American Psychologist
2016, Vol. 71, No. 1, 52–70

0003-066X/16/$12.00 http://dx.doi.org/10.1037/a0039678

The Role of Neuroscience Within Psychology: A Call for Inclusiveness Over Exclusiveness

Seth J. Schwartz
University of Miami

Scott O. Lilienfeld
Emory University

Alan Meca
University of Miami

Katheryn C. Sauvigné
Emory University

In the present article, we appraise the increasingly prominent role of neuroscience within psychology and offer cautions and recommendations regarding the future of psychology as a field. We contend that the conflict between eliminative reductionism (the belief that the neural level of analysis will eventually render the psychological level of analysis superfluous) and emergent properties (the assumption that higher-order mental functions are not directly reducible to neural processes) is critical if we are to identify the optimal role for neuroscience within psychology. We argue for an interdisciplinary future for psychology in which the considerable strengths of neuroscience complement and extend the strengths of other subfields of psychology. For this goal to be achieved, a balance must be struck between an increasing focus on neuroscience and the continued importance of other areas of psychology. We discuss the implications of the growing prominence of neuroscience for the broader profession of psychology, especially with respect to funding agency priorities, hiring practices in psychology departments, methodological rigor, and the training of future generations of students. We conclude with recommendations for advancing psychology as both a social science and a natural science.

Keywords: neuroscience, emergent properties, funding agency priorities, hiring practices, training of students

Psychology has long been a hybrid discipline, bordering on traditional social sciences such as sociology and anthropology (Hedges, 1987), on the one hand, and on biological disciplines such as neuroscience and genetics, on the other (Cacioppo, Berntson, Sheridan, & McClintock, 2000). As a consequence, it is not surprising that psychology has often been beset by intradisciplinary tensions arising from its differing and at times clashing constituencies. Reflecting these tensions, psychology has frequently suffered from an identity crisis (Henriques, 2004): Is our field primarily a social science, a natural science, or both? In recent years, this vexing question has assumed increasing urgency with the heightened emphasis on neuroscience within psychology (Miller, 2010). Yet, the broader implications of this emphasis for the future of psychology as a discipline have received relatively little attention. Our aim in this article is to begin to address this issue, which is critical for the future of our field.

From a social science perspective, psychologists have traditionally pursued such questions as the motivations underlying decisions and behavior, the correlates and causes of personality and intelligence, the nature of intergroup processes, the experiences of racial, ethnic, and cultural groups, and ways of helping employees succeed at work. Psychology has consistently been shaped by its neighboring science of biology, but our field's biological side has been acquiring increasing predominance over the past two decades. This recent shift has given several commentators, even some of those who are sympathetic to biological approaches to psy-

Seth J. Schwartz, Department of Public Health Sciences, Leonard M. Miller School of Medicine, University of Miami; Scott O. Lilienfeld, Department of Psychology, Emory University; Alan Meca, Department of Public Health Sciences, Leonard M. Miller School of Medicine, University of Miami; Katheryn C. Sauvigné, Department of Psychology, Emory University.

Katheryn C. Sauvigné is now at the Department of Psychology, Georgia State University.

We thank Milan Jelenić for the thoughtful conversations that helped to shape this article and Lauren Reinke for her help with coding job advertisements.

Correspondence concerning this article should be addressed to Seth J. Schwartz, Department of Public Health Sciences, Leonard M. Miller School of Medicine, University of Miami, 1120 NW 14th Avenue, 10th Floor, Miami, FL 33136. E-mail: sschwartz@med.miami.edu

Seth J. Schwartz

chology, considerable pause (Berenbaum, 2013; Kagan, 2013; Miller, 2010; Satel & Lilienfeld, 2013).

A number of excellent analyses have explored the conceptual hazards of adopting an overly exclusively biological approach to psychology (e.g., Kagan, 2013; Miller, 2010), and we do not intend to duplicate these efforts here. Instead, our overarching goals in this article are more applied and pragmatic compared with previous analyses. Specifically, we review ways in which funding agency priorities may be, at least to some extent, driving the acceleration of neuroscience research, and we raise a number of issues that should be considered when interpreting the relationship between neural processes and psychological or behavioral phenomena. We maintain that the trend toward a growing focus on neuroscience within psychology carries important, and often unarticulated, metatheoretical assumptions regarding the levels of analysis at which psychological phenomena are best conceived and approached. These assumptions, in turn, carry practical implications of considerable importance for the short- and long-term future of our field. We explore these implications across three major domains—hiring practices, methodological rigor, and the training and education of future generations of students. Finally, and just as importantly, we explore the optimal role of neuroscience within a complete and cohesive science of psychology. We argue that an excessively narrow emphasis on neuroscience may be problematic not only for the more traditionally "psychological" dimensions of our discipline (e.g., social, personality, cross-cultural psychology), but also for neuroscience itself. More precisely, we maintain that for neuroscientific approaches to psychology to realize their full scientific potential, they will need to make concerted efforts to establish fruitful linkages across multiple levels of analysis, including the more traditionally psychological levels, as well as to benefit from methodological advances in other domains of psychology. Hence, we contend that neuroscientific approaches to psychology must be certain not to sever their "vital blood supply" from other fields of psychology.

The Recent Expansion of Neuroscience Within Psychology: Promise and Perils

The recent changes in emphasis on neuroscience within psychology are perhaps best understood within a historical context. Throughout most of the 20th century, much of psychology unjustly neglected the neural level of analysis. The study of psychopathology is a case in point. For example, until the late 1960s, models of the etiology of schizophrenia were dominated by psychogenic explanations (e.g., the schizophrenogenic mother, family interaction patterns, life stressors) that largely ignored the biological level of explanation (see Dolnick, 1998). This nearly exclusive "sociotropic" focus (Meehl, 1972) had baleful consequences; among other things, it contributed to sending researchers down blind alleys and blaming generations of parents for a disorder for which they were not causally responsible.

In recent years, much of psychology's focus has shifted sharply toward the "biotropic" (Meehl, 1972) end of the spectrum (see Deacon, 2013). To some extent, this change appears to have been a healthy self-correction from the radical environmentalism of the early and mid-20th century (Pinker, 2003), which routinely disregarded or deemphasized biological correlates and influences. Nevertheless, the swing of the pendulum toward the "biotropic" end of the spectrum has provided ample cause for concern.

The Dangers of Fervent Monism

As Kendler (2014) observed, there are hazards to "fervent monism" of any kind in psychology and psychiatry. By fervent monism, he meant the propensity to rely too heavily on only one explanatory level in Comte's (1830-1842; see also Cole, 1983) famed hierarchy of the sciences. Foremost among these dangers is an undue neglect of explanatory levels that may be crucial for solving the riddle of highly multifaceted psychological problems such as psychopathology, aggression, divorce, intergroup conflict, and prejudice. All of these problems can probably be understood fully and remediated only by an examination of multiple levels of analysis, including the neuroscientific, the motivational, the social, and the cultural.

The most recent past president of the Association for Psychological Science, Nancy Eisenberg (2014), recently expressed similar cautions regarding fervent monism. While applauding the remarkable advances in genetics, neurosci-

Scott O. Lilienfeld

ence, and autonomic psychophysiology within psychology, Eisenberg commented with some alarm on the "increasing tendency to assume that studying genetic/neural/physiological processes is more important than research on behavior and psychological processes *per se* because biological findings will eventually explain most of human psychological functioning" (p. 1). She further voiced concerns that this propensity is increasingly evident in "the funding priorities at some of the National Institutes of Health . . . it can also be seen in the hiring patterns of many psychology departments that place a priority on hiring people who study biological processes or aspects of cognition that can be tied to neuroscience" (p. 1).

As one informal, but perhaps telling, manifestation of N. Eisenberg's (2014) concerns, a number of psychology departments have recently modified their names to underscore a focus on neuroscience (Beins, 2012). Such names include "Department of Psychological and Brain Sciences" (e.g., University of California, Santa Barbara, Johns Hopkins University, Indiana University, Dartmouth University, Boston University, University of Louisville, University of Massachusetts–Amherst) and "Department of Psychology and Neuroscience" (e.g., Duke University, Baylor University, University of Colorado at Boulder). On the one hand, these name changes apply to only a minority of psychology departments, so they hardly represent a groundswell. On the other hand, most of these name changes have occurred in the past 5 to 10 years, raising the possibility that more are on the way. Lilienfeld (2012a) noted the logical confusion exemplified by these new department names. Specifically, these names imply that neuroscience stands apart from psychology, as opposed to being one valuable approach to psychology, among many. To press the matter a bit further, imagine individuals' reactions to a department called the "Department of Psychology and Intergroup Processes" or the "Department of Psychology and Personality Research." Many people would be understandably puzzled by these names given that intergroup processes and personality research are merely two approaches to psychology, not disciplines that stand sui generis from psychology.

In many ways, the situation in contemporary psychology parallels that of our sister field of psychiatry, in which the substantial majority of research now focuses on biological correlates and putative etiological factors (Stone, Whitham, & Ghaemi, 2012). In the mid-1980s, psychiatrist Leon Eisenberg (1986) lamented that his field had gone from being largely "brainless" to being largely "mindless." By mindless, he meant a substantial neglect of the role of psychosocial factors and patients' subjective perceptions of their experiences (see also L. Eisenberg, 2000). We are concerned that psychology may be following in psychiatry's footsteps (see also Satel & Lilienfeld, 2013). To invoke an example that bears on both fields, an analysis of over 9,000 abstracts from international conferences on schizophrenia indicated that 75% of the presentations focused on biological correlates and influences, with only 5% focusing on psychosocial factors (Calton, Cheetham, D'Silva, & Glazebrook, 2009). However, research strongly suggests that life stressors play a key role in the maintenance and perhaps onset of schizophrenia, especially in the presence of a genetic predisposition (Jones & Fernyhough, 2007).

Some of the change afoot in psychology almost surely reflects a shift in scientific priorities and interests, as has happened several times in the history of our field. For example, the appeal of psychoanalysis, at least in the United States, began to fade with the increasing preeminence of radical behaviorism, and the appeal of radical behaviorist approaches in turn diminished markedly during the cognitive revolution of the 1970s (Anderson, 2004; but see O'Donohue, Ferguson, & Naugle, 2003, for a dissenting view on whether this "revolution" was a valid scientific revolution). In the last 20 years or so, we have seen psychology increasingly embrace the brain as the most important level of analysis for understanding psychological phenomena such as emotions, thoughts, mood and anxiety disorders, addictions, and social problems (Miller, 2010). Is this increasing emphasis on neuroscience, which we term the *neuroscience movement*, a scientific epoch that will come and go, much like the psychoanalytic and radical behaviorist movements of the early- and mid-20th century? Or has the neuroscience movement instead laid down roots in a way that psychoanalysis and radical behaviorism arguably did not? It is too early to tell, but there are growing indications that the effects of this movement on psychology are likely to be enduring.

Alan Meca

The Advent of Neuroimaging Technologies

Although neuroscience research within psychology has been thriving for many decades, the introduction of functional magnetic resonance imaging (fMRI) and other exciting brain-imaging tools has breathed new life into many important psychological questions, and accelerated the progress of neuroscience by providing scientists with increasingly direct access to ongoing neural events (Diener, 2010). The advent of these new neuroimaging tools has allowed scientists to further peer into the brain and has helped in identifying the neurobiological correlates of behavioral, social, emotional, and developmental processes. To be fair, many neuroscience-related fields and techniques do not rely on traditional brain imaging, such as single-neuron recording (Moxon, Leiser, Gerhardt, Barbee, & Chapin, 2004), event-related potentials (Liu, Goldberg, Gao, & Hong, 2010), optogenetics (Deisseroth, 2011), and gene-based analyses (Krumm, O'Roak, Shendure, & Eichler, 2014). The fields of behavioral (Nelson & Mizumori, 2013), cognitive (Gazzaniga, Ivry, & Mangun, 2008), and affective (Armony & Vuilleumier, 2013) neuroscience have evolved largely from an interest in identifying the neurobiological circuitry associated with human experience and behavior. In many respects, these endeavors have met with impressive success. For example, we now have a clearer sense of the damage that drugs and alcohol often inflict on the brain (Goldstein & Volkow, 2011; Zeigler et al., 2005); we have gained a better understanding of how cultural contexts and mores help to "soft-wire" the brain to react to environmental stimuli (Park & Huang, 2010); and we know much about the brain regions that are activated when individuals are asked to perform self-evaluations (Pfeifer, Lieberman, & Dapretto, 2007) and express admiration and virtue (Immordino-Yang, McColl, Damasio, & Damasio, 2009). Extremely promising and rapidly growing subfields of psychology, such as social neuroscience (Cacioppo et al., 2002) and cultural neuroscience (Kitayama & Tompson, 2010), have emerged in recent decades from the simultaneous consideration of neurobiological and experiential phenomena.

Shifts in Funding Agency Research Priorities

The neuroscience movement may be motivated by financial as well as scientific shifts. It has become increasing apparent that federal funding agencies, such as the National Institutes of Health (NIH), have been turning their focus increasingly to neuroscience research (Dorsey et al., 2006; Gewin, 2013). The four NIH institutes whose missions are most closely related to psychological research—the National Institute on Child Health and Human Development, the National Institute on Mental Health (NIMH), the National Institute on Drug Abuse (NIDA), and the National Institute on Alcohol Abuse and Alcoholism—have experienced directorship changes in the last decade that have shifted their priorities considerably toward neuroscience and other biological fields, and away from the social sciences. For example, of the four NIDA divisions, only one (epidemiology, services, and prevention) adopts a social-science focus; and of the four NIMH divisions, only one (services and intervention research) adopts a social-science focus. The remaining divisions of both institutes are focused primarily on biological approaches, most notably those in neuroscience, genetics, and microbiology. Although biological research is clearly important, care must also be taken to ensure that social-science research continues to be supported at the funding agency level.

One might contend that NIMH, in particular, has recently embraced an ethos that runs the risk of fervent monism. For example, the draft of NIMH's newest "Strategic Plan" (http://www.nimh.nih.gov/about/strategic-planning-reports/Strategic_Plan_2015_public_comment_148461.pdf) asserts that NIMH "encourages basic scientists to identify molecular or neural mechanisms of specific domains of mental function" (p. 9). Among the strategic objectives of the NIMH plan are "defining the *biological basis* of complex behaviors" (p. 15), "describing the molecules, cells, and neural circuits associated with complex behaviors" (p. 17), and "mapping the connectomes for mental illness" (p. 18). The ostensible implication here is that the psychological level of analysis will be less fruitful than the biological level for breakthroughs in our understanding of psychopathology.

Other recent NIMH initiatives have also fueled concerns regarding a disproportionate emphasis on the biological level of explanation. Several years ago, NIMH proposed the

Katheryn C. Sauvigné

Research Domain and Criteria (RDoC) as a long-term alternative to the current diagnostic manual, the *Diagnostic and Statistical Manual of Mental Disorders*, currently in its fifth edition (Insel et al., 2010; Sanislow et al., 2010). The goal of RDoC, which we believe to be potentially valuable (Lilienfeld, 2014), is to identify markers of brain circuits linked to psychobiological systems (e.g., reward systems, negative emotion systems, attentional systems) that are implicated in mental disorders. Many aspects of RDoC are clearly worthwhile, including loosening the longstanding hegemony of the *Diagnostic and Statistical Manual of Mental Disorders* over descriptive psychiatry and clinical psychology (Lilienfeld, 2014). Furthermore, in principle, RDoC and NIMH's broader initiatives are potentially consistent with a consideration of multiple levels of analysis (Sanislow et al., 2010). Indeed, the RDoC matrix acknowledges levels other than the biological and leaves room for developmental influences on behavior (Cuthbert, 2014). Although RDoC conceptualizes mental disorders as conditions marked by dysfunction in brain circuitry, it is agnostic regarding the etiology of these conditions, as well as regarding the optimal level of analysis at which to assess them.

At the same time, there are risks that RDoC, unless carefully executed, may inadvertently neglect alternative levels of analysis. Five of the eight targeted levels of analysis in the RDoC matrix for research—genes, molecules, cells, circuits, and physiology—focus largely or entirely on the biological rungs of the hierarchy, whereas only two—behavior and self-reports—focus explicitly on the psychological rungs of the hierarchy (see http://www.nimh.nih.gov/research-priorities/rdoc/research-domain-criteria-matrix.shtml). Moreover, several leading figures in the psychiatric community have described RDoC in large measure as a search for "biomarkers" (see Lilienfeld, 2014, for a discussion), suggesting that there may be a widespread perception that RDoC is privileging the search for indicators at the biological level of analysis.

The new "Strategic Plan for the National Institute on Drug Abuse" adopts a similar approach. For example, one of NIDA's goals is to "improve our understanding of brain circuits related to drug abuse and addiction at the cellular, circuit, and connectome levels" (National Institute on Drug Abuse, 2015). The implication is that addiction is a disease of the brain, and that treating this diseased neurobiology is the key to ameliorating drug and alcohol addiction (Satel & Lilienfeld, 2013). A number of critics, however, have identified problems with this brain-disease model of addiction (e.g., Hall, Carter, & Forlini, 2015). Although NIDA's focus on neuroscience is somewhat less prominent than NIMH's, the message appears to be that the NIH is focusing more and more on neuroscience and other biological levels of analysis.

These existing NIH initiatives are augmented by President Obama's new Brain Research Through Advancing Innovative Neurotechnologies (BRAIN) initiative (http://www.whitehouse.gov/share/brain-initiative), which directs research almost exclusively to developing more sophisticated technological tools to unlock mysteries at the biological levels of analysis, particularly at the neuronal level (Insel, Landis, & Collins, & The NIH BRAIN Initiative, 2013). The Obama BRAIN initiative complements the Human Brain initiative, funded by the European Commission. These two ambitious funding efforts may be well worth pursuing, although a growing cadre of scholars has expressed concerns that they may yield less long-term fruit than hoped. As cognitive scientist Gary Marcus (2014) pointed out, we will ultimately need more than advanced technologies. For genuine breakthroughs to occur, we need better theories of brain functioning and, especially, better conceptual models of how the neural and psychological levels of analysis intersect. Marcus noted that "What we are really looking for is a *bridge*, some way of connecting two separate scientific languages—those of neuroscience and psychology" (p. A17; emphasis in original). In the lingo of philosophy of science, substantial breakthroughs in many psychological domains will probably necessitate the development of "bridge laws" (De Jong, 2002; see also Lilienfeld, 2007) to connect adjacent levels of analysis (see Akiskal & McKinney, 1973, for a landmark early effort in this regard in the domain of clinical depression). For such bridge laws to be discovered, investments must be made not only in neuroscience per se but also in the crucial interfaces between neuroscience and more traditional psychological disciplines, such as social, affective, and personality psychology. These efforts, in turn, will require bidirectional cross-talk and collaboration between scholars in both neuroscience and other domains of psychology.

The Place of Neuroscience Within the Broader Discipline of Psychology: Conceptual Issues

Needless to say, the proper role of neuroscience within psychology is exceedingly complex and controversial. A delineation of several crucial conceptual issues, some of which involve metatheoretical assumptions that have often received insufficient attention within psychology, is therefore needed to frame discussions regarding the implications for neuroscience for the future of our field. We begin with reductionism, which is an essential component of the brain–behavior relationship.

Reductionism: Two Flavors

The majority of neuroscience research rests on the bedrock assumption of reductionism—the belief that all behavioral, experiential, cognitive, and emotional processes are rooted in neurobiology (Satel & Lilienfeld, 2013). Nevertheless, the relation of neuroscience to other fields of psychology hinges crucially on *which kind* of reductionism is assumed. At least two overarching types of reductionism can be distinguished: *constitutive* and *eliminative* (also termed *greedy reductionism* by Dennett, 1993; see also Fodor, 1968; Lilienfeld, 2007). These two forms of reductionism hold dramatically different implications for the role of neuroscience within psychology (Lilienfeld, 2007).

Constitutive reductionism accepts the largely uncontroversial position, which we endorse, that the brain enables the mind, and that the mind is not a spooky, immaterial essence separate from the brain. Hence, constitutive reductionists grant that the mind is what the brain (and the rest of the central nervous system) does. This view rejects substance dualism, the position that the mind and brain are materially different, but leaves open the possibility of property dualism, the position that mind and brain have different properties that coexist at different levels of analysis. In contrast, eliminative reductionism goes considerably further to contend that the brain-based level of analysis will ultimately "explain away" and subsume all of psychology. Hence, eliminative reductionists reject both substance and property dualism. From their perspective, the psychological level of analysis is, in principle, superfluous to understanding behavior, adding little or nothing to the physiological level, which will eventually "gobble up" the psychological level. In other words, the psychological level of analysis will eventually be shown to be unnecessary, and is already well on the way to being eroded by new discoveries in neuroscience.

Levels of analysis in psychology. We have referred on several occasions to the concept of different levels of analysis within psychology, but we have not yet formally explicated this concept. The levels of analysis concept is essential for an adequate understanding of eliminative reductionism (Kendler, 2005; Lilienfeld, 2007; but see Miller, 2010, for a critique of the levels of analysis view). From the levels of analysis perspective, we can conceptualize psychological phenomena from the vantage point of differing rungs on a hierarchy of explanation, ranging from the molecular and physiological levels of explanation at the lower rungs, to the cognitive, emotional, motivational, and personological levels of the middle rungs, to the social, cultural, and historical levels at the highest rungs. The traditionally "psychological levels" occupy the middle (especially) and higher rungs in the hierarchy of explanation. Furthermore, this perspective posits that all levels are needed for a complete understanding of human psychological phenomena, with differing research problems best lending themselves to different levels. For example, investigators striving to understand the causes of Alzheimer's disease will justifiably focus their efforts on the lower levels of the hierarchy; in contrast, those striving to understand the causes of marital conflict will justifiably focus their efforts at the middle and perhaps higher levels. Although there is clear evidence that psychotherapeutic interventions change brain function (which is to be fully expected from a constitutive reductionist view) and in some cases change brain structure (e.g., Matto et al., 2014), a counselor attempting to analyze a married couple's emotional conflicts would be unlikely to subject them to functional brain imaging. Rather, the counselor would be more likely to focus on the motives, conflicts, interests, and other key influences at the psychological level of analysis, that can serve as targets for intervention (Satel & Lilienfeld, 2013). Indeed, one might contend that a focus on the neural level of analysis in this case would be ill-advised, as it could distract the counselor from other, potentially more profitable, points of intervention.

Emergent properties. When understood from the levels of analysis perspective, eliminative reductionists (e.g., Searle, 2002) believe that only the lowermost rungs of explanation will ultimately be necessary to understand human behavior. Skeptics of eliminative reductionism, ourselves included, posit the existence of emergent properties (O'Connor, 1994; but see Searle, 2002, for a critique of emergent properties). Emergent properties are higher-order functions that arise from exceedingly complex interactions among lower-order properties; hence, they cannot merely be reduced to lower-order properties. For example, the phenomena of traffic and the schooling of fish are frequently cited emergent phenomena that may not be fully reducible to the lower-order behavior of the individual units (cars and fish, respectively) involved. Similarly, many psychological phenomena, such as motives, emotions, and personality traits, may be higher-order, emergent properties that are not fully reducible to the level of neural elements (Kagan, 2013). In the example of the married couple in the counselor's office, the fact that these conflicts can be mapped or imaged in the couple's brains does not obviate the need for the counselor to examine their thoughts, feelings, motives, and other higher-level psychological properties. This position is not new. Indeed, a little over a century ago, pioneering psychiatrist Adolph Meyer (1912) took issue with the "dogma of the neurologizing tautology . . . that only those facts are scientific which can be reduced to terms of nerve cells" (p. 321).

As a social science, psychology encompasses the study of such phenomena as intergroup conflicts and wars (Moshman, 2011; Tajfel & Turner, 1986), the development of personal meaning and identity (Erikson, 1950; Frankl, 1959; Steger, Kashdan, & Oishi, 2008; Vignoles, Schwartz, & Luyckx, 2011), spirituality and religiosity (Paloutzian & Park, 2008), international migration and acculturation (Sam & Berry, 2010), and sexual orientation (Savin-Williams & Ream, 2007), all of which may be emergent properties that are not readily decomposable into lower-order neural elements. Although neuroscience methods will almost certainly contribute to our understanding of these phenomena (and have already done so in some cases), an integrative science of psychology will ostensibly require expertise in and attention to emergent properties as well as to the neural processes that facilitate them.

To the extent to which the emergent properties view has merit, social-science constructs such as self-esteem, agency, well-being, and identity should be studied alongside (and in some cases, apart from) neural processes. Supporting the concept of emergent properties, Swann, Chang-Schneider, and Larsen McClarty (2007) reviewed evidence that people's views of themselves are important, and neurological evidence suggests that low self-esteem and life satisfaction predict poor cortisol regulation and hippocampal decline in adulthood (Pruessner et al., 2005). The finding that self-evaluations at the conscious level can predict biological processes at the cellular level raises questions regarding the assumption that social-science processes are expendable and that neurobiology is necessarily a first cause. As a further example, Antoni et al. (2009) found that, among women in breast cancer treatment, a cognitive–behavioral intervention to reduce anxiety was efficacious in maintaining immunologic functioning during treatment, and that reductions in anxiety mediated the effects of the intervention on immunologic outcomes. This finding illustrates that social-science processes matter and can be important markers of health.

Among humans, brain activity is clearly necessary to support agentic functioning and other aspects of consciousness—that is, that constitutive reductionism is a fundamental truism. For example, someone with an impaired prefrontal cortex cannot make reasoned decisions, and someone with hippocampal damage will experience difficulties with episodic memory. Moreover, the emergent properties hypothesis does not preclude brain activity or impairment from directly influencing conscious experience, as in the effects of oxytocin injections on feelings of closeness and attachment (e.g., Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005). The effects of psychotropic medication on anxiety and depression are also examples of how chemical changes in the brain can directly affect mood (e.g., Katzman, 2004). Nevertheless, as Beauregard (2012) inferred from his experiments, individuals can often distinguish effects that were caused by a drug or other external influence from those that the person believes to have caused on her or his own. Similarly, Baumeister (2008) found that volitional actions, such as solving puzzles, are more mentally tiring compared with "automatic" actions that are undertaken without conscious effort. To the extent to which active, volitional, deliberate actions reflect agency, some support may be provided for an emergent properties perspective (but see Pronin, Wegner, McCarthy, & Rodriguez, 2006, for an alternative view).

Psychosocial adjustment indices such as self-esteem, life satisfaction, and well-being are premised on the presence of a self that is reflexively evaluated. All of these constructs refer to introspectively posed questions such as "How am I doing in my life?" (Ryan & Deci, 2001, 2006). Such questions may reflect events that cannot be understood exclusively at the neural level of analysis. As a result, the "me" asking these questions may not be reducible entirely to neurobiological processes. Indeed, social science adjustment indices such as self-esteem are important largely to the extent that subjective experience can be separated from neurobiology. For example, self-esteem is often invoked as a mechanism through which people view their lives as having meaning and view themselves as important (see Pyszczynski, Greenberg, Solomon, Arndt, & Schimel, 2004; Zeigler-Hill, 2013). As another example, someone with low self-esteem would typically be referred to counseling or "talk therapy" only if improving self-esteem is considered a worthy outcome in its own right. Conversely, if the goal is to alter the brain chemistry associated with low self-esteem, then psychotropic medication will typically be the initial treatment of choice (Deacon, 2013; Insel, 2009). Of course, interventions, such as psychotherapy, delivered to affect emergent-property outcomes can also exert important effects on neurobiological outcomes (Linden, 2006)—suggesting that the links between neural and experiential processes are often bidirectional.

Logical Leaps in Interpreting Neural-Psychological Connections

To conceptualize the optimal role of neuroscience within psychology, careful thinking and dialogue among researchers possessing differing types of expertise will be necessary.

Nevertheless, one unappreciated hazard of eliminative reductionism may be the embrace of certain logical leaps, which often reflect a propensity to draw inferences that extend beyond one's data and the methods used to collect those data (see Satel & Lilienfeld, 2013; and Shermer, 2008, for discussions). We discuss some of these logical leaps here.

Especially with regard to neuroimaging, several logical leaps that are especially salient: (a) inferring causation from correlational evidence (Miller, 2010); (b) neuroessentialism, the assumption that neural processes are all that are needed to understand thoughts, feelings, and behavior (Haslam, 2011); (c) neurorealism, the assumption that brain imaging is an inherently more dependable and genuine source of data than are mental states (Racine, Bar-Ilan, & Illes, 2005); and (d) neuroredundancy, the failure of brain imaging data to provide information that could instead be gleaned by extant information, such as by simply asking people about their subjective experiences (Satel & Lilienfeld, 2013). Another logical challenge to the interpretation of neuroimaging data is reverse inference, the conclusion that activation in a brain area reflects an underlying psychological state (Poldrack, 2006), such as the assumption that amygdala activation in a given individual necessarily reflects fear. Although reverse inferences drawn from brain imaging data are sometimes accurate and are not logical errors per se (Ariely & Berns, 2010), they are inevitably fallible conclusions that should be invoked with caution and corroborated by means of triangulation with other data. All of these inferential leaps, some of which can contribute to error, can lead individuals to place more weight on neuroscientific data than is objectively warranted. Given that brain imaging techniques are in their relative infancy, it is entirely possible that stronger conclusions will be able to be drawn as these technologies continue to evolve. At the present time, however, more caution may be warranted when interpreting brain imaging data.

As we mentioned at the outset of this article, although neuroimaging is among the fastest accelerating and most widely known neuroscience methods, a range of other methods are also used by neuroscience researchers to understand the links between neural and behavioral or experiential phenomena. Many of these other methods focus on molecular and cellular levels of analysis (see Krumm et al., 2014; Soltesz & Staley, 2008, for examples), although many researchers who conduct work using these methods are keenly interested in spanning multiple levels of analysis, including more traditional "psychological" levels that encompass emotion and overt behavior (Gross, 2013). These approaches generally do not involve the logical leaps that we have enumerated vis-à-vis neuroimaging research. As a consequence, the reader should not interpret the caveats regarding neuroimaging that we have described as applying in equal force to all neuroscience-related methods.

Neuroseduction. Fueling the overarching concern regarding logical leaps inferred from neuroimaging studies are findings that many individuals may be susceptible to being persuaded by dubious conclusions when they are accompanied by neuroscience explanations, a phenomenon sometimes termed *neuroseduction*. For example, in a now-famous study, Weisberg, Keil, Goodstein, Rawson, and Gray (2008) found that merely inserting the words "brain scans show" can lead undergraduates (but not neuroscience researchers) to accept logically flawed explanations derived from neuroimaging studies (but see Farah & Hook, 2013, for a critique of "neuroseduction" research). In particular, nonexperts were more likely to endorse tautological (circular) explanations, such as the hypothesis that the curse of knowledge occurs "because" of frontal lobe circuitry implicated in knowledge of oneself, when these explanations contained a brief mention of neuroimaging data. In a recent study of college students, Fernandez-Duque, Evans, Christian, and Hodges (2015) reported that including superfluous neuroscience information in the descriptions of studies similarly rendered participants more likely to accept tautological explanations as logical.

As a consequence, neuroscience researchers must be especially careful to draw only those conclusions that their data can support. Overstating causal conclusions that can be drawn from neuroscience research, as in other domains of psychological research, can readily foster misunderstandings among members of the lay public (Satel & Lilienfeld, 2013). For instance, numerous studies refer to the "effects" of the neuropeptide oxytocin on human social behavior (e.g., Heinrichs & Domes, 2008; McDonald & McDonald, 2010), including parenting and interpersonal closeness, even though much of the evidence for this assertion derives from correlational data. Similarly, some authors have argued or implied that immaturity in the prefrontal cortex *causes* adolescent risk taking (Cauffman & Steinberg, 2000), or that dysfunction in the mirror neuron system is causally implicated in autism spectrum disorder (see Hickok, 2014, for a critique). Most recently, neurosurgeon Itzhak Fried has claimed that genocidal behavior is rooted largely in an interrelated set of neurobiological dysfunctions that he labels "Syndrome E" (Abbott, 2015). In other cases, the media have presented brain imaging data as implying a causal link between the size of, or activity in, certain brain structures and psychopathology. For example, a press release for a study in the prestigious British medical journal *Lancet*, which reported differences in the volume of certain brain areas in individuals with and without attention-deficit/hyperactivity disorder, proclaimed that "Brain-imaging study sheds more light on underlying cause of attention-deficit hyperactivity syndrome" (EurekAlert, 2003). Nevertheless, it is unclear whether these brain differences contribute to attention-deficit/hyperactivity disorder, result from it, or are reflections of unidentified third variables.

Mental disorders as brain diseases. Another important domain in which logical slippage has at times been evident is the framing of mental disorders. As many authors have observed (e.g., Deacon, 2013; Gustavsson et al., 2011), mental disorders are increasingly being conceptualized—in both psychology and psychiatry—as "brain diseases." For example, Thomas Insel (Insel et al., 2013; see also Insel & Cuthbert, 2015), current director of NIMH, has consistently argued that "We need to think of these [mental disorders] as brain disorders" (National Institute on Mental Health, 2013).

Although we certainly applaud the increasing incorporation of the biological level of analysis and of biological indicators in conceptualizations of psychopathology, conceptualizing mental disorders as brain diseases is both logically confused and confusing. From the standpoint of constitutive reductionism, mental disorders are necessarily brain diseases at *some level*, because all psychological phenomena, normal and abnormal, are necessarily mediated by the brain and the remainder of the central nervous system. In this respect, the assertion that psychological disorders are brain diseases is not testable; rather, this assertion is a scientifically uninteresting truism. Although mental disorders are of course brain diseases at some level of analysis, mental disorders can just as validly be regarded as psychological diseases, as the psychological level of functioning is by definition impaired in mental disorder (Wakefield, 1992). Hence, the decision to prioritize the neural level of analysis above the psychological level when conceptualizing psychopathology (e.g., Insel & Cuthbert, 2015) appears difficult to justify on logical grounds. Moreover, regarding psychological disorders exclusively as brain diseases risks confusing biological *mediation* with biological *etiology*. The fact that all mental disorders are *enabled* by brain functioning does not necessarily imply that they are *caused* by abnormalities in brain hardware (see Harre, 2002, for a discussion of the distinction between enabling and causation in neuroscience). Instead, at least some mental disorders may be largely or entirely psychosocial in etiology, although these psychosocial influences necessarily operate by exerting proximal effects on brain functioning. Further, from a clinical perspective, there is evidence that conceptualizing mental disorders as brain diseases decreases clinicians' empathy toward patients (Lebowitz & Ahn, 2014), suggesting that the "brain disease" model can have adverse impacts on clinical practice.

Neuroscience and psychological intervention. A final domain of potential concern that we address is the at times premature insertion of neuroscience into clinical and educational practice, especially psychotherapy. We view the movement to develop "brain-based psychotherapies" with ambivalence. On the one hand, we concur with authors (e.g., Barlow, 2014) who have contended that neuroscience may ultimately inform the design of effective psychotherapies. For example, the basic neuroscience of fear conditioning and extinction may assist in crafting more effective interventions for anxiety disorders (Milad, Rosenbaum, & Simon, 2014). In addition, there is preliminary but encouraging evidence that functional neuroimaging data may predict differential response to treatment (see also Craske, 2014), such as response to cognitive–behavioral therapy versus selective serotonin reuptake inhibitors in patients with major depression (McGrath et al., 2013).

On the other hand, it is presently unclear whether neuroscience offers treatment developers or practitioners much tangible guidance above and beyond what is afforded by an understanding of overt behavior, affect, and cognition alone (Andreas, 2013), suggesting that the recent trend toward brain-based therapies often runs afoul of the neuroredundancy problem (Satel & Lilienfeld, 2013). An illustration of this difficulty can be found in an article (Cappas, Andres-Hyman, & Davidson, 2005; see also Cozzolino, 2002) outlining seven principles of psychotherapy derived from basic research on neuroscience. Most or all of these principles, such as "experience transforms the brain" (Cappas et al., 2005, p. 375), "cognitive and emotional processes work in partnership" (p. 377), and "bonding and attachment provide the foundation for change" (p. 379), may possess substantial validity, but it is not clear whether any of them provide fresh insights that have not been evident to psychologists for decades. For example, the proposition that "experience transforms the brain" is unquestionably true, but it appears to do little more than recast the truism that "Experience can change behavior" in neural language. Nor does it point to novel approaches to clinical intervention.

Nevertheless, this limitation has not prevented enthusiastic advocates from developing and promoting brain-based therapies and other interventions, such as Brainspotting, which supposedly draw on basic knowledge about the brain to inform clinical interventions. For example, Brainspotting claims to use the visual field to turn the "scanner" [in the visual system] back on itself and to guide the brain to find internal information. "By keeping the gaze focused on a specific external spot, we maintain the brain's focus on the specific internal spot where the trauma is stored, in order to promote the deep processing that leads to the trauma's release and resolution" (Grand, 2013, p. 4). Nevertheless, like most brain-based treatments, Brainspotting has never been subjected to controlled experimental tests. Arguably, the deeper problem with importing neuroscience into the psychotherapy domain is that we do not presently know enough about the linkages between brain and behavior to meaningfully bridge the relevant levels of analysis in a way that could inform the design or implementation of psychological treatments.

Many of the same considerations, we might add, also apply to the premature application of neuroscience concepts to early education in the guise of "brain-based learning techniques." To take merely one example among many (Goswami, 2004), the popular educational technique Brain Gym, now used in over 80 countries, purports—among other things—to boost blood flow to the brain by massaging specific bodily regions ("brain buttons"), thereby ostensibly enhancing child learning. Nevertheless, this technique has not been subjected to controlled experimental trials, nor is it supported by biological plausibility (see Howard-Jones, 2014, for a critique).

Effects of the Neuroscience Movement on Psychological Research and Hiring Practices

Given the direction that NIMH and other federal funding agencies have taken in directing more of their funding toward neuroscience, it is important to ascertain the potential effects that these funding priorities have had on psychological researchers and on hiring practices within psychology departments. To examine these effects systematically, we collected data from two sources—an online survey of researchers in three fields of psychology and statistics on psychology job postings over a 3-year period.

Pressures on Researchers to Include Neuroscience Measures

During the fall of 2014, we conducted a brief online survey of members of three medium-to-large psychological organizations (one developmental, one social/personality, and one clinical). We did not recruit from neuroscience organizations because we were interested in the extent to which individuals from other fields of psychology would report being pressured by funding agencies to engage in neuroscience research. Messages were posted to the listservs for these three organizations. The survey was posted online for 5 weeks, and a total of 204 U.S.-based respondents provided data. Of the 204, 26 participants were excluded because they were not employed in academic institutions. The remaining 178 participants ranged in rank as follows: graduate student (15.7%), postdoctoral associate (8.8%), adjunct instructor (3.4%), assistant professor (17.6%), associate professor (10.3%), full professor (24.5%), and other professional (6.4%). Although, not surprisingly, the majority of participants were from developmental (30.9%), social/personality (14%), and clinical (32.6%) disciplines, the sample also included participants from other disciplines including cognitive (4.5%), counseling (1.7%), health (1.7%), industrial/organizational (1.1%), and quantitative psychology (1.1%).

The survey asked a number of questions related to the state of psychology as a field, but here we report data on respondents who had submitted at least one federal grant application. Specifically, of those individuals who had submitted at least one grant proposal (n = 133; 69.1% of the total sample), 16.4% indicated that they had been directly asked by a grant review committee to include neuroscientific measures in at least one proposal. In addition, 42.0% of the participants stated they have "sometimes" (15.0%), "often" (13.2%), or "always or almost always" (13.8%) felt pressured to include neuroscientific measures in their research and grant applications. To the extent to which these results are generalizable, many non-neuroscientists who are engaging in neuroscience-related research may be doing so, at least in part, due to pressure from funding agencies. One limitation of our survey data is that we cannot ascertain how often the recommendations of grant review committees to include neuroscience measures were scientifically legitimate. Nevertheless, our findings raise the distinct possibility that perceived funding agency priorities and directives toward neuroscience research may be driving the design of psychological research, perhaps in many cases unduly so.

Analysis of Psychology Department Hiring Trends

Using past issues of the *American Psychological Association Monitor*, we compiled a list of all tenure-track or tenured faculty positions advertised in psychology departments in "very research-intensive universities" (see http://classifications.carnegiefoundation.org/) during calendar years 2011, 2012, and 2013, the 3 full years in which advertisements from back issues of the *Monitor* were available during the summer of 2014 (when the coding was conducted). We selected "very research intensive universities" because these are the institutions most likely to require or strongly encourage faculty to submit grant applications. Duplicate advertisements (i.e., instances in which the same advertisement was posted during multiple months) were analyzed only for the first month in which they appeared. Lecturer, postdoctoral, and research associate positions were excluded from our analysis.

The third author and a trained research assistant coded each advertisement in terms of the extent to which the position was targeted toward each of several subfields of psychology (clinical, cognitive, developmental, social/personality, neuroscience, counseling, and quantitative). For each advertisement, coders indicated, on a 4-point scale, whether each subfield was not mentioned (0), listed as one of several potential target areas (1), preferred (2), or required (3). A reliability check between the two coders, estimated using the 2013 advertisements, indicated agreement rates ranging from 87% to 100% in terms of the extent to which each subdiscipline was not referenced, mentioned, preferred, or required for each position.

We report results in terms of advertisements in which each subfield was required, encouraged, and/or mentioned (see Table 1). Neuroscience was among the most prevalent subfields in all 3 years, especially in 2013, although clinical was also prominent. The representation of neuroscience within psychology job advertisements increased from 40% in 2011 and 33% in 2012% to 50% in 2013, whereas the representation of clinical remained fairly steady across years (between 33% and 40%). Cognitive and neuroscience fluctuated together across the 3 years, with no greater than 3 percentage points separating the two categories in any of the 3 years. This trend may be reflective of a hiring trend involving new variants of cognitive neuroscience, such as computational cognitive neuroscience (Gros, 2009). Social/personality also increased from 24% in 2011% to 29% in 2012% to 48% in 2013, perhaps at least in part reflecting the increasing prominence of social neuroscience (e.g., Cacioppo & Decety, 2011; Ochsner & Gross, 2008). Within positions referencing, preferring, or requiring neuroscience expertise, neuroimaging was at least mentioned in 22% of advertisements in 2011, 50% of advertisements in 2012, and 44% of advertisements in 2013.

These statistics suggest that faculty hiring in neuroscience occupies a prominent role in psychology departments, with positions including a neuroscience emphasis accounting for one third to half of faculty lines in recent years (and with neuroimaging positions accounting for up to half of faculty lines in the neuroscience category). Whether this trend is healthy or unhealthy for our field is a legitimate topic of debate. To the degree to which neuroscience research is interdisciplinary, this trend may be viewed to some extent as expanding or supplementing, rather than replacing, other areas of expertise. In contrast, decreasing the emphasis on hiring faculty in nonneuroscience fields of psychology may in some cases be problematic, especially if neuroscientists in certain psychology departments do not have a sufficient number of potential collaborators in other domains (e.g., social psychology, personality, developmental psychology, cross-cultural psychology) to forge meaningful connections in their research across diverse levels of analysis.

Table 1
Percent of Advertisements in Which Subfields Were Required, Encouraged, and/or Mentioned

Subfield	2011 Advertisements	2012 Advertisements	2013 Advertisements
Neuroscience	39.7%	33.3%	50.0%
Social/Personality	24.1%	29.2%	47.8%
Developmental	27.6%	19.8%	41.3%
Cognitive	41.4%	30.2%	50.0%
Clinical	39.7%	33.3%	37.0%
Quantitative	22.4%	20.8%	17.4%

Along with research programs undertaken by individual researchers, hiring priorities and decisions hold substantial implications regarding which subfields of psychology will be allowed to flourish. In turn, new faculty hires will be training future generations of students. Moreover, the breadth versus narrowness of candidates who are hired will shape the breadth versus narrowness to which future generations of students will be exposed and with which they are trained. If the percentage of tenure-track psychology faculty lines geared toward neuroscientists continues to increase, the risk is that we may witness a gradual atrophying of other subfields as individuals working in these subfields age, retire, and are not replaced with new hires working in the same or similar areas. Hence, these statistics merit further thoughtful investigation and discussion by psychology faculty members and administrators.

Methodological Rigor and Implications for Methodological Training

The neuroscience movement may also hold implications for the conduct and methodological rigor of research in psychology. One might legitimately contend that our unmatched capacity to design, conduct, analyze, and interpret behavioral research is what makes psychology unique as a discipline (Lilienfeld, 2012b). Heretical as it may appear to ask, might the heightened focus on neuroscience diminish our field's distinctive contribution in this regard?

Statistical Power and Replicability in Neuroscience Studies

Although statistical power has been a concern in many areas of psychology for several decades (Cohen, 1962; Rosnow & Rosenthal, 1989), recent concerns regarding the replicability of findings in medicine, psychology, and other fields (Ioannidis, 2005; Pashler & Wagenmakers, 2012) have sensitized psychological researchers to the need to ensure that studies are adequately powered. It is commonly understood that underpowered studies may be less likely than adequately powered studies to detect genuine effects. What appears to be less well known is that, when positive results do emerge from underpowered studies, they are more likely than results from adequately powered studies to be statistical flukes, a phenomenon known as the "winner's curse" (Button et al., 2013). For example, Forstmeier and Schielzeth (2011) found that, when using generalized linear modeling techniques with small sample sizes ($N \leq 50$), Type I error rates may be as high as 60% if interaction terms are included in the model. Those authors found that this Type I error inflation is most likely due to overestimation of effect sizes. By definition, findings based on Type I errors should not be replicable.

These considerations are relevant to ongoing debates concerning the role of neuroscience in psychology, because many human neuroscience studies, especially those in the field of neuroimaging, are severely underpowered. Button et al. (2013) found that the average post hoc statistical power of neuroimaging studies was approximately 8% (one tenth of the standard 80% that is considered desirable as a lower bound for statistical power; Cohen, 1988), and the average post hoc statistical power for human neuroscience studies in general was approximately 18%. Along with low sample sizes, high levels of measurement error are another potential challenge for the statistical power of neuroimaging studies. In a review of imaging studies, Bennett and Miller (2010) reported that the test-retest reliabilities of fMRI measures were generally modest, with intraclass correlations averaging .50. These reliabilities would not typically be deemed acceptable for standard psychological measures such as questionnaires or interviews. Given NIMH's ambitious agenda, and given its current director's expressed stance that "we can understand mental disorders as developmental brain disorders . . . [where] recent research hints at the heterogeneity of mental disorders at the level of genes and brain circuits" (Insel, 2009, p. 130), it is critical that research conducted to implement this agenda and test these propositions be adequately powered and replicable.

Exacerbating concerns regarding the winner's curse in neuroscience is a review (Jennings & Van Horn, 2012) suggesting that the neuroimaging literature is characterized by positive publication bias, such that studies that do not support linkages between brain activation patterns and either behavior or subjective experience are considerably less likely than other studies to be accepted for publication. If so, the linkages between neural correlates and psychological phenomena—and the contention that neural processes underlie psychological processes—may be weaker in magnitude than often assumed. In fairness, however, the problem of positive publication bias within psychology is hardly unique to neuroscience (Ferguson & Brannick, 2012).

Further, if researchers are to be pressured by grant review committees to engage in neuroscience research, and if psychology departments are increasingly directing their tenure-track faculty lines toward neuroscientists, then the level of methodological rigor of research in this area, especially the statistical power of empirical studies, must increase. One means of accomplishing this goal is to strongly encourage collaboration across neuroimaging laboratories that use a common methodological protocol (see Poline et al., 2012). This approach is not a panacea, in part because variations across fMRI laboratories account for about 8% of the variance in blood oxygen-level dependent signal results (Costafreda et al., 2007). Another investigation found that the median intraclass correlation of fMRI findings across imaging centers that used the same hardware configurations was only .22 (Friedman et al., 2008). These formidable methodological challenges notwithstanding, data sharing procedures across laboratories will be necessary steps toward boosting statistical power and thereby diminishing the risk of both false negative findings and the winner's curse.

Training of Students

The breadth of psychology as a field has traditionally been an advantage for students, in that there are many potential areas and subfields from which to choose. Psychology is applicable to the school system, the legal system, intergroup processes, the workplace, the family, inpatient and outpatient psychological clinics, medical settings, the armed forces, and many other arenas. A wide variety of disciplinary and theoretical approaches can be drawn upon to address problems in these and other settings, providing a rich array of opportunities for students to receive training and seek employment. For example, students seeking to study the workplace can adopt a social, clinical, developmental, or legal psychology perspective and can choose from among a diverse array of theoretical and metatheoretical orientations.

The increasing biologization and medicalization of our field poses a challenge in this regard. One often-overlooked implication of the recent neuroscience movement within psychology concerns the training of students, particularly graduate students. As we noted earlier, the trend toward hiring more faculty members with neuroscience interests almost certainly decreases the number of faculty lines available in other areas. If taken to an extreme, this movement has the potential to constrict the range of areas in which students receive training. If sufficient numbers of faculty members are not hired in areas related to potential emergent-property phenomena, such as adolescent peer affiliations and the intergroup processes responsible for political conflict, there is a risk that graduate students would not be exposed to the sufficient breadth of training that they need to understand, appreciate, and master the broader subject matter of psychology. As a consequence, opportunities to train students for careers in these areas—either within or outside academia—may erode along with them. If emergent-property areas are deemphasized, students may lose opportunities to be trained in methodological approaches (e.g., psychometrics) and conceptual foundations (e.g., the phenomenology of emotion) that lie at a largely psychological level of analysis.

An interrelated concern relates to graduate training in methodology and statistics. As observed earlier, this concern has taken on renewed importance with the recognition that many findings in psychology, including neuroscience, may be less replicable than previously assumed (Pashler &

Wagenmakers, 2012). This may even be true in domains often assumed to be highly replicable, such as structural brain imaging research (Boekel et al., 2013). Indeed, given the well-documented problems with replicability in biologically and medically based research (Dwan et al., 2008; Ioannidis, 2008), and given that the NIH is now emphasizing the replicability of scientific research (Collins & Tabak, 2014), it is essential that students in all fields of psychological science be trained in the most rigorous scientific and statistical methods.

We therefore sought to obtain a sense of the extent of methodological and statistical training that neuroscience graduate students are receiving in psychology departments, relative to the extent of such training obtained by students in other subfields of psychology. We identified the top 50 universities as ranked by *U.S. News and World Report* where a neuroscience doctoral program was housed within a psychology department, and in which a social/personality psychology doctoral program (where social/personality psychology is known for rigorous methodological training; Smith & Harris, 2006) was also available. We contacted the program directors for these doctoral programs and asked for the number of methodological and statistics courses required for each program. Of the 50 programs that we contacted, 32 (64%) responded and indicated that they had both neuroscience and social/personality doctoral programs housed within their psychology department, and of these 32, 23 provided information on both neuroscience and social/personality doctoral programs. Within these 23 programs, on average, neuroscience students were required to take 2.22 ($SD = 1.13$) methodological and statistical courses, whereas social/personality students were required to take 3.22 ($SD = 1.54$) methodological and statistical courses. The difference between the number of required methodology/statistics courses across the two types of programs was statistically significant, $t(22) = 2.90$, $p < .01$, Cohen's $d = .74$, reflecting a large effect size. These numbers suggest that, at least relative to their counterparts in social/personality psychology, neuroscience students in psychology departments may not be receiving potentially crucial methodological and statistical training. Moreover, these findings corroborate and update those of a previous survey of psychology graduate programs, which similarly suggested that neuroscience graduate students in psychology departments received significantly less exposure to statistics and methodology compared with students in other areas of psychology (Aiken, West, & Millsap, 2008). Of course, given that neuroscience research is often conducted—and neuroscience courses taught—in multiple departments (e.g., psychology, biology, medicine, engineering, economics), some universities may provide statistical or other methodological training in nonpsychology departments (and such training would not have been counted in either our or Aiken et al.'s reviews). Students may also take methodological and statistical courses beyond what is required by their respective programs. Nonetheless, at the very least, these findings raise the question of whether neuroscience graduate students in psychology departments will enter research positions with sufficient statistical and methodological knowledge to benefit from and collaborate effectively with colleagues in other subfields of psychology.

Quo Vadis? The Role of Neuroscience Within a Full-Fledged Discipline of Psychology

With these considerations in mind, how should our field move forward, and what role should neuroscience play within a complete discipline of psychology? The myriad challenges we have outlined will require psychology to give further thought to its boundaries. Clearly, neuroscience is an essential component of psychology because it allows us to understand the workings of the brain, the effects of brain damage on psychological and neurological functioning, and the brain regions and processes associated with specific mental activities. Such information is helpful, and at times critical, for such clinical disciplines as neurology and neurosurgery, whose missions focus on restoring brain functioning in impaired or disabled individuals. Information gleaned from neuroscience studies is also enormously useful for clinical neuropsychology, which focuses largely on identifying functional deficits tied to damage in specific brain regions. We are also certain that neuroscience will become increasingly important for an adequate understanding of psychological and social problems, especially in conjunction with higher levels of analysis. Our question, again, is, "What *else* is important in psychology?" Although sociologists often study social problems such as unemployment, nonmarital childbearing, and immigration, psychology is needed to study how these problems affect the lives of individuals and the ways in which they can be ameliorated through interventions. A combination of neuroscience and social science approaches will be necessary for addressing these issues.

One step that would be helpful in this regard is to expand the nomological network surrounding the term *health*. Probably fueled in part by the appointments of physicians and biologists as directors of the majority of NIH institutes, "health" is now defined in largely biological terms. The U.S. government's Healthy People 2020 initiative (Healthy People, 2012) includes such biological indicators as arthritis, blood disorders, cancer, diabetes, and HIV, as well as such health-related behaviors as substance use and nutrition. For the first time, psychological well-being, defined in social-science terms, is listed as an objective of Healthy People 2020. This is certainly grounds for optimism, provided that funding agencies are willing to support research with well-being as a primary outcome. Further, "health" could be expanded to include a supportive work or school environment, a coherent sense of identity that can support effective decision-making regarding career and relationships, and successful postmigration adaptation among immigrants. As we have discussed throughout this article, psychology is both a social science and a natural science, and both of these aspects of our discipline must be nurtured and allowed to flourish. Indeed, collaborations between social-science and biologically based psychologists will be needed to address key health challenges of the 21st century, especially when health is conceptualized in both social-science and biological terms.

Implications for the Training and Education of Students

Psychology is both a basic science and an applied, service-oriented field, and this dual mission requires a focus on complementary natural-science and social-science topics and methods. As observed earlier, as a field, we need to ensure that graduate students in biological areas of psychology receive adequate training in statistics and methodology to allow them to profit from collaborations with researchers in other domains. In addition, these students, as well as students in other subfields of psychology, need to be equipped not merely with the substantive and technical skills of their specialty, but also with critical thinking skills that will allow them to avoid the inferential leaps about which we have cautioned, such as neuroessentialism, neurorealism, and uncorroborated reverse inference (Racine et al., 2005). In this way, they should hopefully be less susceptible to widespread and tempting misinterpretations of data derived from neuroimaging methods and other paradigms.

To allow them to bridge across multiple levels of analysis when they become full-fledged researchers, graduate students across all domains of psychology also need to be provided with as broad a knowledge base as possible (Cacioppo, 2013; Lilienfeld & O'Donohue, 2007). They cannot reasonably be expected to become experts in all psychology subfields, of course, but they need sufficient exposure to—and appreciation of the scientific value of—diverse levels of analysis to profit from collaborations with scholars who approach psychology from diverse explanatory perspectives. The recently articulated Delaware Project model of clinical science training (Shoham et al., 2014) may serve as a useful blueprint not only for clinical psychology, but also for many other psychological domains. Among other goals, this project emphasizes "collaborative fluency" (p. 12) and exposure to cutting-edge developments across multiple domains of psychology, including neuroscience, the basic sciences of learning, affect, and cognition, social psychology, and the like.

Conclusion: The Future of Psychology

We have begun with a noncontroversial proposition: Brain science *is* an integral component of psychology. The argument we have advanced is simply that social-science concerns are essential as well, and that psychology must maintain a focus on such concerns as it continues to expand into natural science domains. If traditional psychology is to increase its areas of convergence with the natural sciences, a goal we applaud, it must also retain at least one foot in social science so that a wider, integrative scientific perspective can be formulated to include both social and biological components. Conversely, if neuroscience is to thrive and flourish, it must collaborate effectively with other domains of psychology to establish bridge laws and forge meaningful linkages across different levels of analysis (Marcus, 2014). In doing so, it must be careful not to accord short shrift to one or more of these levels.

Clearly, neuroscience has brought an enormous wealth of data and knowledge to the field of psychology. It has helped psychologists to begin to demystify the brain, to learn how the brain develops and adapts, and to better identify the links between brain functions and psychological processes. Understandably, psychologists have become fascinated by neuroscience and the scientific potential that it brings. Our mission has been to acknowledge these important advances while raising key caveats regarding how subfields of psychology that lie higher in the explanatory hierarchy must also be encouraged to flourish. We have also argued that neuroscience must be humble in its aspirations, and not advance claims or make promises that go well beyond the extant data, such as assertions that an understanding of the brain is leading to a revolution in psychotherapy (e.g., Cozzolino, 2002). Just as important, we have aimed to advance the complementary argument that neuroscientific approaches to psychology are unlikely to flourish without an adequate consideration of higher levels of analysis.

In the terminology of Knudsen (2003), the field of psychology must be careful to avoid falling into a "unification trap" (see also Henriques, 2014). Such a trap occurs when one dominant paradigm, in this case neuroscience, becomes so powerful that it begins to discourage intellectual growth in other paradigms, resulting in the fervent monism that troubled Kendler (2014; see also N. Eisenberg, 2014). As Knudsen observed, unification traps can become reinforced by the short-term success of a single methodological or conceptual approach at Kuhnian puzzle-solving (see Kuhn, 1970), which can in turn lead to premature enthusiasm regarding this approach's scientific potential. Although striving toward unification and consilience is a laudable scientific goal (Wilson, 1998), this goal cannot be accomplished without a full appreciation of multiple levels of analysis.

The optimal contribution of neuroscience is, in our view, to *add to* and *complement*, rather than to *replace*, social-science literatures. The growing priorities placed on the hiring of neuroscientists in psychology departments may be counterproductive in this regard, especially if these trends continue to accelerate. If we are seeking to harness the interdisciplinary potential of both natural science and social science approaches to psychology (Magnusson, 2012), our hiring priorities and funding initiatives need to reflect this goal.

As observed earlier (see also Miller, 2010; Satel & Lilienfeld, 2013), the causal links between psychological and biological processes are almost certainly bidirectional in most cases. An eliminative reductionist perspective, in which behaviors, thoughts, feelings, and other experiences can be completely explained by biological processes at the cellular and molecular levels, may be difficult to square with much current scholarship in neuroscience and in the broader field of psychology. Nevertheless, given the dependence of researchers, departments, and universities on federal grant funding, priorities emphasized by funding agencies and by their review committees may "force the hands" of researchers, departments, and universities to prioritize neuroscience at the expense of other approaches. In our view, this state of affairs would be counterproductive. The bidirectional links between neural and behavioral processes can be studied adequately only if such research is robustly and consistently supported at the funding agency level.

Moreover, if some psychological questions are most effectively addressed at the social-science level, such as the unemployment crisis among young adults and the best means of ameliorating marital conflict, social-science research must continue to be among the major priorities at funding agencies. A Department of Psychological Science can focus primarily on social science research and still be true to its name. With the benefit of hindsight, we can understand why Watson (1928) and other early methodological behaviorists argued for delimiting psychology to the science of observable behavior. Their position was largely in response to the predominance of both psychoanalytic approaches on unconscious conflicts and to the research of introspectionists, such as Titchener and his colleagues (who purported to use the self-examination of mental contents to derive a model of the structure of consciousness; Green, 2010), which they viewed with some justification as undermining psychology's aspiration to scientific rigor. At the same time, we can acknowledge that research on personality traits and motives, values, self-perceptions, and agency can be scientific. As a field, psychology should aim to be inclusive, rather than exclusive, in terms of what is included under its auspices (Pervin, 2012). If our field is to be inclusive, funding agency priorities, hiring practices in psychology departments, and the training of graduate students must reflect this goal (Cacioppo, 2013).

Finally, psychologists must continue to focus on the areas in which our expertise is sorely needed. These domains range from understanding the roots of, and solutions for, intergroup conflict to improving relationship stability and career trajectories to inhibiting the progression of diabetes, cancer, HIV, and other chronic and infectious diseases. Both social-science and biologically based psychological expertise will be needed to accomplish these goals, and each type of expertise will be more or less important for specific questions. Some social problems will require social-science expertise; some physiological problems will require natural-science expertise, and most problems will surely require both types of expertise. We must therefore ensure that both types of expertise are promoted, retained, and nurtured. It is our hope that this article will play at least a modest role in launching an important and long overdue conversation about the future of psychology and our shared investment in that future.

References

Abbott, A. (2015, May 11). What makes peaceful neighbours become mass murderers? *Nature*. Retrieved from http://www.nature.com/news/what-makes-peaceful-neighbours-become-mass-murderers-1.17504. http://dx.doi.org/10.1038/nature.2015.17504

Aiken, L. S., West, S. G., & Millsap, R. E. (2008). Doctoral training in statistics, measurement, and methodology in psychology: Replication and extension of Aiken, West, Sechrest, and Reno's (1990) survey of PhD programs in North America. *American Psychologist, 63,* 32–50. http://dx.doi.org/10.1037/0003-066X.63.1.32

Akiskal, H. S., & McKinney, W. T., Jr. (1973). Depressive disorders: Toward a unified hypothesis. *Science, 182,* 20–29. http://dx.doi.org/10.1126/science.182.4107.20

Anderson, J. R. (2004). *Cognitive psychology and its implications* (6th ed.). New York, NY: Worth.

Andreas, S. (2013, July/August). *Therapy isn't brain science. Psychotherapy Networker*. https://www.psychotherapynetworker.org/magazine/recentissues/2013-julaug/item/2158-therapy-isnt-brain-science

Antoni, M. H., Lechner, S., Diaz, A., Vargas, S., Holley, H., Phillips, K., . . . Blomberg, B. (2009). Cognitive behavioral stress management effects on psychosocial and physiological adaptation in women undergoing treatment for breast cancer. *Brain, Behavior, and Immunity, 23,* 580–591. http://dx.doi.org/10.1016/j.bbi.2008.09.005

Ariely, D., & Berns, G. S. (2010). Neuromarketing: The hope and hype of neuroimaging in business. *Nature Reviews Neuroscience, 11,* 284–292. http://dx.doi.org/10.1038/nrn2795

Armony, J., & Vuilleumier, P. (Eds.). (2013). *The Cambridge handbook of human affective neuroscience*. Cambridge, United Kingdom: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511843716

Barlow, D. H. (2014). The neuroscience of psychological treatments. *Behaviour Research and Therapy, 62,* 143–145. http://dx.doi.org/10.1016/j.brat.2014.09.003

Baumeister, R. F. (2008). Free will in scientific psychology. *Perspectives on Psychological Science, 3,* 14–19. http://dx.doi.org/10.1111/j.1745-6916.2008.00057.x

Beauregard, M. (2012). *Brain wars: The scientific battle over the existence of the mind and the proof that will change the way we live our lives*. New York, NY: HarperOne.

Beins, B. C. (2012). Is psychology the other-than science science? Retrieved from http://www.apa.org/ed/precollege/ptn/2012/08/other-science.aspx

Bennett, C. M., & Miller, M. B. (2010). How reliable are the results from functional magnetic resonance imaging? *Annals of the New York Academy of Sciences, 1191,* 133–155. http://dx.doi.org/10.1111/j.1749-6632.2010.05446.x

Berenbaum, H. (2013). Classification and psychopathology research. *Journal of Abnormal Psychology, 122,* 894–901.

Boekel, W., Wagenmakers, E. J., Belay, L., Verhagen, J., Brown, S., & Forstmann, B. U. (2013). A purely confirmatory replication study of structural brain-behavior correlations. *The Journal of Neuroscience, 12,* 4745–4765.

Button, K. S., Ioannidis, J. P., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S., & Munafò, M. R. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience, 14,* 365–376. http://dx.doi.org/10.1038/nrn3475

Cacioppo, J. T. (2013). Psychological science in the 21st century. *Teaching of Psychology, 40,* 304–309. http://dx.doi.org/10.1177/0098628313501041

Cacioppo, J. T., Berntson, G. G., Adolphs, R., Carter, C. S., Davidson, R. J., McClintock, M. K., . . . Taylor, S. E. (Eds.). (2002). *Foundations in social neuroscience*. Cambridge, MA: MIT Press.

Cacioppo, J. T., Berntson, G. G., Sheridan, J. F., & McClintock, M. K. (2000). Multilevel integrative analyses of human behavior: Social neuroscience and the complementing nature of social and biological approaches. *Psychological Bulletin, 126,* 829–843. http://dx.doi.org/10.1037/0033-2909.126.6.829

Cacioppo, J. T., & Decety, J. (2011). Social neuroscience: Challenges and opportunities in the study of complex behavior. *Annals of the New York Academy of Sciences, 1224,* 162–173. http://dx.doi.org/10.1111/j.1749-6632.2010.05858.x

Calton, T., Cheetham, A., D'Silva, K., & Glazebrook, C. (2009). International schizophrenia research and the concept of patient-centredness: An analysis over two decades. *International Journal of Social Psychiatry, 55,* 157–169. http://dx.doi.org/10.1177/0020764008093449

Cappas, N. M., Andres-Hyman, R., & Davidson, L. (2005). What psychotherapists can begin to learn from neuroscience: Seven principles of a brain-based psychotherapy. *Psychotherapy: Theory, Research, Practice, Training, 42,* 374–383. http://dx.doi.org/10.1037/0033-3204.42.3.374

Cauffman, E., & Steinberg, L. (2000). (Im)Maturity of judgment in adolescence: Why adolescents may be less culpable than adults. *Behavioral Sciences & the Law, 18,* 741–760. http://dx.doi.org/10.1002/bsl.416

Cohen, J. (1962). The statistical power of abnormal-social psychological research: A review. *The Journal of Abnormal and Social Psychology, 65,* 145–153. http://dx.doi.org/10.1037/h0045186

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.

Cole, S. (1983). The hierarchy of the sciences? *American Journal of Sociology, 89,* 111–139. http://dx.doi.org/10.1086/227835

Collins, F. S., & Tabak, L. A. (2014). Policy: NIH plans to enhance reproducibility. *Nature, 505,* 612–613. http://dx.doi.org/10.1038/505612a

Comte, A. (1830–1842). *Cours de philosophie positive* (selections translated by Margaret Clarke as The essential Comte). New York, NY: Barnes and Noble.

Costafreda, S. G., Brammer, M. J., Vêncio, R. Z., Mourão, M. L., Portela, L. A., de Castro, C. C., . . . Amaro, E., Jr. (2007). Multisite fMRI reproducibility of a motor task using identical MR systems. *Journal of Magnetic Resonance Imaging, 26,* 1122–1126. http://dx.doi.org/10.1002/jmri.21118

Cozzolino, L. J. (2002). *The neuroscience of psychotherapy*. New York, NY: Norton.

Craske, M. G. (2014). Introduction to special issue: How does neuroscience inform psychological treatment? *Behaviour Research and Therapy, 62,* 1–2. http://dx.doi.org/10.1016/j.brat.2014.08.014

Cuthbert, B. N. (2014). Response to Lilienfield. *Behaviour Research and Therapy, 62,* 140–142. http://dx.doi.org/10.1016/j.brat.2014.08.001

Deacon, B. J. (2013). The biomedical model of mental disorder: A critical analysis of its validity, utility, and effects on psychotherapy research. *Clinical Psychology Review, 33,* 846–861. http://dx.doi.org/10.1016/j.cpr.2012.09.007

Deisseroth, K. (2011). Optogenetics. *Nature Methods, 8,* 26–29. http://dx.doi.org/10.1038/nmeth.f.324

De Jong, H. L. (2002). Levels of explanation in biological psychology. *Philosophical Psychology, 15,* 441–462. http://dx.doi.org/10.1080/09515080210000420003

Dennett, D. C. (1993). *Consciousness explained*. London, United Kingdom: Penguin.

Diener, E. (2010). Neuroimaging: Voodoo, new phrenology, or scientific breakthrough? Introduction to the special section on fMRI. *Perspectives on Psychological Science, 5,* 714–715. http://dx.doi.org/10.1177/1745691610388773

Dolnick, E. (1998). *Madness on the couch: Blaming the victim in the heyday of psychoanalysis*. New York, NY: Simon & Schuster.

Dorsey, E. R., Vitticore, P., De Roulet, J., Thompson, J. P., Carrasco, M., Johnston, S. C., . . . Moses, H., III. (2006). Financial anatomy of neuroscience research. *Annals of Neurology, 60,* 652–659. http://dx.doi.org/10.1002/ana.21047

Dwan, K., Altman, D. G., Arnaiz, J. A., Bloom, J., Chan, A. W., Cronin, E., . . . Williamson, P. R. (2008). Systematic review of the empirical evidence of study publication bias and outcome reporting bias. *PLoS ONE, 3,* e3081. http://dx.doi.org/10.1371/journal.pone.0003081

Eisenberg, L. (1986). Mindlessness and brainlessness in psychiatry. *The British Journal of Psychiatry, 148,* 497–508. http://dx.doi.org/10.1192/bjp.148.5.497

Eisenberg, L. (2000). Is psychiatry more mindful or brainier than it was a decade ago? *The British Journal of Psychiatry, 176,* 1–5. http://dx.doi.org/10.1192/bjp.176.1.1

Eisenberg, N. (2014). *Is our focus becoming overly narrow?* Retrieved September 7, 2014 from http://www.psychologicalscience.org/index.php/publications/observer/2014/september-14/is-our-focus-becoming-overly-narrow.html

Erikson, E. H. (1950). *Childhood and society*. New York: Norton.

EurekAlert. (2003, November 20). *Brain-imaging study sheds more light on underlying cause of attention-deficit hyperactivity syndrome*. Retrieved September 10, 2014 from http://www.eurekalert.org/pub_releases/2003-11/l-bss111903.php

Farah, M. J., & Hook, C. J. (2013). The seductive allure of "seductive allure." *Perspectives on Psychological Science, 8,* 88–90. http://dx.doi.org/10.1177/1745691612469035

Ferguson, C. J., & Brannick, M. T. (2012). Publication bias in psychological science: Prevalence, methods for identifying and controlling, and implications for the use of meta-analyses. *Psychological Methods, 17,* 120–128. http://dx.doi.org/10.1037/a0024445

Fernandez-Duque, D., Evans, J., Christian, C., & Hodges, S. D. (2015). Superfluous neuroscience information makes explanations of psychological phenomena more appealing. *Journal of Cognitive Neuroscience, 27,* 926–944. http://dx.doi.org/10.1162/jocn_a_00750

Fodor, J. (1968). *Psychological explanation: An introduction to the philosophy of psychology*. New York, NY: Random House.

Forstmeier, W., & Schielzeth, H. (2011). Cryptic multiple hypotheses testing in linear models: Overestimated effect sizes and the winner's curse. *Behavioral Ecology and Sociobiology, 65,* 47–55. http://dx.doi.org/10.1007/s00265-010-1038-5

Frankl, V. (1959). *Man's search for meaning*. Boston: Beacon Press.

Friedman, L., Stern, H., Brown, G. G., Mathalon, D. H., Turner, J., Glover, G. H., . . . Potkin, S. G. (2008). Test–retest and between-site reliability in a multicenter fMRI study. *Human Brain Mapping, 29,* 958–972.

Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2008). *Cognitive neuroscience: The biology of the mind* (3rd ed.). New York, NY: Norton.

Gewin, V. (2013). Neuroscience: A head start for brain imaging. *Nature, 503,* 153–155. http://dx.doi.org/10.1038/nj7474-153a

Goldstein, R. Z., & Volkow, N. D. (2011). Dysfunction of the prefrontal cortex in addiction: Neuroimaging findings and clinical implications. *Nature Reviews Neuroscience, 12,* 652–669. http://dx.doi.org/10.1038/nrn3119

Goswami, U. (2004). Neuroscience and education. *British Journal of Educational Psychology, 74,* 1–14. http://dx.doi.org/10.1348/000709904322848798

Grand, D. (2013). *Brainspotting: The revolutionary new therapy for rapid and effective change*. Boulder, CO: Sounds True.

Green, C. D. (2010). Scientific objectivity and EB Titchener's experimental psychology. *Isis, 101,* 697–721.

Gros, C. (2009). Cognitive computation with autonomously active neural networks: An emerging field. *Cognitive Computation, 1,* 77–90. http://dx.doi.org/10.1007/s12559-008-9000-9

Gross, C. (2013). Between brain and imaging hype. *Science, 340,* 1526. http://dx.doi.org/10.1126/science.1240697

Gustavsson, A., Svensson, M., Jacobi, F., Allgulander, C., Alonso, J., Beghi, E., . . . Olesen, J. (2011). Cost of disorders of the brain in Europe in 2010. *European Neuropsychopharmacology, 21,* 718–779.

Hall, W., Carter, A., & Forlini, C. (2015). The brain disease model of addiction: Is it supported by the evidence and has it delivered on its promises? *Lancet Psychiatry, 2,* 105–110. http://dx.doi.org/10.1016/S2215-0366(14)00126-6

Harre, R. (2002). *Cognitive science: A philosophical introduction*. London, United Kingdom: Sage.

Haslam, N. (2011). Genetic essentialism, neuroessentialism, and stigma: Commentary on Dar-Nimrod and Heine (2011). *Psychological Bulletin, 137,* 819–824. http://dx.doi.org/10.1037/a0022386

Healthy People. (2012). *Topics and objectives index: Healthy People*. Retrieved from http://www.healthypeople.gov/2020/topicsobjectives2020/default.aspx

Hedges, L. V. (1987). How hard is hard science, how soft is soft science? *American Psychologist, 42,* 443–455. http://dx.doi.org/10.1037/0003-066X.42.5.443

Heinrichs, M., & Domes, G. (2008). Neuropeptides and social behaviour: Effects of oxytocin and vasopressin in humans. *Progress in Brain Research, 170,* 337–350. http://dx.doi.org/10.1016/S0079-6123(08)00428-7

Henriques, G. R. (2004). Psychology defined. *Journal of Clinical Psychology, 60,* 1207–1221. http://dx.doi.org/10.1002/jclp.20061

Henriques, G. (2014, January 18). Psychology's fragmentation trap. *Psychology Today Blogs*. Retrieved from http://www.psychologytoday.com/blog/theory-knowledge/201401/psychologys-fragmentation-trap

Hickok, G. (2014). *The myth of mirror neurons: The real neuroscience of communication and cognition*. New York, NY: Norton.

Howard-Jones, P. A. (2014). Neuroscience and education: Myths and messages. *Nature Reviews Neuroscience, 15,* 817–824. http://dx.doi.org/10.1038/nrn3817

Immordino-Yang, M. H., McColl, A., Damasio, H., & Damasio, A. (2009). Neural correlates of admiration and compassion. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 106,* 8021–8026. http://dx.doi.org/10.1073/pnas.0810363106

Insel, T. R. (2009). Translating scientific opportunity into public health impact: A strategic plan for research on mental illness. *Archives of General Psychiatry, 66,* 128–133. http://dx.doi.org/10.1001/archgenpsychiatry.2008.540

Insel, T. R., & Cuthbert, B. N. (2015). Brain disorders? Precisely. *Science, 348,* 499–500. http://dx.doi.org/10.1126/science.aab2358

Insel, T., Cuthbert, B., Garvey, M., Heinssen, R., Pine, D. S., Quinn, K., . . . Wang, P. (2010). Research domain criteria (RDoC): Toward a new classification framework for research on mental disorders. *The American Journal of Psychiatry, 167,* 748–751. http://dx.doi.org/10.1176/appi.ajp.2010.09091379

Insel, T. R., Landis, S. C., Collins, F. S., & The NIH BRAIN Initiative. (2013). Research priorities. *Science, 340,* 687–688. http://dx.doi.org/10.1126/science.1239276

Ioannidis, J. P. A. (2005). Why most published research findings are false. *PLoS Medicine, 2,* e124. http://dx.doi.org/10.1371/journal.pmed.0020124

Ioannidis, J. P. A. (2008). Why most discovered true associations are inflated. *Epidemiology, 19,* 640–648. http://dx.doi.org/10.1097/EDE.0b013e31818131e7

Jennings, R. G., & Van Horn, J. D. (2012). Publication bias in neuroimaging research: Implications for meta-analyses. *Neuroinformatics, 10,* 67–80. http://dx.doi.org/10.1007/s12021-011-9125-y

Jones, S. R., & Fernyhough, C. (2007). A new look at the neural diathesis—Stress model of schizophrenia: The primacy of social-evaluative and uncontrollable situations. *Schizophrenia Bulletin, 33,* 1171–1177. http://dx.doi.org/10.1093/schbul/sbl058

Kagan, J. (2013). Equal time for psychological and biological contributions to human variation. *Review of General Psychology, 17,* 351–357. http://dx.doi.org/10.1037/a0033481

Katzman, M. (2004). Venlafaxine in the treatment of anxiety disorders. *Expert Review of Neurotherapeutics, 4,* 371–381. http://dx.doi.org/10.1586/14737175.4.3.371

Kendler, K. S. (2005). Toward a philosophical structure for psychiatry. *The American Journal of Psychiatry, 162,* 433–440. http://dx.doi.org/10.1176/appi.ajp.162.3.433

Kendler, K. S. (2014). The structure of psychiatric science. *The American Journal of Psychiatry, 171,* 931–938. http://dx.doi.org/10.1176/appi.ajp.2014.13111539

Kitayama, S., & Tompson, S. (2010). Envisioning the future of cultural neuroscience. *Asian Journal of Social Psychology, 13,* 92–101. http://dx.doi.org/10.1111/j.1467-839X.2010.01304.x

Knudsen, C. (2003). *The essential tension in the social sciences: Between the "unification" and "fragmentation" trap*. Cheltenham, United Kingdom: Edward Elgar.

Kosfeld, M., Heinrichs, M., Zak, P. J., Fischbacher, U., & Fehr, E. (2005). Oxytocin increases trust in humans. *Nature, 435,* 673–676. http://dx.doi.org/10.1038/nature03701

Krumm, N., O'Roak, B. J., Shendure, J., & Eichler, E. E. (2014). A *de novo* convergence of autism genetics and molecular neuroscience. *Trends in Neurosciences, 37,* 95–105. http://dx.doi.org/10.1016/j.tins.2013.11.005

Kuhn, T. S. (1970). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.

Lebowitz, M. S., & Ahn, W.-K. (2014). Effects of biological explanations for mental disorders on clinicians' empathy. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 111,* 17786–17790. http://dx.doi.org/10.1073/pnas.1414058111

Lilienfeld, S. O. (2007). Cognitive neuroscience and depression: Legitimate versus illegitimate reductionism and five challenges. *Cognitive Therapy and Research, 31,* 263–272. http://dx.doi.org/10.1007/s10608-007-9127-0

Lilienfeld, S. O. (2011, October). Letter to the Editor: Identity shift. *APS Observer, 24*. Retrieved from https://www.psychologicalscience.org/index.php/publications/observer/2011/october-11/letter-to-the-editor-2.html

Lilienfeld, S. O. (2012). Public skepticism of psychology: Why many people perceive the study of human behavior as unscientific. *American Psychologist, 67,* 111–129. http://dx.doi.org/10.1037/a0023963

Lilienfeld, S. O., & O'Donohue, W. (2007). *The great ideas of clinical science: 17 principles that all mental health professionals should understand*. New York, NY: Routledge.

Linden, D. E. J. (2006). How psychotherapy changes the brain: The contribution of functional neuroimaging. *Molecular Psychiatry, 11,* 528–538. http://dx.doi.org/10.1038/sj.mp.4001816

Liu, T., Goldberg, L., Gao, S., & Hong, B. (2010). An online brain-computer interface using non-flashing visual evoked potentials. *Journal of Neural Engineering, 7,* 036003. http://dx.doi.org/10.1088/1741-2560/7/3/036003

Magnusson, D. (2012). The human being in society: Psychology as a scientific discipline. *European Psychologist, 17,* 21–27. http://dx.doi.org/10.1027/1016-9040/a000079

Marcus, G. (2014, July 11). The trouble with brain science. *New York Times,* A14.

Matto, H. C., Hadjiyane, M. C., Kost, M., Marshall, J., Wiley, L., Strolin-Goltzman, J., . . . VanMeter, J. W. (2014). Functional magnetic resonance imaging clinical trial of a dual-processing treatment protocol for substance-dependent adults. *Research on Social Work Practice, 24,* 659–669. http://dx.doi.org/10.1177/1049731513515056

McDonald, K., & McDonald, T. M. (2010). The peptide that binds: A systematic review of oxytocin and its prosocial effects in humans. *Harvard Review of Psychiatry, 18,* 1–21.

McGrath, C. L., Kelley, M. E., Holtzheimer, P. E., Dunlop, B. W., Craighead, W. E., Franco, A. R., . . . Mayberg, H. S. (2013). Toward a neuroimaging treatment selection biomarker for major depressive disorder. *Journal of the American Medical Association Psychiatry, 70,* 821–829. http://dx.doi.org/10.1001/jamapsychiatry.2013.143

Meehl, P. E. (1972). Specific genetic etiology, psychodynamics, and therapeutic nihilism. *International Journal of Mental Health, 1,* 10–27.

Meyer, A. (1912). Conditions for a home of psychology in the medical curriculum. *The Journal of Abnormal Psychology, 7,* 313–325. http://dx.doi.org/10.1037/h0074979

Milad, M. R., Rosenbaum, B. L., & Simon, N. M. (2014). Neuroscience of fear extinction: Implications for assessment and treatment of fear-based and anxiety related disorders. *Behaviour Research and Therapy, 62,* 17–23. http://dx.doi.org/10.1016/j.brat.2014.08.006

Miller, G. A. (2010). Mistreating psychology in the decades of the brain. *Perspectives on Psychological Science, 5,* 716–743. http://dx.doi.org/10.1177/1745691610388774

Moshman, D. (2011). *Adolescent rationality and development: Cognition, morality, and identity*. Philadelphia, PA: Taylor & Francis.

Moxon, K. A., Leiser, S. C., Gerhardt, G. A., Barbee, K. A., & Chapin, J. K. (2004). Ceramic-based multisite electrode arrays for chronic single-neuron recording. *IEEE Transactions on Bio-Medical Engineering, 51,* 647–656. http://dx.doi.org/10.1109/TBME.2003.821037

National Institute on Drug Abuse. (2015). *FY 2016–2020 strategic plan for the National Institute on Drug Abuse, National Institutes of Health*. Retrieved March 3, 2015 from http://grants.nih.gov/grants/guide/notice-files/NOT-DA-15-005.html

National Institute on Mental Health. (2013, April 23). *Director's update: Mental disorders as brain disorders: Thomas Insel at TEDxCaltech*. Retrieved September 10, 2014 from http://www.nimh.nih.gov/about/updates/2013/mental-disorders-as-brain-disorders-thomas-insel-at-tedxcaltech.shtml

Nelson, R. J., & Mizumori, S. J. Y. (Eds.). (2013). *Handbook of psychology, Vol. 3*: *Behavioral neuroscience*. New York, NY: Wiley.

Ochsner, K. N., & Gross, J. J. (2008). Cognitive emotion regulation: Insights from social cognitive and affective neuroscience. *Current Directions in Psychological Science, 17,* 153–158. http://dx.doi.org/10.1111/j.1467-8721.2008.00566.x

O'Connor, T. (1994). Emergent properties. *American Philosophical Quarterly, 31,* 91–104.

O'Donohue, W., Ferguson, K. E., & Naugle, A. E. (2003). The structure of the cognitive revolution: An examination from the philosophy of science. *The Behavior Analyst, 26,* 85–110.

Paloutzian, R. F., & Park, C. L. (Eds.). (2008). *Handbook of the psychology of religion and spirituality*. New York, NY: Guilford Press.

Park, D. C., & Huang, C.-M. (2010). Culture wires the brain: A cognitive neuroscience perspective. *Perspectives on Psychological Science, 5,* 391–400. http://dx.doi.org/10.1177/1745691610374591

Pashler, H., & Wagenmakers, E. J. (2012). Editor's introduction to the special section on replicability in psychological science: A crisis of confidence? *Perspectives on Psychological Science, 7,* 528–530. http://dx.doi.org/10.1177/1745691612465253

Pervin, L. A. (2012). Psychology as a scientific discipline, cross-disciplinary research, and the issue of levels. *European Psychologist, 17,* 33.

Pfeifer, J. H., Lieberman, M. D., & Dapretto, M. (2007). "I know you are but what am I?!": Neural bases of self- and social knowledge retrieval in children and adults. *Journal of Cognitive Neuroscience, 19,* 1323–1337. http://dx.doi.org/10.1162/jocn.2007.19.8.1323

Pinker, S. (2003). *The blank slate: The modern denial of human nature*. New York, NY: Penguin.

Poldrack, R. A. (2006). Can cognitive processes be inferred from neuroimaging data? *Trends in Cognitive Sciences, 10,* 59–63. http://dx.doi.org/10.1016/j.tics.2005.12.004

Poline, J. B., Breeze, J. L., Ghosh, S., Gorgolewski, K., Halchenko, Y. O., Hanke, M., . . . Kennedy, D. N. (2012). Data sharing in neuroimaging research. *Frontiers in Neuroinformatics, 6,* 9. http://dx.doi.org/10.3389/fninf.2012.00009

Pronin, E., Wegner, D. M., McCarthy, K., & Rodriguez, S. (2006). Everyday magical powers: The role of apparent mental causation in the overestimation of personal influence. *Journal of Personality and Social Psychology, 91,* 218–231. http://dx.doi.org/10.1037/0022-3514.91.2.218

Pruessner, J. C., Baldwin, M. W., Dedovic, K., Renwick, R., Mahani, N. K., Lord, C., . . . Lupien, S. (2005). Self-esteem, locus of control, hippocampal volume, and cortisol regulation in young and old adulthood. *NeuroImage, 28,* 815–826. http://dx.doi.org/10.1016/j.neuroimage.2005.06.014

Pyszczynski, T., Greenberg, J., Solomon, S., Arndt, J., & Schimel, J. (2004). Why do people need self-esteem? A theoretical and empirical review. *Psychological Bulletin, 130,* 435–468.

Racine, E., Bar-Ilan, O., & Illes, J. (2005). fMRI in the public eye. *Nature Reviews Neuroscience, 6,* 159–164. http://dx.doi.org/10.1038/nrn1609

Rosnow, R. L., & Rosenthal, R. (1989). Statistical procedures and the justification of knowledge in psychological science. *American Psychologist, 44,* 1276–1284. http://dx.doi.org/10.1037/0003-066X.44.10.1276

Ryan, R. M., & Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annual Review of Psychology, 52,* 141–166. http://dx.doi.org/10.1146/annurev.psych.52.1.141

Ryan, R. M., & Deci, E. L. (2006). Self-regulation and the problem of human autonomy: Does psychology need choice, self-determination, and will? *Journal of Personality, 74,* 1557–1586. http://dx.doi.org/10.1111/j.1467-6494.2006.00420.x

Sam, D. L., & Berry, J. W. (2010). Acculturation: When individuals and groups of different cultural backgrounds meet. *Perspectives on Psychological Science, 5,* 472–481.

Sanislow, C. A., Pine, D. S., Quinn, K. J., Kozak, M. J., Garvey, M. A., Heinssen, R. K., . . . Cuthbert, B. N. (2010). Developing constructs for psychopathology research: Research domain criteria. *Journal of Abnormal Psychology, 119,* 631–639. http://dx.doi.org/10.1037/a0020909

Satel, S., & Lilienfeld, S. O. (2013). *Brainwashed: The seductive appeal of mindless neuroscience*. New York, NY: Basic.

Savin-Williams, R. C., & Ream, G. L. (2007). Prevalence and stability of sexual orientation components during adolescence and young adulthood. *Archives of Sexual Behavior, 36,* 385–394.

Searle, J. R. (2002). Why I am not a property dualist. *Journal of Consciousness Studies, 9,* 57–64.

Shermer, M. (2008). Why you should be skeptical of brain scans. *Scientific American Mind, 19,* 66–71. http://dx.doi.org/10.1038/scientificamericanmind1008-66

Shoham, V., Rohrbaugh, M. J., Onken, L. S., Cuthbert, B. N., Beveridge, R. M., & Fowles, T. R. (2014). Redefining clinical science training: Purpose and products of the Delaware Project. *Clinical Psychological Science, 2,* 8–21. http://dx.doi.org/10.1177/2167702613497931

Smith, R. H., & Harris, M. J. (2006). Multimethod approaches in social psychology: Between- and within-method replication and multi-method assessment. In M. Eid & E. Diener (Eds.), *Handbook of multimethod measurement in psychology* (pp. 385–400). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/11383-026

Soltesz, I., & Staley, K. (Eds.). (2008). *Computational neuroscience in epilepsy*. San Diego, CA: Academic Press.

Steger, M. F., Kashdan, T. B., & Oishi, S. (2008). Being good by doing good: Daily eudaimonic activity and well-being. *Journal of Research in Personality, 42,* 22–42.

Stone, K., Whitham, E. A., & Ghaemi, S. N. (2012). A comparison of psychiatry and internal medicine: A bibliometric study. *Academic Psychiatry, 36,* 129–132. http://dx.doi.org/10.1176/appi.ap.10030048

Swann, W. B., Jr., Chang-Schneider, C., & Larsen McClarty, K. (2007). Do people's self-views matter? Self-concept and self-esteem in everyday life. *American Psychologist, 62,* 84–94. http://dx.doi.org/10.1037/0003-066X.62.2.84

Tajfel, H., & Turner, J. C. (1986). The social identity theory of intergroup behavior. In S. Worchel & W. G. Austin (Eds.), *The psychology of intergroup behavior* (2nd ed., pp. 7–24). Chicago, IL: Nelson Hall.

Vignoles, V. L., Schwartz, S. J., & Luyckx, K. (2011). Introduction: Toward an integrative view of identity. In S. J. Schwartz, K. Luyckx, & V. L. Vignoles (Eds.), *Handbook of identity theory and research* (pp. 1–28). New York: Springer.

Wakefield, J. C. (1992). The concept of mental disorder. On the boundary between biological facts and social values. *American Psychologist, 47,* 373–388. http://dx.doi.org/10.1037/0003-066X.47.3.373

Watson, J. B. (1928). *Psychological care of infant and child*. New York, NY: Norton.

Weisberg, D. S., Keil, F. C., Goodstein, J., Rawson, E., & Gray, J. R. (2008). The seductive allure of neuroscience explanations. *Journal of Cognitive Neuroscience, 20,* 470–477.

Wilson, E. O. (1998). *Consilience: The unity of knowledge*. New York, NY: Random House.

Zeigler, D. W., Wang, C. C., Yoast, R. A., Dickinson, B. D., McCaffree, M. A., Robinowitz, C. B., . . . the Council on Scientific Affairs, American Medical Association. (2005). The neurocognitive effects of alcohol on adolescents and college students. *Preventive Medicine: An International Journal Devoted to Practice and Theory, 40,* 23–32. http://dx.doi.org/10.1016/j.ypmed.2004.04.044

Zeigler-Hill, V. (Ed.). (2013). *Self-esteem: Current issues in social psychology*. New York, NY: Psychology Press. http://dx.doi.org/10.1093/OBO_dataset_home

Received February 20, 2014
Revision received May 18, 2015
Accepted June 17, 2015 ■