).

Neurohype and Its Prevalence

For reasons that we will later explain, the *New York Times* op-ed was in many respects a quintessential example of *neurohype*. By neurohype, we refer to a broad class of neuroscientific claims that greatly outstrip the available evidence (see also Caulfield et al., 2010, Schwartz et al., 2016). Neurohype and its variants have gone by several other names in recent years, including neuromania, neuropunditry, and neurobollocks (Satel and Lilienfeld, 2013). Because the tendency to advance bold assertions in the absence of convincing data is often considered a cardinal indicator of pseudoscience (Lilienfeld et al., 2012), the unchecked proliferation of neurohype poses a threat to the scientific credibility of neuroscience.

Goals of the Chapter

In this chapter, we turn a much needed critical eye to neurohype. To do so, we (a) canvass its prevalence and manifestations, (b) describe its principal sources, (c) examine its dangers, (d) delineate widespread logical pitfalls that contribute to it, along with concrete examples of these pitfalls from media and academic outlets, and (e) present user-friendly tips for evaluating neuroimaging findings reported in the popular media.

In fairness, the hyping of scientific findings is hardly unique to neuroscience. In an examination of cancer news stories arising in the wake of the most recent convention of the *Annual Society of Clinical Oncology*, an author team (Abola and Prassad, 2015) uncovered no fewer than 94 news stories originating from 66 news sources that described recent findings with one or more "superlatives"—which included such terms as "breakthrough," "miracle," "cure," "revolutionary," "groundbreaking," and "marvel." In 55% of cases, these superlatives were issued by journalists covering the conference; yet about a quarter of the time, they derived from the original researchers themselves. Not surprisingly, in many or most cases, these superlatives were largely or entirely unwarranted. Half of the 36 novel medications described with superlatives had not yet received approval from the Food and Drug Administration; and 5 of these 36 medications had not yet been subjected to controlled clinical trials in humans. Such "oncohype" is hardly innocuous, as unjustified hype can easily give way to unjustified hope. Such hope can eventually engender not merely bitter disappointment but also resources that could have been better invested elsewhere. The same state of affairs, we maintain, applies to neurohype.

The Promises and Perils of Neuroscience

Before embarking on our mission, we should be explicit about what we are *not* saying. In turning a critical eye to the purveyors of neurohype, we are not implying that neuroscience as a whole is overrated (cf. Tallis, 2011). Quite the contrary. It is clear that recent findings in neuroscience have already begun to transform our understanding of such phenomena as sensation, perception, emotion, and cognition and may soon afford valuable insights into the correlates and perhaps causes of psychological maladies. Ever since President George H.W. Bush declared the years from 1990 to 2000 to be the Decade of the Brain, neuroscience has borne witness to the development and proliferation of a number of spectacular technological developments, including fMRI, magnetoencephalography, diffusion tensor imaging, optogenetics, and several others. Furthermore, recently launched endeavors, such as the BRAIN (Brain Research through Advancing Innovative Neurotechnologies) Initiative launched by Barack Obama, the European Commission's Human Brain Project, and the Human Connectome Project, hold the potential to alter and perhaps revolutionize our understanding of the structure and functioning of the human brain. The future of neuroscience is exceedingly bright.

Yet because neurohype is ubiquitous in popular culture, it may impel many laypersons, policy makers, and scientists outside of neuroscience, including psychologists, to reflexively dismiss many of the legitimate advances and promises of neuroscience. Hence, curbing the rhetorical excesses of neurohype is essential to safeguarding the scientific integrity of neuroscience. Neurohype can also render many people, including educated laypersons, vulnerable to the seductive charms of "brainscams" (Beyerstein, 1990; see "Brainscams").

Heightened vigilance toward neurohype is especially crucial in light of the increasing incursion of neuroimaging data into the courtroom (Patel et al., 2007; Satel and Lilienfeld, 2013). In a study of judicial opinions, Farahany (2016) found that mentions of neurobiological data in criminal trials climbed from about 100 per year to 250 to 300 per year from 2005 to 2012. Of these opinions, 40% were in capital cases and 60% were in cases involving serious felonies, such as violent assault, robbery, or fraud. Nearly half of the mentions of neurobiological evidence in the sentencing phase of criminal trials stemmed from defendants who charged that their attorneys were negligent in failing to investigate their potential neurological abnormality. Other data broadly corroborate these results. In 2015, U.S. president Barack Obama's bioethics commission estimated that neuroscience data, including structural brain imaging, is used in approximately one quarter of death penalty cases (Farahany, 2016). Hence, it is imperative that triers of fact not succumb to the kinds of inferential errors that can accompany interpretation of brain-based data.

The Purveyors of Neurohype

The primary purveyors of neurohype are the news and entertainment media, both of which are notorious for oversimplifying and sensationalizing scientific claims. As Gilovich (1991) noted, the media frequently engage in s*harpening* and *leveling*: salient details that are believed to capture the essence of the story are emphasized and even exaggerated (sharpening), while uninteresting details that are believed to be inessential are deemphasized or omitted (leveling). The result is often grossly distorted news coverage.

Nevertheless, we can also place a hefty chunk of the blame for neurohype at the feet of a small minority of zealous neuroscientists themselves, some of whom have been insufficiently circumspect in their claims when communicating with the media (Satel and Lilienfeld, 2013). For example, some psychiatrists have fallen prey to premature enthusiasm regarding the potential of brain-imaging techniques to inform psychiatric diagnosis and treatment. In 1984, Nancy Andreasen, one of the doyennes of American psychiatry, wrote that "as they improve and become more accurate, these imaging techniques and other laboratory tests for mental illness will become part of standard medical practice during the coming years, thereby improving the precision of diagnosis" (Andreasen, 1984, 260). That statement was made more than three decades ago. She was far from alone in her optimism. In the 1980s, many researchers were confidently forecasting that neuroimaging techniques would soon render more "primitive" diagnostic methods, such as psychiatric interviewing, questionnaires, and careful behavioral observation, obsolete. Yet 29 years following Andreasen's upbeat forecast, when the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013) was released, none of its more than 300 diagnostic criterion sets featured even a single brain-based indicator. In other cases, neuroscientists themselves have not been guilty of neurohype but have stood by idly as the news media have exaggerated their findings and conclusions.

The Prevalence and Manifestations of Neurohype

Survey data, now about a decade old, suggest that neurohype is ubiquitous, at least in the domain of functional brain imaging. In an analysis of 132 news articles published between 1991 and 2004, Racine et al. (2006) found that coverage of neuroimaging data was largely uncritical. Two thirds of the articles contained no mention of the methodological limitations of fMRI (see "Neuro-pitfalls"), and 79% were deemed to be optimistic about fMRI; only 5% referred to potential methodological challenges associated with the method.

Although we are unaware of more recent systematic surveys of neuroimaging or other neuroscience coverage in the media, anecdotal evidence—despite its undeniable evidentiary limitations (Lilienfeld, 2005)—affords ample evidence for concern regarding the prevalence of neurohype in the media. Two high-profile examples should suffice to drive this point home; we refer the reader to Jarrett (2015) for a plethora of others.

The first comes from work on oxytocin, a hormone that plays a key role in social behavior (see Lilienfeld et al., 2015). Much of this work is explicitly neuroscientific in nature, deriving in many cases from intranasal injections of oxytocin, which are purported to cross the blood-brain barrier into the central nervous system (but see Walum et al., 2015, for a critique of this body of research). More than 17,000 websites have dubbed the hormone oxytocin the "love molecule." Others have termed oxytocin the "trust molecule," "moral molecule" (Zak, 2012), or "cuddle hormone" (Griffiths, 2014). One blog posting even listed "10 Reasons Why Oxytocin Is the Most Amazing Molecule in the World" (Dvorsky, 2012).

Nevertheless, data from controlled studies demonstrate that all of these appellations are woefully simplistic (Jarrett, 2015, Shen, 2015). Most psychological and neuroscientific evidence suggests that oxytocin merely renders individuals more sensitive to social information (Stix, 2014), both positive and negative. For example, although intranasal oxytocin seems to increase within-group trust, it may also increase out-group mistrust (Bethlehem et al., 2014). In addition, among individuals with high levels of trait aggressiveness, oxytocin boosts propensities toward intimate partner violence following provocation (DeWall et al., 2014).

The second example stems from research on *mirror neurons*, a class of nerve cells in the premotor cortex that was discovered in macaque monkeys (Rizzolatti et al., 1996). Mirror neurons become activated whenever a monkey witnesses an action (say, grabbing a raisin) performed by another monkey. Not long after the discovery of these cells, a number of neuroscientists began to speculate that they had uncovered the Rosetta Stone to the secret of empathy, still one of the most mysterious of all psychological capacities. For example, at the turn of the millennium, eminent University of California at San Diego neuroscientist Vilayunar Ramachandran (2000) predicted that "mirror neurons will do for psychology what DNA did for biology; they will provide a unifying framework and help explain a host of mental abilities that have hitherto remained mysterious and inaccessible to experiments." Many other scholars proclaimed that mirror neurons were a key to unlocking the causes of autism (now termed autism spectrum disorder), invoking the so-called broken mirror theory of autism (e.g., Iacoboni, 2009), which posits that the profound cognitive empathy deficits of autism result from defects in the mirror neuron system. It was not long before the media followed suit (see Jarrett, 2015). The *New York Times* titled an article on mirror neurons "Cells That Read Minds," and a 2013 article in the U.K.'s *Daily Mail* maintained that mirror neurons help to explain why some romantic films are more successful than others.

Yet once again, research demonstrated that these expansive claims were massively overstated (Hall, 2014). Among other things, mirror neuron activity may merely reflect rather than cause motor actions (Hickok, 2014, Jarrett, 2015). Moreover, brain-imaging data provide scant support for the existence of generalized mirror neuron dysfunction in autism spectrum disorder or other conditions (Gernsbacher, 2011; Hamilton, 2013).

As can be seen in Table 16.1, the past decade or so has been witness to a parade of terms heralded by the prefix "neuro-," presented here in alphabetical order (see also Miller, 1986, for a discussion of "neurobabble"). Not surprisingly, this explosion in neuro-terms has spawned numerous parodies, with one Twitter user proposing a new field of "neurometeorology," which has capitalized on brain-imaging methods to discover that "hurricanes live in constant agony" (see https://twitter.com/thepatanoiac/status/435439436747137025). As one psychologist

Table 16.1 Selected Newly Minted Terms with "Neuro-Prefixes".

Neuroadvertising	Neuroconsulting	Neuroliterature
Neuroanalysis	Neurocriminology	Neuromagic
Neuranthropology	Neuroeconomics	Neuromarketing
Neuroaesthetics	Neuroeducation	Neurophilosophy
Neuroarcheology	Neuroethics	Neuroprofiling
Neuroarchitecture	Neurofashion	Neuropsychoanalysis
Neurobotany	Neuroforecasting	Neurosexology
Neurocapitalism	Neurogastronomy	Neurosociology
Neurocinema	Neurohistory	Neuroteaching
Neurocomputing	Neurolaw	Neurowine
Neurocosmetics	Neurolinugistic	Neurozoology

Source: Table created by authors.

observed, "Unable to persuade others about your viewpoint? Take a Neuro-Prefix—influence grows or your money back" (Laws, 2012).

The dramatic rise in the number of these terms, which reflects the insinuation of neuroscience into a myriad of traditionally unrelated domains, is not by itself a cause for concern. For example, some of these terms describe relatively new fields, such as neuroeconomics, that are scientifically promising and are already beginning to bear scientific fruit in the form of intriguing correlations between brain activation and laboratory behavior (Lowenstein et al., 2008).

For more on the neuroscientific turn in the social sciences, see Chapter 2.

In other cases, though, these "neurologisms" (itself a neologism; see http://mindhacks.com/2006/03/21/neurologism/) refer to fields whose scientific *bona fides* are at best dubious. Take neuromarketing, a relatively new discipline that purports to use brain-imaging data to discern consumers' preferences for products. The assumption, which is not entirely implausible, is that brain-imaging data can sometimes detect information about product preferences that consumers either cannot or do not wish to reveal (Ariely and Berns, 2010), either because they are largely or entirely unaware of their genuine preferences or because they are reluctant to admit these preferences to advertisers in focus groups (for example, a consumer may not want to confess to liking a gaudy piece of jewelry). Nevertheless, there is at present minimal evidence that functional brain-imaging data provide useful information about consumers' preferences above and beyond far simpler and cheaper self-reports (Jarrett, 2015, Satel and Lilienfeld, 2013; for a potential exception, see Berns et al., 2010, who found that medial temporal gyrus activation among adolescents predicted ratings of song popularity above and beyond ratings of song liking).

Brainscams

Neurohype may render many of us vulnerable to what the late neuroscientist Barry Beyerstein (1990) termed *brainscams*: commercial products that capitalize on neuroscientific assertions that are largely or entirely devoid of scientific support (see also Lilienfeld and Arkowitz, 2008). Even though many brainscams may appear innocuous, they can engender substantial indirect harm stemming from what economists term opportunity costs (see also Lilienfeld, 2007). Specifically, the time, energy, effort, and money invested in brainscams may deprive consumers of greatly needed resources to seek out and obtain better-supported diagnostic and treatment techniques.

Brainscams have a lengthy history in popular psychology. To take one example, phrenology, the pseudoscience of inferring personality by examining the pattern of bumps on people's skulls, was all the rage through much of the 19th century in the United States and Europe (Sabbatini, 1997). People of the time could stroll into a neighborhood phrenology parlor to "have their heads examined," the origin of this now-familiar phrase. The best known phrenologist, Viennese physician Franz Joseph Gall, supposedly identified 27 regions of the skull tied to specific psychological "faculties," such as aggressiveness, vanity, friendliness, and even a love of colors; later phrenologists expanded the number to 43. Phrenology made cameo appearances in the writings of Edgar Allan Poe and in Hermann Melville's masterpiece, *Moby Dick*. Thomas Edison and Ralph Waldo Emerson, among others, were devotees of phrenology who reveled in having their skull bumps measured by using a "psychograph," a metallic, spring-loaded device that clamps down on an individual's head and dutifully prints out a detailed read-out of personality traits.

The phrenology craze eventually lost momentum in the late 19th century when it became evident that patients with damage to specific brain areas didn't suffer the kinds of psychological changes that phrenologists had predicted. Even more strikingly, it became clear that enlargements in the brain did not even produce changes in skull shape, vitiating the key presupposition of phrenology. Although phrenology has been thoroughly discredited, it is apparently alive, if not well: in 2007, the state of Michigan extended its 6% sales tax to commercial phrenological services (http://blog.mlive.com/michigan/2007/10/extended_list_of_services_affe.html). As we will discover later (see "The Fallacy of Localization"), some writers (e.g., Zuger, 2013) have likened contemporary neuroimaging to phrenology, at times dubbing it "neo-phrenology." Nevertheless, this accusation reflects a misunderstanding of brain-imaging research, because all sophisticated neuroimaging investigators today regard extreme localizationism as simplistic (see Uttal, 2001, for a more sophisticated analysis).

In recent decades, brainscams in innumerable guises have become thriving business enterprises, and brain-based self-help products have been estimated to net marketers \$11 to \$12 billion annually (Gunter, 2014). This figure does not include the rapidly expanding brain-based health food market, which encompasses such brain supplements as *Ginkgo biloba* (gingko) and kava, and such drinks as Neurobliss and Neuropassion, which collectively amass another 2 billion dollars a year. The research bases for all of these products range from slim to none (e.g., see review by Gold et al., 2002, which found little compelling evidence that gingko and other purported cognitive enhancers improve memory). Among the seemingly endless gizmos marketed by the hawkers of brain-based self-help products are brain stimulation headsets, which shine light directly into the ears to enhance mood; subliminal DVDs (many of them adorned with attractive photos of human brains on their covers), which purportedly present listeners with consciously undetectable messages designed to increase their self-esteem, memory, sexual potency, breast size, or penis size; and brain tuners of various kinds, which supposedly boost people's mental capacities by modifying their brain waves (Beyerstein, 1995, Gunter, 2014). Of increasing popular interest, transcranial direct current stimulation devices (tDCS), neurostimulation headsets that use electrical currents to stimulate specific brain regions, have spawned a large do-it-yourself community on YouTube and Reddit. People can now choose from a variety of tDCS gadgets that purport to enhance attention, memory, and focus. Unsurprisingly, the efficacy of tDCS is unknown (Horvath et al., 2015).

More recently, a host of commercial products designed to enhance attention and intelligence by means of user-friendly computer games have acquired substantial traction. Perhaps the best known such product is Lumosity, a company whose website boasted 70 million members as of early 2015. Lumosity offers customers access to a variety of games intended to enhance their intellectual capacities by increasing their working memory. For many years, Lumosity's advertisements maintained that its products could delay or ward off memory-related decline and dementia. For example, the company website insisted that "healthy people have also used brain training to sharpen their daily lives and ward off cognitive decline" (Span, 2016). Yet controlled data call into question the assertion that working memory games improve intelligence (Redick et al., 2013), and there is no especially compelling evidence that they exert protective effects against memory loss. In January 2016, Lumosity agreed to a multimillion-dollar settlement with the Federal Trade Commission, which concluded that the company had engaged in misleading advertising.

The use of questionable products extends to the diagnosis and treatment of mental disorders. One of the most indefatigable entrepreneurs of inadequately validated neuroscience commercial claims is psychiatrist Daniel Amen, who is a familiar fixture on U.S. public television. In 2012, the *Washington Post* named Amen "the most popular psychiatrist in America" (Tucker, 2012), and for good reason; approximately 1,200 patients pass through his clinic doors each month. Amen purports to use single-proton emission computed tomography (SPECT), a brain-imaging technique with relatively poor spatial resolution (the ability to differentiate brain activation in one region from adjacent regions; Khali et al., 2011), to assist in the identification and treatment of attention-deficit hyperactivity disorder (ADHD), anxiety disorders, and mood disorders, Alzheimer's disease, and marital conflicts, among scores of other psychological problems. For example, Amen claims to have pinpointed a "ring of fire" pattern of over-activation on the SPECT scans of many ADHD patients, and a "lights are low" pattern of under-activation in the SPECT scans patients with mood and anxiety disorders (neither of these patterns has been supported by independent research). After performing his diagnostic workups, Amen prescribes an often dizzying array of treatments, which may include standard medications, scientifically unsupported herbal remedies, neurofeedback (brain wave biofeedback), hyperbaric oxygen therapy, and even candy bars (e.g., Brain on Joy bars) purported to enhance brain health. His claims are expansive; his website boasts 85% improvement rates compared with 30% rates from standard treatments (www.amenclinics.com/atlanta/).

After perusing his websites and other promotional materials, however, one would be hard pressed to locate any acknowledgment that Amen's principal claims are largely or entirely devoid of scientific support (Farah and Gillihan, 2012). For example, there is no good evidence that advanced brain-imaging methods, let alone SPECT, are especially helpful in the diagnosis of any mental disorders (Kapur et al., 2012), nor is there consistent evidence for the efficacy of many of Amen's recommended complementary and alternative remedies, including his herbal treatments or hyperbaric oxygen therapy (Burton, 2008, Hall, 2007).

Psychological Sources of Neurohype

There are numerous potential psychological sources underlying the appeal of neurohype and our susceptibility to brainscams; we examine the most plausible culprits here.

Fascination with the Human Brain

In many respects, the lay public's fascination with the brain is entirely understandable. The human brain is the most complex structure in the known universe (Stam and Reijneveld, 2007), so much so that the person it inhabits has a difficult time fathoming the astonishing intricacy of its own architecture and functioning. Here, for readers' consideration, is an unabashedly selective listing of fascinating facts about the "three-pound universe" (Hooper and Teresi, 1986) packed inside of our skulls (see Alban, 2016). There are:

- Approximately 12 times more neurons in our brains than there are people on Earth
- More than 100 trillion—that's 100,000,000,000,000—interconnections among our neurons
- 3.6 million miles of neurons in each of our brains
- 100,000 miles of blood vessels in each of our brains
- About 100,000 chemical reactions in our brain occurring each second

These factoids remind us that scientific truth is almost always more remarkable than is scientific fiction (see also Sagan, 1979). Although most laypersons may be unfamiliar with these specific findings, they are well aware that the human brain is capable of magnificent cognitive feats. As poet Robert Frost quipped, "The brain is a wonderful organ; it starts working the moment you get up in the morning and does not stop until you get into the office" (www.brainyquote.com/quotes/quotes/r/robertfros101173.html).

Indeed, the human brain is unrivaled in many of its capacities, such as pattern recognition and the ability to infer meaning from language. For example, as remarkably sophisticated as many computer programs are, they are no match for the human brain when it comes to drawing conclusions regarding people's mental states. Cognitive scientist Gary Marcus (2013) offers the example of a Stanford computer system, Deeply Moving, which was designed to distinguish positive from negative movie reviews. All things considered, Deeply Moving does a serviceable job; it will easily recognize "The latest Coen Brothers flick is a masterpiece" as a glowing review. But feed Deeply Moving a review that reads "Woody Allen's latest film can hardly be said to be one of its best," and it becomes hopelessly confused by the word "best," incorrectly tagging it as a positive review. Yet any bright 10-year-old can make this distinction effortlessly, easily discerning the meaning intended by the reviewer.

Implicit Dualism

It is easy to forget that throughout much of history, humans did not take for granted that the brain is the seat of consciousness. For example, prior to burial, the ancient Egyptians sometimes scooped out the brains of mummies through the nose (Finger, 2001), presuming the brain to be little more than a dispensable, gooey stuffing lodged inside of the head (we will spare the reader an illustration of this procedure). The Egyptians, like the ancient Greeks after them, believed the heart, not the brain, to be the theatre of mental activity; Aristotle famously believed the brain to be little more than a radiator that cooled the heart (Grusser, 1990). This whopping error is understandable. After all, we feel our hearts, not our brains, beating rapidly when we experience the agitation of the throes of romantic passion; and we feel our hearts, not our brains, slowing down when we are gripped with overwhelming terror.

Today, all educated persons recognize that the brain, not the heart, is the locus of psychological activity. Yet curious residues of earlier ways of thinking remain in our language and visual depictions. When we have memorized a poem or song, we say that we "know it by heart"; when we share our most intimate thoughts with a friend or loved one, we have a "heart-to-heart talk," and when we send a Valentine's Day card, the affectionate words are accompanied by a large red heart rather than a large red brain, even though the latter would be more physiologically accurate (although considerably less romantic).

These intriguing quirks of language may be developmental carryovers of our propensity to be "natural-born dualists"—to assume that the mind and brain are somehow distinct (Bloom, 2004,

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Bloom and Weisberg, 2007). Most mind–body dualists regard the mind as a nonmaterial, often spiritual entity that coexists with the brain but is distinct from it. Data demonstrate that most young children are at least partial dualists: Ask a typical preschool child if her brain is necessary to do math, and she will respond yes; yet ask her whether her brain is necessary to love her brother, and she will maintain that it is not. Although most of us largely outgrow mind–body dualism by the time we reach adulthood, subtle traces of this erroneous belief may persist in our thinking.

Furthermore, this implicit mind–body dualism may be an unappreciated source of neuroscience's intuitive appeal to the public. When laypersons read of a brain-imaging study depicting neural correlates of a psychological attribute, such as jealousy, or of a psychological condition, such as depression, they may experience surprise, even incredulity: "You mean that jealousy isn't just in the mind, but it's in the brain too?" they may ask. Of course, virtually all contemporary psychologists and neuroscientists would think such a finding to be entirely unsurprising, as they take it as a self-evident truism that all psychological attributes are instantiated in brain tissue. Yet to many members of the general public, such information may come as a revelation given that they have not fully outgrown dualistic thinking. If so, our analysis suggests an intriguing paradox. Although neuroimaging, perhaps more than any other technology, has shattered any lingering illusions of mind–body dualism, it may nonetheless draw much of its popular appeal from such dualism.

Neuroessentialism and Neurorealism

Partly underpinning the rhetorical power of neuroscience, especially neuroimaging information, may be two intertwined notions: *neuroessentialism* and *neurorealism* (Racine, 2005; Racine et al., 2010). The former, which we discuss only briefly, refers to the tendency to attribute human-like properties to the brain, an error also termed the *mereological fallacy* (Bennett and Hacker, 2007). For example, a National Public Radio story segment was entitled "How Your Brain Remembers Where You Parked the Car" (Hamilton, 2015), and a *Science Times* story was entitled "How the Brain Perceives Time" (Sanders, 2015). Both headlines imply erroneously that "people are their brains." Yet the brain *per se* can neither remember nor perceive, as these psychological capacities are performed by full-fledged organisms.

Neurorealism, which appears to be even more germane to the popularity of neurohype, refers to the often inchoate belief that brain-based information is somehow more genuine or valid than is non–brain-based information. Once we learn that an ineffable psychological capacity is "in the brain," it somehow seems to take on an objective reality that it had previously lacked. As a consequence, neurorealism may lead people to accord more credence to neuroimaging data than is warranted. Consider the following headlines:

"A Relatively New Form of Brain Imaging Provides Visual Proof That Acupuncture Alleviates Pain" (*Pain and Central Nervous System Week*, 1999)
"Placebo Effect Shown as Real Brain Reaction" (*Health News*, 2005)
"Is Hysteria Real? Brain Images Say Yes" (*New York Times*, 2006)
"This is Your Brain on Love: Are People in Couples Truly Addicted to Each Other?" (*Psychology Today Blog*, 2015)

The first headline implies that brain images are needed to demonstrate that acupuncture alleviates pain. Yet because pain is inherently subjective, this headline is misleading: The only way to know whether people experience less pain following an intervention is to ask them. Moreover, we knew that acupuncture could alleviate pain in some people many centuries before the advent of brain imaging (although most evidence indicates that acupuncture works just as well when practitioners insert the needles in the "wrong" as in the "right" acupoints, suggesting that the effects of acupuncture probably derive from placebo or other nonspecific effects). The next two headlines imply that the existence of placebo effects and hysteria was somehow in doubt prior to their verification by brain images. Yet hysteria and placebo effects are unquestionably "real," brain images notwithstanding. The final headline implies that neuroimaging data alone can ascertain whether love is an "addiction," when in fact addiction is in large measure a behavioral phenomenon marked by tolerance, withdrawal, and excessive engagement in maladaptive behavior despite adverse consequences.

To be fair, in many or most cases, researchers themselves are not responsible for these and other misleading headlines, which routinely are inserted by editors eager to spice up a scientific story. Nevertheless, such headlines underscore the need for investigators to emphasize caveats when communicating their findings to reporters.

Another striking example of neurorealism can be found in a 2014 episode of the CBS News show *60 Minutes* featuring correspondent Anderson Cooper. Cooper was interviewing neuroscientist Gregory Berns regarding his neuroimaging work with dogs. To set the stage, Cooper was asking how dog owners could ascertain whether their beloved canine companions experienced genuine affection for them. Berns, in turn, was discussing his research demonstrating that dogs display activation in the ventral striatum, a brain region linked to reward, when exposed to the smells and sights of their owners. The conversation continued:

Cooper: So just by smelling the sweat of their owner, it triggers something in a much stronger way than it does with a stranger?

Berns: Right. Which means that it's a positive feeling, a positive association.

Cooper: And that's something you can prove through MRIs? It's not just, I mean, previously people would say, "Well, yeah, obviously my dog loves me. I see its tail wagging and it seems really happy when it sees me."

Berns: Right. Now we're using the brain as kind of the test to say, "Okay, when we see activity in these reward centers that means the dog is experiencing something that it likes or it wants and it's a good feeling."

Cooper: My takeaway from this is that I'm not being scammed by my dog.

Berns: Did you have that feeling before?

Cooper: Yeah, totally. I worry about that all the time.

Cooper's comments imply that before learning about Berns' research, he could not have been certain that his dog loved him. The neurorealistic assumption here, which is dubious and empirically unsubstantiated, is that a dog's ventral striatal activation is inherently a more valid indicator of canine love than is a dog's repeatedly licking its owner, running toward and jumping up to his owner when she arrives home, wagging his tail when he sees his owner, whimpering when his owner is about to leave, and so on.

Neuroseduction

Many or all of the influences we have discussed thus far may conspire to generate *neuroseduction*: the tendency to be unduly swayed by neural images, neural explanations, or both. Chabris and Simons (2011) coined the term "neuroporn" to refer to brain-based information that can bewitch and bamboozle unwary laypersons. In an amusing albeit disconcerting demonstration of what the authors dubbed "neuroenchantment" (Ali et al., 2014), a team of investigators brought undergraduates—about half of whom were enrolled in an advanced course on neuroimaging—into the laboratory for an ostensible study of the "Neural Correlates of Thought." In fact, the "study" was bogus. Participants were seated underneath a mock scanner, which was actually the dome of an old-fashioned salon hair dryer, and were informed that the exciting new technology developed by the researchers, called "Spintronics," could read their minds. While being "scanned," participants viewed a high-tech prerecorded video displaying spinning images of three-dimensional brains, lending the nonsensical procedure a cachet of scientific credibility. Then, using a simple magic trick (a sleight of hand), the researchers duped participants into believing that the scanning technique could discern what number, color, and country they had in mind. Remarkably, 67% of participants, including 65% of those in the advanced imaging course, found the new scanning technology credible as a decoder of their innermost thoughts.

Research on neuroseduction has become something of a cottage industry in recent years. In neuroseduction studies, investigators typically supply some participants with brain images, brain-based explanations, or both (and other participants with either no information or non–brain-based information) and examine the extent to which such information renders them more likely to accept dubious or flawed scientific explanations. In this way, researchers can ascertain the extent to which neural information "seduces" participants by diminishing their critical-thinking skills, thereby rendering them vulnerable to specious claims.

The first such study, by McCabe and Castel (2008), asked participants to read scientific news articles that featured either a brain image or a simple bar graph. Despite conveying the same findings, the articles with brain images were rated as more scientifically credible than those with a bar graph. The authors took these results as evidence for brain images' power to mislead readers into assuming that a neuroscientific finding was more credible than a similar finding that did not feature a picture of the brain.

Weisberg and colleagues (2008) asked participants to rate how convincing they found either logically flawed or scientifically sound explanations of psychological findings to be. In contrast to the study by McCabe and Castel (2008), none of these explanations included brain images. Instead, the experimenters varied whether the reported finding contained the phrase "brain scans indicate" as opposed to "the researchers claim." Participants rated "explanations" that were in fact poor scientific descriptions containing a superfluous reference to a brain scan as more believable than poor explanations that did not mention the brain. Strikingly, the superfluous inclusion of neuroscience information influenced not only participants with limited scientific background but also students who had taken a college-level cognitive neuroscience course.

Together, these two widely cited studies have prompted many scholars to examine whether brain scans disproportionally enhance the credibility of scientific explanations. It is now unclear, however, whether the findings of McCabe and Castel (2008) are replicable (Farah and Hook, 2013). For example, in studies of online and college samples, Michael and colleagues (2013) failed to replicate their finding that people judge an article as more scientific when a brain image is included than when it is not.

Still, neuroseduction research has converged on a reasonably consistent finding: Although many studies have cast doubt on the seductive power of brain images alone, they suggest that the addition of superfluous references to the brain lowers people's thresholds for accepting poor explanations of scientific research (Michael et al., 2013, Weisberg et al., 2015). Furthermore, the inconsistent results of neuroseduction research may reflect the specificity of the findings to only individuals with certain beliefs.

To test this possibility, Munro and Munro (2014) asked participants to evaluate a vignette regarding a politician who suffered from a psychological ailment, which was verified either through magnetic resonance imaging (MRI) or through cognitive testing. This ailment would render him incompetent to continue serving in his position. Participants found the MRI evidence more persuasive than the cognitive testing explanation. Moreover, the preference for the neuroscience explanation was especially pronounced among those who identified with the opposite political affiliation of the politician in the vignette, presumably because they stood to benefit from the validity of the neuroscientific explanation.

In other studies, investigators have examined whether brain images, brain-based information, or both influence judgments of criminal responsibility or punishment in simulated courtroom settings. These legally oriented neuroseduction studies typically ask participants to dole out hypothetical punishment to a criminal who suffers from a psychological problem, such as schizophrenia or psychopathy. Participants read expert testimony that couches the criminal's disorder in either brain-based or psychological terms. This experimental setup allows researchers to test whether the "my brain made me do it" legal defense aids in mitigating a criminal's sentence.

Schweitzer and colleagues (2011) found that mock jurors did not lessen a hypothetical criminal's sentence when expert testimony corroborated a criminal's diagnosis with a brain image compared with a brain-based explanation lacking an image. Nevertheless, participants rated expert evidence that appealed to neurological evidence as more persuasive than evidence that relied on conventional diagnostic methods, such as interview or self-report techniques. These findings suggest that brain-based explanations may influence mock jurors' sentencing judgments compared with psychological explanations (but see Greene and Cahill, 2012, for different findings). This finding is worrisome given that mock jurors often appear to place a premium on brain-based diagnostic explanations (Aspinwall et al., 2012; Gurley and Marcus, 2008, Schweitzer and Saks, 2011).

Neuromythology

Further fueling the popularity of neurohype is the persistence of "neuromythology," the diverse collection of erroneous but widely held beliefs about the brain and the rest of the nervous system (Beyerstein, 1995, Dekker et al., 2012, Jarrett, 2015). A number of neuromyths feed on misconceptions regarding the brain's alleged untapped potential, leading people to believe that the latest brain-based portal to advanced consciousness is only one publication away.

For example, in one survey of American community residents, 72% of respondents expressed agreement with the incorrect belief—perhaps most roundly discredited by functional brain-imaging research—that we use only 10% of our brains (Chabris and Simons, 2010). Another survey revealed that this myth was held even by 6% of neuroscientists (Herculano-Houzel, 2002). The 10%-of-the-brain misconception is surely one of the most enduring and persistent of all neuromyths (Jarrett, 2015, Lilienfeld et al., 2009). For that, we have the entertainment media to thank. This myth has been promulgated by scores of popular magazine articles, television shows, and Hollywood movies, perhaps the most recent of which was the 2014 film *Lucy* (starring Scarlett Johansson), whose promotional poster featured the following teaser: "The average person uses 10% of their brain capacity. Imagine what she could do with 100%" (see Beyerstein, 1990, Jarrett, 2015, and Lilienfeld et al., 2009, for discussions of the potential origins of this myth).

A second remarkably persistent neuromyth is the "learning styles myth": the erroneous belief that students learn best when teachers match their lessons to students' preferred learning styles (Lilienfeld et al., 2009). Many of these learning styles are ostensibly rooted in differences in brain architecture, functioning, or both. For example, by virtue of their brains' constitution, some students supposedly are characterized by visual learning styles, others by verbal learning styles. Yet controlled studies offer scant support for the matching hypothesis of tailoring teaching styles to learning styles (Newton, 2015; Pashler et al., 2008). Still, in one survey, 93% of British teachers and 96% of Dutch teachers subscribed to this unsupported belief (Dekker et al., 2012). Another survey revealed that 89% of recent articles on learning styles supported the matching of teaching styles to students' learning styles (Newton, 2015).

Both of these neuromyths and a score of others, such as the unsubstantiated beliefs that (a) some of us are right-brained whereas others of us are left-brained, (b) people can achieve higher states of consciousness by boosting their production of alpha waves, and (c) neurofeedback (electroencephalogram biofeedback) can lead us to states of enlightenment, contentment, and bliss (see Lilienfeld and Arkowitz, 2008, and Jarrett, 2015, for discussions) share a central underlying theme. Specifically, they all presume that the human brain possesses considerable unused reserve that can, in principle if not in practice, be exploited by means of novel brain-based technologies. Neurohype and brainscams are the inevitable byproducts.

Neuro-Pitfalls

The misinterpretation of neuroimaging data is perhaps the most widespread and publicly visible manifestation of neurohype. Such data lend themselves to a number of inferential errors and questionable logical leaps, many of which are routinely glossed over in media reports of brain-imaging findings. Here, we examine five potential inferential and methodological pitfalls that can contribute to misinterpretations of brain-imaging data. In contrast to some of the psychological sources underlying neurohype discussed earlier, such as neurorealism, these pitfalls are especially relevant to the evaluation of brain-imaging data.

Fallacy of Localization

As noted earlier, some critics have alleged that modern brain-imaging techniques are similar in many ways to phrenology. Yet this charge is unfair, as virtually all modern neuroscientists recognize that complex, multiply determined psychological capacities, such as jealousy, prejudice, and happiness, are not restricted to single brain areas but are instead widely distributed across multiple brain networks (Satel and Lilienfeld, 2013).

Still, the fallacy of localization is routinely committed by the news media, which frequently write and speak of finding a single "region for" a psychological capacity. For example, psychologist Michael Persinger constructed a helmet—the "God helmet"—to induce religious feelings in people by stimulating their "God Spot," a putative brain region located in the temporal lobe (see Biello, 2007). Nevertheless, given that religious belief is an exceedingly complex and multiply determined psychological capacity, not to mention one that differs substantially across individuals and cultures, it is exceedingly unlikely that it is localized to a single brain area. Still other authors have spoken of "jealousy," "irony," or "humor" spots in the brain (Jarrett, 2015, Lilienfeld et al., 2015); needless to say, the research support for these regions is no more impressive than that for the God Spot. Fortunately, the localization fallacy has not gone unchallenged by neuroscientists and others: A slate of 2012 media articles trumpeted the greatly overdue demise of the idea of the "God Spot" (Jarrett, 2015, Lilienfeld et al., 2015).

Reverse Inference

Reverse inference refers to drawing conclusions regarding psychological traits or states from brain-imaging data (Poldrack, 2006; see also Krueger, in press). When performing a reverse inference, we are in essence "working backward," attempting to discern what psychological characteristic(s) of interest are revealed by the pattern of brain activity. For example, many researchers routinely assume that amygdala activation reflects fear. Reverse inference is not a logical fallacy *per se*, as it is not invariably incorrect (Ariely and Berns, 2010). At the same time, it hinges on the crucial assumption that there is a close mapping between neural activation in a brain region and certain psychological states. When this assumption is violated, all bets are off. Reverse inference is not unique to neuroimaging data, as it arises in many domains of psychology. When a personality researcher treats the response to a self-report item (e.g., "I enjoy going to parties") as an indicator of an underlying personality trait (e.g., extraversion), he or she is similarly making a reverse inference, which may or may not be correct. Examples of unbridled reverse inference—reverse inference without appropriate caveats—are, however, particularly rampant in media descriptions of brain-imaging findings.

For example, in a 2011 *New York Times* article titled "You love your iPhone. Literally," neuromarketeter Martin Lindstrom cited activation in the insular cortex in response to the sights and sounds of participants' cellular devices as evidence that people genuinely love their iPhones. Within 48 hours, *Psychology Today*, *Wired*, and *Forbes* all published articles denouncing his conclusions and attacking the *Times* for publishing them. The critics were right. Because the insula is involved in disgust as well as in feelings of passion, Lindstrom could have just as readily concluded that we are disgusted by our iPhones. Ironically, Lindstrom centered his argument on love, rather than addiction, as a "more scientifically accurate" interpretation of the insula activation, but this activation could just as readily been invoked in support of the perhaps equally dubious claim that people are addicted to their iPhones.

As another example, a 2015 *Gizmodo* article entitled "Here's What Breaking Up Does to Your Brain" did just that, positing that love and addiction are essentially the same neurological beast. Lovers and addicts, the author argued, are both marked by activation of "reward systems," ostensibly reflecting the same psychological experience of craving. Craving cocaine or missing a romantic partner are, according to the author, both "fixes" at a neurological level and therefore at the psychological level too. Dopaminergic activity in the caudate nucleus and ventral tegmental area, however, could indicate any number of diverse psychological states or processes. For example, asking for a raise and interior decorating may activate similar brain circuits, but the decisions involved are drastically different.

The inferential ambiguities associated with reverse inference bear implications well beyond the academic realm: For example, fMRI lie detection measures have become increasingly popular and may soon make their way into the legal system (Miller, 2010, Satel and Lilienfeld, 2013). These indices purport to measure whether a subject is (a) lying or (b) possesses direct experiential knowledge of a cue (e.g., the way in which a murder victim died) by detecting neural responses to those cues during an examination. Although some researchers and governments hope that this technology could one day solve cold cases or thwart terrorist plots, others fear that these tests are the heirs of the discredited polygraph ("lie detector") test and criticize the dearth of peer-reviewed publications justifying their use. Our limited ability to reliably pair brain-imaging responses with psychological correlates calls for an attitude of healthy skepticism toward technologies that purportedly detect direct involvement with a crime with 95 to 100% certainty (see Spence, 2008).

Confusing Correlation With Causation

Even the most rigorously designed and well-articulated neuroscience studies can be distorted by media reports that confuse correlation with causation. Structural or functional imaging findings, as useful as they can be, cannot allow us to draw conclusive inferences of causal linkages between brain activations and psychological states or traits. At best, they can only establish statistical associations that in turn can provide fruitful grist for the causal hypothesis mill.

For example, reduced hippocampal volume may predispose people to stress-related pathology (Gilbertson et al., 2002), but animal models demonstrate that stress can lead to cortisol-induced damage at cellular and genetic levels (Chetty et al., 2014). Hence, data linking stress to hippocampal damage are open to multiple causal interpretations. As another example, the attempted suicide of an acquaintance's 9-year-old son inspired a writer for *Everyday Health* to advise parents that screen time, along with sugar and antibiotics, can cause depression, citing a study suggesting a correlation between internet addiction and structural differences (Yuan et al. 2011). The debate continues to evolve and has taken fascinating turns, but most articles gravitate to the "X kills brain cells" model—sometimes on their own and sometimes helped along by public personalities such as British neuroscientist Susan Greenfield.

Dr. Greenfield—a senior research fellow at Oxford University, founder of a biotechnology company, and member of the House of Lords—has long argued that technology of various sorts exerts harmful effects on the brain. She has repeatedly invoked correlational studies as evidence of a causal relation between technology use and brain decay. In a 2011 *New Scientist* interview, for instance, she cited a review (Bavelier et al., 2010) as evidence that technology contributes to violence and autism spectrum disorders. Nevertheless, in the review, the authors cautioned that "the vast majority of the work is correlational in nature," which they warned poses a particular danger in this area of study given that "technology use, in particular, is highly correlated with other factors that are strong predictors of poor behavioral outcomes." They also observed that children with attentional problems may be drawn to technology given their preexisting personality traits. Yet these caveats were largely absent from Greenfield's causal conclusions.

Neuroredundancy

A fundamental desideratum for a newly developed psychological measure is *incremental validity* (Sechrest, 1963). This psychometric property refers to the ability of an assessment technique to provide predictively useful information that is not afforded by other measures, especially information that is readily and inexpensively collected. Yet most neuroimaging findings have yet to meet the fundamental challenge of incremental validity. Put in other terms, most neuroimaging findings in the applied realm run afoul of the problem of *neuroredundancy*, whereby neural data are redundant with extant behavioral data (Satel and Lilienfeld, 2013).

For example, neuromarketers nearly always assume that brain-imaging information can offer insights into consumers' purchasing preferences that are not afforded by brief questionnaires, focus groups, and the like (Morin, 2011). As we noted earlier, the evidence for this presumption is presently scant, although in fairness this is more a reflection of absence of evidence than of evidence of absence: Few researchers have examined this question systematically, so there is ample reason for caution.

Multiple-Comparisons Problem

Finally, when interpreting neuroimaging findings, it is imperative to appreciate the limitations of the data collection methods, as is the case when interpreting any scientific finding. Nevertheless, neuroimaging has breathed new life into long-discussed statistical challenges that have emerged because of the sheer size of brain-imaging datasets. These datasets are enormous because neuroimaging investigators measure brain activity in a unit called a voxel, a one- to three-centimeter cube that is analogous to a pixel on a computer screen. One voxel represents a spatial unit that encompasses millions of neurons. To determine areas of the brain that are activated beyond normal levels, researchers typically perform a statistical test on each voxel in the brain and subsequently isolate areas of the brain that exhibit enhanced or attenuated activation. The brightly colored portions of neuroimages usually depict the averaged results of these analyses across multiple individuals.

The nature of examining activity in the brain at multiple time points across thousands of voxels can generate the *multiple-comparison problem*. When conducting numerous statistical tests, the proportion of false positive (spurious) results increases substantially. A hilarious yet powerful example of this problem in action involves brain imaging and, surprisingly, a study of a dead salmon. The recipients of the 2010 Ig Nobel Prize (Bennett et al., 2009)—not to be confused with the Nobel Prize—placed a dead salmon in a scanner, asking the fish to "look at" different emotional stimuli, and then performed the typical set of statistical analyses on the fish. Not correcting for multiple comparisons yielded a nonsensical finding—the dead fish exhibited neural activity in response to the stimuli. These absurd results emerged because the researchers—to demonstrate the hazards of not correcting for multiple comparisons—had conducted more than a thousand statistical tests (as commonly done in some neuroimaging research), some of which were bound to emerge as statistically significant merely by chance. The multiple-comparisons problem, which is by no means unique to brain-imaging research, can be remedied by using analytic tools that we need not discuss in detail here.

Another important statistical challenge to bear in mind when evaluating neuroimaging work is the *circularity problem*, also a result of slippage in analysis of brain-imaging datasets. Neuroimaging researchers are rarely interested exclusively in the brain activation of certain anatomical regions: More typically, they are concerned with correlating neural activity with one or more behavioral measures, such as a depression or anxiety index. This is where the circularity problem can come into play.

In a groundbreaking but controversial paper that has largely stood the test of time, Edward Vul and colleagues (Vul et al., 2009) pointed out that many functional imaging articles report implausibly high associations (for example, correlations of .90 or above) between activation in certain brain areas and behavioral measures. In attempting to ascertain the source of these aberrantly high relations, they uncovered a serious but subtle and insufficiently appreciated methodological flaw. By first identifying a broad brain region that appears to be activated and then later homing in on that same region for more detailed analyses, investigators are "double dipping," effectively capitalizing on chance and thereby inflating the magnitudes of reported statistical associations. Fortunately, the use of unbiased data-analytic procedures and corrections for multiple comparisons can circumvent the circularity problem.

The often arcane but crucial limitations of the statistical methods involved in neuroimaging are rarely explained or discussed in popular news outlets. They are even omitted routinely in many presentations of academic research. Fortunately, constructive criticisms, such as those of Vul and his colleagues, can allow researchers and neuroscience consumers alike to become more discerning consumers of data on brain–behavior correlations. Indeed, these methodological criticisms have not only improved the quality of brain-imaging research but have played an invaluable role in combatting neurohype.

Concluding Thoughts

These are exciting times for neuroscience. Recent remarkable technical advances in neuroscience, especially functional brain imaging, are contributing significantly to our knowledge of the brain correlates of complex psychological capacities, such as cognitive processes, moods, prejudice, personality traits, and mental disorders. In the long term, they may even begin to transform

Box 16.1 A Reader's Guide to Avoiding Neurohype: 10 Simple Tips

(1) Be skeptical of the attribution of human-like attributes, such as thinking and feeling, to the brain.
(2) Avoid assuming that brain-based data are inherently more genuine or valid than behavioral data.
(3) Be skeptical of expansive claims for brain-based products in the absence of compelling evidence.
(4) Do not presume that scientific conclusions accompanied by a brain image or brain-based explanation are more valid than are scientific conclusions without such information.
(5) Be on the lookout for neuromyths, especially claims regarding the unlimited capacity of the human brain (e.g., "most people use only 10 percent of their brain capacity").
(6) Be skeptical of claims implying the localization of complex psychological capacities to single brain regions (e.g., "a spot for X," "a region for Y").
(7) Carefully evaluate assertions regarding reverse inference, bearing in mind that activations in specific brain regions almost always reflect the operation of multiple psychological capacities.
(8) Beware of causal phrases (e.g., "brain area X caused psychological capacity Y"), because functional and structural brain-imaging measures allow only for correlational, not causal, inferences.
(9) When evaluating whether a novel brain-imaging measure is ready for practical application, ask whether it is merely redundant with extant behavioral information.
(10) When evaluating media reports of brain-imaging findings, ask yourself whether the data were corrected for multiple comparisons; if this information is not presented in the report, consult the original article.

our understanding of ourselves. We are optimistic that the forthcoming decade of research in neuroscience will help to bring forth a wealth of significant new discoveries, including those regarding risk factors for psychopathology.

At the same time, neurohype in both the popular and academic arenas poses a threat to the public, as well as to the credibility of neuroscience in the public eye. Without explicit guidance for distinguishing well-supported and appropriately tempered claims regarding neuroscience from poorly supported and exaggerated claims, laypersons and even academicians without formal neuroscience training can easily fall prey to dubious proclamations, not to mention blatant pseudoscience. In Box 16.1, we offer 10 straightforward tips for resisting the seductive charms of neurohype, including brainscams and exaggerated claims derived from neuroimaging data. We hope that these tips, and more broadly the caveats presented in this chapter, will arm readers with the critical-thinking tools needed to differentiate legitimate from illegitimate claims regarding the breathtakingly complex three-pound universe between their ears.

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