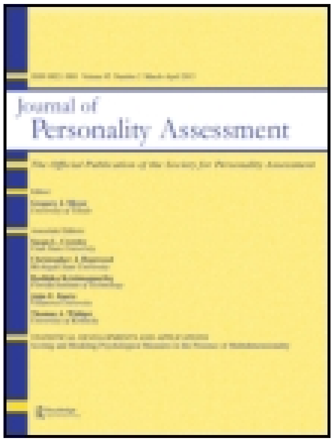
A Review of Systems for Psychology and Psychiatry: Adaptive Systems, Personality Psychopathology Five (PSY-5), and the DSM-5

Article *in* Journal of Personality Assessment · August 2013

DOI: 10.1080/00223891.2013.823438 · Source: PubMed

Allan R Harkness
University of Tulsa

Shannon Reynolds Miles
James A. Haley Veterans Hospital



Journal of Personality Assessment
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/hjpa20

A Review of Systems for Psychology and Psychiatry: Adaptive Systems, Personality Psychopathology Five (PSY-5), and the DSM-5

Allan R. Harkness [a] , Shannon M. Reynolds [a] & Scott O. Lilienfeld [b]
[a] Department of Psychology and Institute for Biochemical and Psychological Study of Individual Differences , The University of Tulsa
[b] Department of Psychology , Emory University

Published online: 13 Aug 2013.

Journal of Personality Assessment, 96(2), 121–139, 2014

ISSN: 0022-3891 print / 1532-7752 online
DOI: 10.1080/00223891.2013.823438

Routledge
Taylor & Francis Group

SPECIAL SECTION: The Personality Psychopathology Five (PSY–5) and *DSM–5* Trait Dimensional Diagnostic System for Personality Disorders: Emerging Convergence

A Review of Systems for Psychology and Psychiatry: Adaptive Systems, Personality Psychopathology Five (PSY–5), and the *DSM–5*

Allan R. Harkness,[1] Shannon M. Reynolds,[1] and Scott O. Lilienfeld[2]

[1]*Department of Psychology and Institute for Biochemical and Psychological Study of Individual Differences, The University of Tulsa*
[2]*Department of Psychology, Emory University*

We outline a crisis in clinical description, in which atheoretical categorical descriptors, as in the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*), has turned focus away from the obvious: evolved major adaptive systems. Adaptive systems, at the core of a medical review of systems (ROS), allow models of pathology to be layered over an understanding of systems as they normally function. We argue that clinical psychology and psychiatry would develop more programmatically by incorporating 5 systems evolved for adaptation to the external environment: reality modeling for action, short-term danger detection, long-term cost–benefit projection, resource acquisition, and agenda protection. These systems, although not exhaustive, coincide with great historical issues in psychology, psychopathology, and individual differences. Readers of this journal should be interested in this approach because personality is seen as a relatively stable property of these systems. Thus, an essential starting point in ROS-based clinical description involves personality assessment. But this approach also places demands on scientist-practitioners to integrate across sciences. An ROS promotes theories that are (a) compositional, answering the question: What elements comprise the system?; (b) dynamic, answering: How do the elements and other systems interact?; and (c) developmental: How do systems change over time? The proposed ROS corresponds well with the National Institute of Mental Health's recent research domain criteria (RDoC) approach. We urge that in the RDoC approach, measurement variables should be treated as falsifiable and theory-laden markers, not unfalsifiable criteria. We argue that our proposed ROS promotes integration across sciences, rather than fostering the isolation of sciences allowed by atheoretical observation terms, as in the *DSM*.

We advocate a fundamental change in the way clinical description is conducted in clinical psychology and psychiatry. Specifically, we argue for a review of systems (ROS), which has been used successfully in many other clinical disciplines. Readers of this journal should be vitally interested in the ROS approach, because this proposal establishes personality assessment as a primary starting point for all psychiatric and psychological description. Our proposed ROS begins with an examination of five major evolved systems that allow adaptation to major themes in the external environment. Personality is interpreted as the stable properties of these dynamic and adaptive systems (Harkness & Lilienfeld, 1997). The five systems exert effects not just on personality disorders, and not just on what were formerly termed Axis I clinical disorders; they underlie all normal psychological functioning as well. The systems represent not only potential failure points in clinical problems, but also the major psychological resources that all human beings—in fact all mammals—use to adapt to the environment. We argue that the ROS approach brings falsifiability to clinical description, unites disparate sciences, and reveals the great cross-cutting themes in the history of psychology and psychopathology. Although an ROS might begin with personality assessment, it will demand more from both scientists and practitioners in integrating across the sciences.

The Crisis in Clinical Description

We must accept the fact that our diagnostic classification is the result of historical accretion and accident without any real underlying system or scientific necessity. The rules for entry have varied over time and have rarely been very rigorous. Our mental disorders are no more than fallible social constructs.

—Allen Frances (Phillips et al., 2012, p. 25)

There is a crisis in clinical description. At the same time that we have witnessed massive gains in other sciences, the classification and understanding of people with problems addressed by clinical psychology and psychiatry have been marked by dismayingly little progress. Where are the breakthroughs in the diagnosis, treatment, or prevention of major depression, schizophrenia, or personality disorders? To take merely one example, it is not clear that the treatment of schizophrenia is markedly more efficacious today than it was several decades ago (e.g., Kishimoto et al., 2011). The titles of many engaging articles suggest the broad outlines of this crisis: "Through a Glass Darkly: The Disutility of the *DSM* Nosology of Depressive Disorders" (Parker, 2006); "Genetics of Anxiety: Would the Genome Recognize the *DSM*?" (Smoller, Gardner-Schuster, &

Received January 14, 2013; Revised May 15, 2013.
Address correspondence to Allan R. Harkness, Department of Psychology, The University of Tulsa, 800 South Tucker Avenue, Tulsa, OK 74104; Email: allan-harkness@utulsa.edu

Misiaszek 2008); "Molecular Genetics and the Kraepelinian Dichotomy: One Disorder, Two Disorders, or Do We Need to Start Thinking Afresh?" (Craddock & Owen, 2010); and "Common Disorders Are Quantitative Traits" (Plomin, Haworth, & Davis, 2009). A recent large-scale genetic study made international headlines (Smoller et al., 2013) by showing shared differences in genes across attention-deficit/hyperactivity disorder, autism spectrum disorder, bipolar disorder, major depressive disorder, and schizophrenia.

The sense that cross-disciplinary science has achieved advances not evident in disorder- driven clinical psychology and psychiatry was well expressed by Jablensky (2010):

> General medicine is becoming increasingly "molecular," hence more attractive and intellectually challenging to young minds. This kind of transformation has not occurred in psychiatry. Hardly any recent advances in neuroscience, molecular genetics and genomics has translated into practical clinical tools, disease markers treatments or novel conceptual paradigms in our understanding of the nature of mental disorders. (p. 29)

The concern about the glacial pace of progress in clinical description has prompted a major initiative within the National Institute for Mental Health (NIMH): research diagnostic criteria (RDoC). Rather than pathological categories, RDoC suggests that a number of well-established behavioral systems could be examined using variables from "psychological, neuroscience, genetic, and biochemical domains" (Insel et al., 2010, p. 49). Some proposed systems are "fear/extinction, reward, executive function, and impulse control" (p. 749). The relevance of these systems to the current proposal for a review of systems, as well as the Personality Psychopathology Five (PSY–5) model, and *Diagnostic and Statistical Manual of Mental Disorders* (*DSM–5*; American Psychiatric Association, 2013) personality disorders work group traits proposal will become clear in the balance of the article. We agree with proponents of the RDoC initiative that we should focus on basic systems that are sufficiently well understood to provide variables spanning many scientific disciplines.

We Need Compositional, Dynamic, Developmental, Integrative, and Testable Theories, Not a Heap of Hypotheses

> *For most* DSM–III *disorders, however, the etiology is unknown . . . . The approach taken in* DSM–III *is atheoretical with regard to etiology or pathophysiological process except for those disorders in which this is well established and therefore included in the definition of the disorder*.
>
> —American Psychiatric Association (1980, p. 6)

Theory in clinical psychology and psychiatry has often been at the lowest possible level of analysis—namely, observation terms, often generated as "operational definitions." This level often leads to hypotheses that are little more than empirical assertions; for example, persons operationally diagnosed with borderline personality disorder (PD) will be more physically aggressive on some other measure than those not so diagnosed. Such a hypothesis is indeed testable. But these hypotheses often lack meaningful connections to an underlying theory that describes what comprises the system under study, how the elements comprising the system interact, how the system changes over time, and how the system relates to other sciences (Wilson, 1998). With respect to the latter, Stanovich (2009) noted that "connectivity," the capacity of a research program to connect with broader findings in other well-established disciplines, is a key component of successful sciences. Psychological definitions must be reasonably explicit, but "operational definitions" in the sense of being purely measurement operations, devoid of any theoretical content (Bridgman, 1927), cannot be generative unless there is connectivity to falsifiable theories, in this case connected to real, evolved, and generally adaptive systems.

Falsifiability, the capacity of a theory to be put to the test (Popper, 1959), is a *necessary,* but not *sufficient,* condition for that theory's scientific status. If the theory is composed only of observation terms, we have only the Baconian empiricism found in many grant applications. Indeed, the "specific aims" of many grant proposals are merely tests of hypotheses that have few or no generative powers, because they are linked purely to observation terms. No matter how the hypothesis test turns out, few or no new and bold predictions are advanced. Note that a truly operational definition, defined by set of measurement operations, is not in itself falsifiable. If one operationally defines a "long stick" as a meter or more in length and a "short stick" as less than a meter, one can never falsify the definition—one can only make mistakes in labeling individual sticks. In similar fashion, if (as we contend) the *DSM* criteria for virtually all diagnostic categories are atheoretical operational measurement terms, then they are only the latest measurement definition of the committee, and are not in any real sense falsifiable.

Facts themselves cannot make theory; only theorists can. Generative power derives from theories that describe the composition of systems (e.g., circulatory system, planetary system, molecules made from entries on the periodic table), that describe the dynamic interaction of the system's parts (e.g., Fechner's law, Ohm's law, ideal gas law), that detail the development of systems (e.g., evolution, cosmology, embryology), and theories that create connections across sciences. Unlike mere operational definitions, generative ideas are theoretical; they link sciences and generate new hypotheses. And they can be falsified. Without the engine of testable theory, we only have what Meehl called a "heap of hypotheses" (Harkness, 2005).

Why have clinical psychology and psychiatry opted for Baconian empiricism instead of generative theories found in most other branches of science? We speculate that psychology and psychiatry are still trying to "undo" much of psychoanalytic theory, which appeared to be compositional (e.g., ego, id, superego), dynamic, and developmental. Unfortunately, it was often untestable, and slippery when testable. Meehl (1978) further conjectured that statistical significance-based hypothesis testing approaches give rise to weak theories. And the Webberian concept of "social science," which separated us from the natural sciences, allowed us to feel comfortable claiming a right to work in ignorance or isolation from the full body of sister sciences.

Are compositional, dynamic, developmental, integrative, and testable theories intellectual achievements beyond the reach of clinical psychology and psychiatry? We do not believe so. We already have a model of successful theory building for clinical sciences. We have a blueprint that tells us how to construct generative theories, the ROS.

Review of Systems: A Model for Theory Building in Clinical Sciences

In medicine, a ROS is an examination of a person organized by major adaptive systems. The visual system, the respiratory system, and cardiovascular system are examples of major adaptive systems that provide an organizing framework for a medical

ROS for the patient. Although problems within each system are topics for description, the focus is on the functioning of normally adaptive systems. The reviewed systems are described at a level such that the adaptive function of the system is reasonably well agreed on:[1] for example, eyesight affords short- and long-distance detection and resolution of stimuli, forwarding information to multiple and parallel perception systems for complex analysis. Psychologists played a major role in the study of the visual system. They contributed psychophysical methods, developed models of sensation and perception, and worked alongside other sensory physiologists to identify and understand the subsystems of visual analysis. Today, the signs and symptoms of clinical problems of vision are understood only in the context of the physics, chemistry, biology, and psychology of an evolved system.

Another, less psychological, example is the cardiovascular system—with the function of transporting essential gases, energy-bearing molecules, between-cell signals, immune system operatives, and so on, out to cellular suburbs. Compare modern cardiology, in which the lists of signs and symptoms are mapped onto an understanding of the anatomy and physiology of the cardiovascular system, with an imaginary *atheoretical* cardiology organized merely by "shoulder pain disorder," "excessive breathlessness disorder," and "lower-limb edema disorder."

Internal medicine has long used an ROS approach to anchor the understanding of clinical problems in normal physiology, yet psychology and psychiatry have lagged behind with their continued insistence on atheoretical observation terms. Admittedly, some of this slower progress is attributable to the fact that there is less consensus regarding the functions of some psychological systems (e.g., the sadness system) compared with those of well-established physiological systems (e.g., the respiratory system), but it also reflects institutional inertia and our field's intellectual isolation from broader sciences. Ironically, the International Classification of Diseases (9th ed. [ICD–9]) and proposals for ICD–10 rely on an ROS organizing principle, except in their psychiatry sections.

Many scholars in psychology and psychiatry argue on behalf of retaining atheoretical descriptions (e.g., Widiger & Clark, 2000). We understand their rationale for such descriptions, and agree that they allow comparison across alternative research conceptualizations (e.g., psychodynamic, behavioral, cognitive) using theory-neutral operationalizations (Wakefield, 1998, 1999). Nevertheless, this once defensible approach has begun to outlive its usefulness. Hence, we argue the other side, namely, that the basic science underpinning psychology and psychiatry is now sufficiently advanced to move beyond atheoretical lists of signs and symptoms, toward describing major adaptive systems that underlie thinking, perceiving, emotions, and much of psychological health and pathology.

Reviewing major adaptive systems leads to compositional, dynamic, integrative, and testable theories. And unlike pure operational definitions, assertions about real systems are falsifiable. We will show readers how using major adaptive systems reveals overarching themes in the history of psychology and psychopathology and creates connections among the sciences.

Major Adaptive Systems in General

Major adaptive systems have a general form of organization:

$$\text{Sensory Input} \rightarrow \text{Integration} \rightarrow \text{Motor Output}$$

The patellar ("knee-jerk") reflex is a simple adaptive system with sensory input gathered from stretch receptors in the thigh (quadriceps) muscle. When the ligament below the kneecap is percussed, stretch is detected. Interneurons in the spinal cord integrate sensory input; motor output contracts the quadriceps and relaxes antagonistic muscle, protecting quadriceps length.

Although not often discussed in simple reflex systems, there is a set-point that is defended. In the patellar reflex, a set-point of *muscle tone* is regulated. Although the concept of set-point might lead one to think of a fixed value, set-points can be calibrated or adjusted to different values (Diener, Lucas, & Scollon, 2006). Set-points change dynamically based on events in other adaptive systems.

Figure 1 illustrates the principle that the nervous system contains many parallel basic behavioral systems operating at different levels from low in the spinal cord, progressing upward into the brain stem and the rest of the brain. At each level, there is input, shown schematically as entering on the left side of

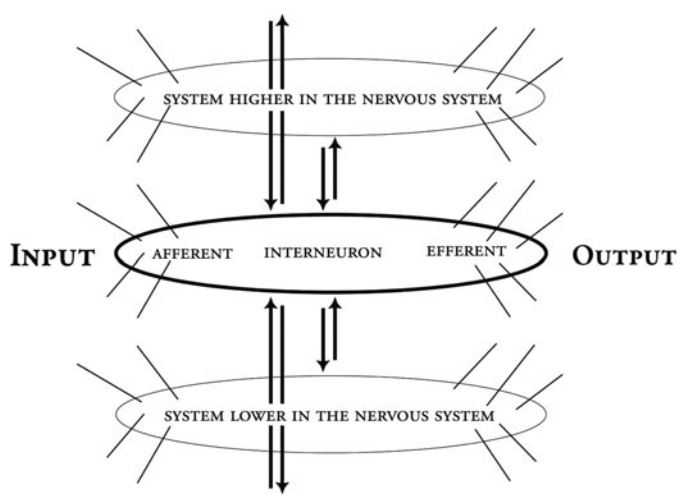


FIGURE 1.—Dynamically interacting behavioral systems.

[1]Because we focus on a few systems for which there is general agreement about function, we clarify two points. First, noting that a few systems enjoy general agreement over their function does not mean that we subscribe to the Wakefield (1992) "harmful dysfunction" formulation, which justified the mental disorders as damaging breakdowns in evolutionarily selected systems. Wakefield did not anchor his conception of psychopathology in a few psychobiological systems that enjoy widespread agreement on function. Instead, he began from the perspective of disorder, signs, and symptoms, where there might be far less agreement over function, compared to the major adaptive systems we discuss. In addition, whereas Wakefield's formulation addresses the question of which conditions are and are not mental disorders (a question that we suspect is not answerable scientifically), our analysis examines the question of how best to build theory. Second, although major adaptive systems can serve average functions relative to evolutionary history, new environments or demands can always reveal new, previously unconsidered functions. For example, Harvey considered the function of the heart to be to move blood through the circulatory system. When mechanical hearts were tried, it became apparent that a heart had to move blood without damaging red blood cells—the first mechanical hearts caused strokes. Although there might be broad consensus on function, function can never be a "fully settled question" because revealing new environments remain an open set.

Figure 1, then there is integration, shown within the oval symbol (representing the behavioral system), and finally, there is output, shown exiting from the right side of the oval. The arrows pointing up and down in Figure 1 represent another key feature of the nervous system. Levels both higher and lower in the nervous system feed information to the neurons of a behavioral system. This information from higher or lower levels can enhance or attenuate the operation of the system, and alter the set-point. This framework answers the question: "Where do set-points come from?" with the answer, "Other levels of the nervous system." Clinically, the patellar reflex is used to assess these connections with higher levels of the nervous system.

In a more complex example of set-point of behavioral systems, Bowlby (1969) described an attachment system in which proximity to the attachment figure is regulated, but the set-point of acceptable proximity is affected dynamically by an assessment of danger, with closer attachment to the secure base being required in the presence of greater perceived threat (see more recent interpretations; e.g., Mikulincer, & Shaver, 2007). How does nature traverse the great divide between the relatively simple patellar reflex to the psychological sophistication of an attachment system? We next describe the organization of small systems, allowing them to become hubs in larger systems.

Evolution creates hierarchical systems. When two distinct, separately evolved systems exist within the same organism, coordination of those systems can become a bargain add-on, if it creates fresh adaptive value. In the language of evolution, separate and uncoordinated systems are "pre-adaptations" or "exaptations" (Gould, 1991) for the evolution of a larger system composed of a coordinating hub or node connecting the preexisting parts. This evolution of coordination between separately evolved components is powerful in creating the emergent properties of living systems—properties that could not easily have been predicted from the lower order components alone.

Figure 2 sketches the organization of psychological and behavioral systems within the vertebrate nervous system. Dynamically interacting behavior systems, introduced in Figure 1, become the oval components on a larger map of the nervous system, Figure 2. The bottom of the figure represents the *caudal* (or lower) end of the spinal cord, and the top represents the *rostral* direction (moving up the spinal cord), to the anterior pole of the central nervous system. This caudal to rostral direction is so important that it is dubbed the *neuraxis,* a contraction of neural axis. These caudal to rostral levels relate to a fundamental principle of vertebrate, and more narrowly, mammalian and primate psychology. Throughout the levels of the nervous system, behavioral systems tend to be laid out segmentally, at one level along this neuraxis from the spinal cord, up to the brain stem and beyond, bringing input from one body segment into a specific level of the nervous system, integrating it locally, and then sending segmental output from that level. At brain levels, specialized senses bring information to the nervous system by cranial nerves. In turn, this information can be processed and integrated across senses, in turn exerting influence on many behavioral systems, leading to motor outputs of cranial or spinal nerves.

The up and down arrows in Figures 1 and 2 stand for integration across different levels of the nervous system, information moving either rostrally or caudally along the neuraxis. This

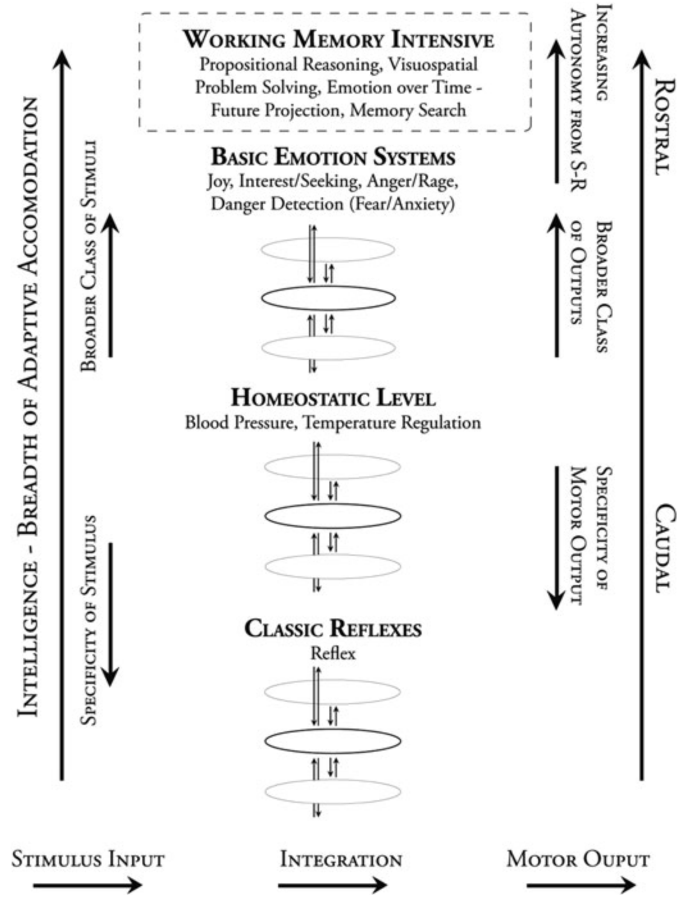


FIGURE 2.—Organization of behavioral systems within the nervous system.

integration across levels becomes a system in itself, the reticular system (Butler & Hodos, 2005). From rostral levels of the spinal cord all the way to the rostral extent of the thalamus, a reticular network of cells allows massive integration of sensory systems, motor patterns, the modulation of arousal and tone states, spreading coordinating signals locally as well as both up to the cortex and down to the spinal cord, using neuromodulators such as serotonin, norepinephrine, dopamine, and acetylcholine. Many influential psychological theories notwithstanding, there is not one form of "arousal" (cf. Schachter & Singer, 1962); instead, there are many ascending and descending coordinating systems making up the reticular system. This system helps bring unity to the behavior of the organism.

A profound organizing principle is that as one moves to more rostral levels in the nervous system, broader classes of stimuli are integrated as inputs, there is more vertical integration, and the output entrains more information from the rest of the organism. From the late 1820s, starting with Flourens's (1842) pioneering work with the pigeon, one picture has consistently emerged, shown in Figure 2: As one ascends the nervous system (i.e., moves rostrally), input processed by systems becomes more thematic and less specific, interneuron processing incorporates more information, and output becomes more informed and flexible. Allport (1937) expressed it as higher level systems or drives acquiring more *functional autonomy* from the specific stimulus. One could say that there is an increasing "intelligence" of behavioral systems as one moves in the rostral direction: Broader classes of stimuli engage the system, the integration is more profound, and the output of systems has wider behavioral topography. The homeostatic control of blood pressure integrates sensory information not only from the aortic arch, but from many stretch receptors of the circulatory system, and other assays of the extracellular fluid compartment. A drop in blood pressure does not release one specific response—it releases a suite of behavioral responses ranging from vasoconstriction to increased cardiac output to thirst. Having described general properties of adaptive systems, we now offer a specific proposal for an ROS involving five major adaptive psychological systems.

ROS for Clinical Psychology and Psychiatry

We propose that clinical assessment and description should include a review of at least five major systems for adapting to the external environment: reality modeling for action, short-term danger detection, long-term cost–benefit projection, resource acquisition, and the agenda protection systems, listed in the left column of Table 1. These systems are not merely human species-general systems: They are shared across mammals and more broadly, many vertebrates (Panksepp, 1998). This being said, in this article, we focus on the operation of these systems in our species.

Humans build and save internal mental and neural maps of the external environment that allow them to plan and act. This is the operation of the *reality modeling for action* system. We detect immediate threat of bodily injury and cues that are correlated with danger; this is the operation of the *short-term danger detection* system. Humans distinguish past, present, and future. When they easily project into the future to become aware of the potential future costs or benefits of behavior, this is *long-term cost–benefit projection*. When humans are excited or interested by resource opportunities (seeking) or pleasured by the consummation of resources (joy) this is the *resource acquisition* system in action. When humans have an important agenda that is frustrated, energy and thinking are concentrated on overcoming the obstacle; this is the operation of the *agenda protection* system.

The first major advantage to an ROS to clinical description is the recognition that all of the systems constitute critical resources for the individual. Even when a system is contributing to problems, it might also be contributing some essential adaptive functions. Anxiety is not just a disorder, it is nature's "Heads up!" Focusing on the adaptive properties of systems decisively separates the ROS from a purely pathological perspective. In designing therapy and rehabilitation from serious problems, the five major adaptive systems are essential scaffolding for building creative new adaptations. In this way, the ROS is even more positive than "positive psychology." It focuses on the positive adaptive features of systems that can generate psychologically unpleasant states. This remains true even if a particular system is quite unusual in the normative sense.

A second advantage of an ROS in descriptive psychopathology and psychological assessment is that the structure and

Table 1.—Major adaptive systems to be reviewed, related PSY–5 and *DSM–5* individual differences, great topics in the history of psychology, psychopathology, and neuroscience, pharmacology, and between-cell signaling.

Major Systems to Be Reviewed	PSY–5 (1994, 2002)[a]	*DSM–5* (American Psychiatric Association, 2013)	History of Psychology	Psychopathology	Neuroscience, Pharmacology, Between Cell Signaling
Reality modeling for action	Psychoticism PSYC	Psychoticism	Sensation Perception Memory Gestalt & latent learning Cognition Ego function	Psychoses Manias Schizophrenia Schizotypal paranoia Delusions Hallucinations	Hallucinogens DA Auto receptor blockers, long-term amphetamine use
Short-term danger detection	Negative emotionality NEGE	Negative affectivity	Anxiety, fear Aversive learning	Anxiety, Neurosis, Panic, GAD, Agoraphobia Anxiety motivated Defense mechanisms	CRF GABA receptor Benzodiazepine receptive sites 5-HT as general modulator β-blockers
Long-term cost–benefit analysis	Disconstraint DISC	Disinhibition	Lykken Mental maze Evolution: Hunter-gatherer vs. farmer, male vs. female	Psychopath, Character disorders Substance, Gambling & Externalizing	ETOH, reduced frontal lobe modulation
Resource acquisition	Introversion / low positive emotionality vs. high positive emotionality INTR	Detachment	Positive reinforcement Discriminative stimuli Law of effect Seeking/joy Exploratory Introversion/ extroversion	Anhedonia Depression Hypomania appetites and addictions Cathethexis/ decathexis	Endogenous opiates, heroin, morphine Medial forebrain bundle DA antagonists Cocaine Amphetamine
Agenda protection	Aggressiveness AGGR	Antagonism	Anger Hostility Thanatos	Instrumental aggression, submissiveness, passivity	Androgenizing hormone rage 5-HT (-) DA

Note. DA = dopamine; GAD = Generalized Anxiety Disorder; CRF = cortico-trophic releasing factor; ETOH = ethanol, potable alcohol; 5-HT = serotonin; GABA = gamma amino butyric acid.

[a]Harkness and McNulty (1994); Harkness, McNulty, Ben-Porath, and Graham (2002).

function of the systems give rise to natural cleavages, or breaking points, in the domain of mental illness. Engineers refer to "known failure modes" as characteristic and well-understood ways that an apparatus, such as bridge or missile, fails (Harkness, 2007; Marcus, 2009). Good mechanics, aware of how a device normally works, use signature patterns of breakdown to "diagnose" their underlying pathology. Ideally, psychopathology should correspond to known failure modes of major adaptive systems, helping to bring order to the classification, diagnosis, and assessment of mental illness. For example, certain psychotic disorders, like schizophrenia, might correspond to failure modes in the reality modeling for action system, whereas certain anxiety disorders, like panic disorder, might correspond to failure modes in the short-term danger detection system. Rather than providing an atheoretical "grab-bag" list of more than 300 miscellaneous ways in which the human mind goes awry, as in the *DSM–IV* (American Psychiatric Association, 2000) and *DSM–5* (American Psychiatric Association, 2013), an ROS should help to identify the underlying psychobiological systems along which human pathology fails in consistent and characteristic ways. In addition to system failure, "pathology" might also result from a system making a best attempt to adapt in a novel environment (see additional issues in Cosmides & Tooby, 1999). With an ROS, pathology is not abolished; rather, it is anchored to major adaptive systems.

Why These Five for a Clinical Psychology and Psychiatry ROS?

Much of a medical ROS examines systems that maintain what Bernard called the "milieu intérieur" (see Holmes, 1974). Clinical psychology and psychiatry, in contrast, are more concerned with major systems for adapting to external reality. In Figure 2, these homeostatic systems, defending the internal environment, are shown "above" or rostral to the spinal reflexes. Many of the systems in a medical review defend the ranges of blood pressure, the distribution of gases, temperature, ion concentrations, pH levels, energy availability, and other characteristics of the inner environment consistent with the biochemistry of life. This regulation of the internal environment is the province of systems examined in the medical ROS.

Psychology and psychiatry, in contrast, are more concerned with major systems for adapting to the *external environment*. Nevertheless, there is no bright line between internal and external systems. Each system used for adaptation to the external environment has dynamically adjusted set-points or thresholds based on the status of the milieu intérieur. Cabanac (1971) coined the term *alliesthesia* for this process (see also Paulus & Stein, 2010). A dish might either taste sublime or be disgusting depending on one's blood glucose or satiety hormone levels. Alliesthesia captures the idea that the perception of external demands and opportunities is constantly tuned by readings of the milieu intérieur. In Figure 2, for schematic simplicity, we depict emotion systems as rostral or "above" the homeostatic level. However, in reality, homeostatic and emotion systems are mixed in at the same levels extending from hindbrain to forebrain, and are well-integrated. The dynamic interaction of systems both protecting the internal environment and adapting to the external environment was also beautifully conveyed by Maslow's (1970) *hierarchy of needs:* The person needing oxygen is not interested in eating, the person in danger is interested in neither lunch nor self-fulfillment, and so on.

Over 20 Years of Research on the Personality Psychopathology Five

We describe the connection between a well-replicated model of personality and its disorders and the operation of these systems (see the second column of Table 1). We also show that the five systems proposed for our ROS, far from being linked solely to personality disorders, coincide with many of the great cross-cutting historical themes in general psychology and in all of psychopathology.

Robert F. Krueger, a leader in descriptive psychopathology, and his colleagues (Krueger et al., 2011) in describing the relationship of the PSY–5 program of research to a proposed trait model for *DSM–5* noted:

> Harkness (1992) has pursued creative and sophisticated work focused on the development and quantitative analysis of fundamental topics or core themes in PDs (Harkness & McNulty, 1994), leading to the development of the PSY–5 model and the creation of MMPI–2 scales to assess these constructs (Harkness, McNulty, & Ben-Porath, 1995). The PSY–5 includes five major constructs: aggressiveness, psychoticism, disconstraint, neuroticism/negative emotionality, and introversion/low positive emotionality. Harkness (2007, 2009) interprets several of the PSY–5 individual difference variables as indexing the stable properties of emotion systems. One major point of contrast between the PSY–5 and the DAPP and SNAP is that the PSY–5 includes a domain of psychotic experiences. (Krueger et al., 2011, p. 176)

There is now more than 20 years of published work on a PSY–5 program of research, including research leading to the PSY–5 model, the psychometrics of PSY–5 measurement, and the relation of the model to personality and psychopathology (for a review, see Harkness, Finn, McNulty, & Shields, 2012). The PSY–5 model has been constructively (conceptually) replicated (Lykken, 1968), meaning that other research groups, using other methods and samples, have arrived at the same conclusion: The domain level of personality, when including clinical ranges, is best described by a PSY–5-like model. These replications include Tackett, Silberschmidt, Krueger, and Sponheim (2008), Watson, Clark, and Chmielewski (2008), and the trait model proposed by the American Psychiatric Association's *DSM–5* Personality Disorders Workgroup.

Anderson et al. (2013) studied the convergence of the PSY–5RF scales (see Harkness et al., this issue) in the Minnesota Multiphasic Personality Inventory–2 Restructured Form (MMPI–2–RF) with the Personality Inventory for the *DSM–5* (PID–5; Krueger, Derringer, Markon, Watson, & Skodol, 2012) in an $n = 463$ undergraduate sample. They concluded, "In general, results from these analyses showed that there is convergence between the two personality psychopathology models. . . . In addition, the factor structure on the EFA provided additional support for the congruence between the PID–5 model and the PSY–5 model, thus demonstrating that these domains converge appropriately with *DSM–5* trait facets in latent multivariate space" (Anderson et al., 2013, p. 6). The five major adaptive systems assayed by the PSY–5 should exhibit this coherent structure of individual differences whether in unselected samples, undergraduate samples, or samples with clinical problems. It is an interesting irony that American psychiatry, having almost adopted a virtual copy of the PSY–5 in a workgroup proposal for *DSM–5* Personality Traits (see the third column of

Table 1), largely backed away from a possible ROS, declining at the 11th hour to place it in the major section of the new manual.

We contend that this strong replication of the PSY–5 model is not an accident of measurement or sample: It is the work of millions of years of evolution manifesting itself in stable individual differences in major adaptive systems. Although this model overlaps partly with the familiar Big Five model of personality (Goldberg, 1993), it is by no means isomorphic with it (McNulty & Harkness, 2002). Currently, the PSY–5 assessment instruments do not assess subfacets of the five domains. This differs from the Revised NEO Personality Inventory Five-factor model (FFM; Costa & McCrae, 1992), which contains six rationally derived subfacets for each domain. The rational derivation is quite clear from the fact that it would be highly unlikely, from a factor analytic perspective, for each domain to support an identical number of subfacets. Subfacets became a substantial feature of the *DSM–5* personality work group traits model. We contend that those *DSM–5* proposed subfacets represent compromises between various competing assessment programs. Although Anderson et al. (2013) found some basis for optimism about the facet structure fitting the domains, further work must establish how well *DSM–5* personality trait facets map onto the ROS.

The PSY–5 owes much to Tellegen's (1982) Constraint dimension and his emotion disposition interpretation of positive affectivity and negative affectivity (Tellegen, 1982, 1985, 1991). Krueger (2000), in a highly sophisticated analysis, found that covariations between traits assayed in persons of different degrees of relatedness had phenotypic, additive genetic, and nonshared environmental patterns of confluence suggestive of three major neural systems underlying these traits. Krueger's work remains one of the central findings in this field, and a motivating factor in this proposed ROS.

The PSY–5 Model and Individual Differences in Major Adaptive Systems

In any ROS, some problems and clinical conditions are seen as arising from individual variation in the underlying systems. For example, stable differences in visual acuity are related to the condition of the lens or where the focal plane falls relative to the retina. Stable differences in cardiac output might be related to conditions in the circulatory system, controlling nervous structures, or stable properties of particular cardiac valves or chambers. In the ROS for clinical psychology and psychiatry, stable individual differences in the major adaptive systems have long been seen as manifesting themselves as personality and its disorders. In Table 1, the second column lists the PSY–5 individual differences (Harkness & McNulty, 1994; Harkness, McNulty, Ben-Porath & Graham, 2002). The PSY–5 dimensions have long been interpreted as the relatively stable, enduring individual difference expressions of major adaptive systems (Harkness, 2007, 2009; Harkness & Hogan, 1995; Harkness & Lilienfeld, 1997; also see Izard, Libero, Putnam, & Haynes, 1993). Although the set-points guiding system onset and quiescence vary dynamically, by continuous interaction with the rest of the nervous system, there are stable individual differences in the range of set-points. Once a system begins to shape an adaptive response, the intensity and duration of system activation varies across individuals. There are also stable properties in the "intelligence" of integrating interneuron systems and in the contents of onboard learning systems that create individual differences. In addition, memory for context and specific learned cues or triggers influences the dynamic state of the system.

The Major Adaptive Systems in the History of Psychology

Individual differences in reality modeling for action, short-term danger detection, long-term cost–benefit projection, resource acquisition, and the agenda protection system are manifested in personality and its disorders. But the systems go well beyond individual differences to general psychology. The suggested ROS follows the great Darwinian and functionalist tradition in psychology. For example, it echoes the writing of the great functionalist Angell (1907), who emphasized that psychology should be the study of underlying mental operations that serve adaptive purposes, not just superficial mental contents, as the structuralists had proposed. As major evolved adaptive systems, alliesthetically linking internal needs to the dynamically changing external environment, the five systems of the ROS have appeared recurrently as fundamental themes in the history of psychology, as shown in the fourth column of Table 1. For example, the cognitive maps of Tolman's (1948) rats in latent learning and chimps assembling tools in classic Gestalt learning are topics in the reality modeling for action system. In contrast, much of classical aversive conditioning involves on-board learning in the danger detection system. Many classic studies of operant conditioning reduced animals to 90% of free feeding weight or 24 hr without water to optimize seeking and reinforcement potentiation in the resource acquisition system.

Three of the systems—danger detection, resource acquisition, and agenda protection—are emotion systems. Emotion systems allow dynamic adaptation to the external environment. Each of several basic emotion systems detects a single class of environmental challenge, such as threat of bodily injury or the ready availability of resources. Thus, they are following Allportian functional autonomy: An emotion system does not respond reflex-like to a specific stimulus, such as a hammer blow within a narrow target region of the body; instead, emotion systems can respond to the many different triggers in the environment that signal a broad class of events. Tellegen (1991) referred to this property as the *assimilative* nature of psychological systems. If an emotion system is strongly activated, then an appropriate psychological and behavioral response is organized.

Some theorists (e.g., Ekman, 1992; Ekman & Friesen, 1971; Izard, 1989; Panksepp, 1998; but see Barrett, 2011, for a different view) propose that there is a relatively small number of discrete emotion systems (e.g., fear, disgust, sadness), each evolved to detect and respond rapidly to a single class of external major adaptive problems. In the physiological versions of these theories, each distinct emotion system is organized subcortically.

Conceptualizing emotions as major adaptive systems responding to a class of environmental challenges traces its roots to Darwin's (1872/1979) *Expression of the Emotion in Man and Animals*. Many psychologists have developed modern emotion theory and science, but Ekman, Panksepp, and Izard constitute a top tier of modern emotion work. Their approach differs sharply from the James–Lange or neo-Jamesian approach. The Jamesian view begins with the thought experiment of a person seeing a bear, after which the person begins to run. Then the person detects his or her physiology of fight, freezing, or flight, and after appraising it all, concludes, "I am fearful." Note there is a curious lack of explanation of why the person began running in the first place. And note that it is not *random* running. The person is running *away* from the bear!

Cannon (1929) concluded that the Jamesian view had to be incorrect, in part because the emotion typically arose before overt behavior and external physiology had the opportunity to respond to the stimulus. Hence, Cannon contended (in our view correctly) that subcortical thalamic and hypothalamic circuits must be involved in the early stages of emotional response. Understanding of the details of subcortical circuitry has changed since the time of Cannon. Nevertheless, he was a central figure contesting the Jamesian perspective, making way for modern discrete emotion theory. To remind ourselves of some of the roots of discrete emotion theories, we can conveniently call them EPIC (Ekman, Panksepp, Izard, & Cannon) emotion systems. Three of the five systems we propose for an ROS are EPIC emotion systems. A superb treatment of the EPIC emotion systems can be found in chapters of the third edition of *The Handbook of Emotions* (Lewis, Haviland-Jones, & Barrett, 2008), and we refer readers to them in this article because they provide a broad overview and their references provide better access to primary literature than we could provide with a few citations. For each ROS system, we discuss its critical but sometimes unsung role in the history of psychology.

The Systems in the History of Psychopathology

Many of the great concerns and observations in the history of psychopathology can be seen, in retrospect, to devolve from the operation of major adaptive systems (see column five of Table 1). Although psychiatrist Adolf Meyer had some familiarity with functionalism in psychology, and early *DSM*s (which were largely Meyerian in emphasis) regarded some syndromes as "reactions," evolutionary perspectives have not been a major driving force in psychiatry. Instead of seeking underlying systems, with important notable exceptions, modern psychiatry has focused on using operationalized categories to guide empirical, trial-and-error psychopharmacology. As noted by Cosmides and Tooby (1999), "After all, not only is evolutionary biology not a standard feature of medical curricula, but it is often almost unknown" (p. 455). Since *DSM–III*'s statement of commitment to atheoretical description (American Psychiatric Association, 1980, p. 6), there has been change of direction, and each subsequent edition has trumpeted atheoretical criteria as an important advance.

The Systems Across the Sciences

For theory to be integrative, it should show the potential to reach across the sciences (Stanovich, 2009; Wilson, 1998). In reaching across scientific boundaries, a psycho-social-biological picture of an evolved major adaptive system emerges. The claims about a danger detection system, for example, cross disciplinary boundaries. Thus, the stable properties of the danger detection system should be assayed by psychological tests that examine fear and responsiveness to immediate dangers as well as the anxiety and worry associated with environments related to enhanced danger for our species. Much has been learned about the neural system for encoding immediate danger and danger-correlated contexts. Testable theories of classical, operant, and cognitive learning connecting danger signals, contexts, and responses exist. Neuroscience assertions about the input routes of sensory information to subcortical and cortical processing exist. We have assertions about the role of the central nucleus of the amygdala in signaling output to more specific nodes responsible for cortical responses, autonomic motor outputs, and emotion display systems (Davis, 1998). There are well-supported assertions about the role of the bed nucleus of the stria terminalis in organizing detection of danger-laden context (Walker, Miles, & Davis, 2009). There are density studies based on pharmaco-dynamic understanding the function of $GABA_A$ receptors with benzodiazepine binding sites in the joints between α and γ subunits (Chebib & Johnston, 1999). Work on the role of corticotropin releasing hormone in the system—and all such assertions—are the *theory-laden falsifiable* elements of an ROS approach, capable of building connectivity across the sciences.

Another major advantage of articulating each system in the languages of the appropriate sciences is that it avoids the false homogeneity often suggested by the *DSM*. Rather than seeking a single causal sequence for a supposed homogeneous entity such as autism, schizophrenia, depression, or bipolar disorder, an ROS emphasizes understanding the underlying systems as a prerequisite to understanding specific expressions of problems. All patients displaying any of these conditions have all of these evolved adaptive systems, and thus the degree of genetic overlap is no surprise (Smoller et al., 2013).

At least in its broad brushstrokes, the NIMH RDoCs initiative promotes just such a system-oriented approach. For each system, we describe some of the links to the nervous system and the biology and pharmacology of between-cell signaling and neuro-modulation, some examples of which are shown in the last column of Table 1. It is the premise of the NIMH RDoC project that these links will be intensively detailed. However we urge the RDoC initiative to consider measurement variables as being falsifiable markers of systems, not operational and unfalsifiable criteria frozen in time. The "criteria" should change as the understanding of the systems improves. We now examine the specifics of each of the five systems.

Reality Modeling for Action System

Description of the reality modeling system. Humans and other mammals use sensory integration, perception, memory, and working memory to build representations of external reality (Tolman, 1948). The internal models track the *affordances* offered by the external environment (Gibson, 1977); that is, the opportunities and demands for behavior. However, contrary to the intuitive presumption of naive realism (Ross & Ward, 1996), the nervous system does not veridically encode reality; instead, it encodes reality so as to increase local adaptation. Take, for example, how visual contrast is sharpened by lateral inhibition and how movement (for both predators and prey) is weighted more than a static stimulus. Another example is that signals of genetic fitness, such as reproductive capacity in potential partners or signals of vulnerability in the young, set off attraction or valuation mechanisms, whereas low reproductive potential in possible sexual partners (e.g., signs of obvious illness) might set off disgust mechanisms. Thus the system encodes aspects of reality so as to predispose normatively adaptive behavior. If it were to veridically encode some aspects of reality, that result would be *en passant* to its goal of organizing adaptive behavior (Kunda, 1990). Nevertheless, humans typically have complete confidence in their models of external reality. Skepticism—systematic doubt about our grasp of reality and willingness to examine falsifying evidence—so central to scientific endeavor, is an individual and cultural achievement, not a natural proclivity (Cromer, 1993; Lilienfeld, 2010; McCauley, 2011).

Individual differences in the reality modeling system: Psychoticism. Internal modeling of external reality calls on all the senses and both visuospatial and verbal memory. The net functioning of these systems entails multiple individual differences ranging from sensory acuity, as examined by Darwin's cousin Sir Francis Galton, to fluid and crystallized intelligence, to differences in gross mischaracterization of external reality, as seen in psychoticism. In psychoticism, the emphasis is on the degree of reality contact of the internal models. Contact with reality involves balancing assimilation with accommodation. Assimilation and accommodation incorporate old and new information in one of two ways (Piaget, 1951a, 1951b): (a) The new reality is bent to fit the old cognitive schema (assimilation), or (b) the old schema is altered to integrate the new information (accommodation). This can be served by "top down" versus "bottom up" action of all cortically reentrant circuits: The schema or cortical theory can drive the interpretation of sensory input (assimilation) or the sensory facts can drive alterations of cortical models (accommodation).

Both processes are essential to learning about reality. In many psychotic disorders, such as delusional disorder, we see a striking failure of accommodation; new information is merely assimilated into extant schemas. An individual who is certain he is being followed does not see anyone trailing him all day. He then concludes that his enemies are merely clever at concealment.

Reality modeling system in the history of psychology. Many chapters of the modal introductory psychology textbook are concerned with the typical operation of reality modeling for action. Sensation, perception, latent learning, memory, and cognition are highly developed fields examining the typical functioning of the reality modeling system. The important study of illusions in sensation and perception reveals an evolved system composed of many independent processors—separating stimulus from context, estimating size, location, movement, and identity.

Reality modeling system in the history of psychopathology. Major breaks in reality modeling, the loosening of verbal and visual associations, moving beyond illusion to hallucination, and the content of frank delusions are the province of psychopathology. In the history of psychopathology, a blatant disconnection from reality was one of the first remarkable phenomena named by human tribes. Although often accorded religious significance, psychosis was at times deemed to be appropriate for treatment.

Reality modeling system and connection to other sciences. This system is fundamentally cognitive. Debates arguing over whether a process is "cognitive or affective" are pointless without some relatively explicit demarcation of cognition. Panksepp (2008) usefully defined cognition as involving "the neocortical processing of information gleaned largely from environmental inputs via exteroceptive senses" (p. 48). Cognition, in this definition, is taken to include memory encoding, storage, and access. Hence, we regard the reality modeling system as fundamentally cognitive in nature.

The cranial nerves of vertebrates, and more specifically mammals, serve a variety of specialized senses. Most sensory information is processed in the thalamus before it is passed on to mono-sensory areas of the cortex. These primary sensory areas then pass this information on to specialized cortical areas for neural analysis of such questions as these: Where is the stimulus? Is it moving? What is it? Some estimates suggest that up to half of all cortical real estate in humans is involved in visual analysis (Angier, 2010). As another illustration of the link between basic sensory and higher order information processing regions, cortical auditory analysis areas are adjacent to structures serving verbal propositional analysis.

A critical feature of the far rostral or telencephalon end of the nervous system is the existence of many cortically reentrant circuits (Heimer, 2003). This refers to subcortical structures innervating the cortex, and in turn, receiving input back from the cortex. Top-down processing might allow cortical, high-end generalization to influence subcortical detail-oriented processing. Bottom-up processing might allow subcortical sensory detail and preliminary analysis to influence the broader generalizations of cortical processing. This top-down versus bottom-up interplay of cortically reentrant circuits could characterize much of mammalian information processing.

Humans have a strong ability to integrate across the senses; what psychologists and neurologists term synesthesia (Cytowic & Eagleman, 2009) is probably an exaggerated manifestation of this adaptive cross-modal propensity. Cross-sensory integration serves the ability to form a construct of an object, the still mysterious capacity that neuroscientists call *binding*. Take the concept of a key, the kind that opens a lock. When a patient is asked to blindly feel a key, he or she might name it verbally, then later connect it visually it to a picture of a key, or describe its use. This is an example of the power of polysensory integration: Our brains can take "this is what the object felt like" to generate "it probably looks like this" without awareness of the processing. Human capacity for abstraction might draw, in part, on association across sensory systems. We next turn to cortical processes that allow abstraction, working memory, and problem solving.

Working memory-intensive processes. As shown at the top of Figure 2, the rostral end of the nervous system, high-end cognitive processing, consciousness, and volitional decision processes are served by dorso- (in the brain, toward the top) and lateral (toward the sides) frontal lobe structures involved in working memory. A limited number of chunks of information can be subjected to very high-end analysis and processing (although Miller's [1956] Magic Number of 7 ± 2 might have been an overestimate; see Cowan, 2001). Although polysensory integration allows us to form constructs of an object, our unique language abilities greatly expand on the capacity for abstraction. Abstraction depends on both language and perceptual categorization (Edelman, 2008). Once a concept is abstracted, humans can pursue it to extremes. Consider the concept of numbers or of "good versus bad." Any large number can be followed by an even larger one, forming, through mathematical induction, the concept of infinity as indefinite extension. The concept of "good" and "bad" can be extended to the extremes of gods and devils. For Platonists, these abstractions are seen as more real than reality itself, as in Plato's allegory of the cave!

This workbench of consciousness collaborates in the construction and use of cognitive maps of external reality that allow for problem solving and simulation. Working memory can integrate across time and abstraction by drawing from long-term memory and applying logical rules. This ability to mentally manipulate a concept and to extend it beyond the observables serves prediction, reasoning, metacognition, and problem solving.

However, abstraction also allows for the amplification of psychological distress and abstractive disconnection from reality. The abstraction and amplification of fears, many imaginary, accompanies anxiety disorders; the amplification of the prospects for a hopeless future contributes to some cases of major depression. For some species, the fear system is activated primarily when there is a stimulus in the environment that might cause bodily harm or when dangerous context is identified. But for humans, danger analysis is potently amplified by greater abstractive ability. The capacity to think about "danger itself," to imagine things unseen, to contemplate one's death, these abilities come with the cost of fear amplified far beyond tangible events. Language and abstraction allow people to generalize from the specific moment to far broader consequences and theaters of action.

Two types of consciousness. In considering the modeling of reality, it is important to distinguish between two types of consciousness: phenomenal core consciousness and working memory-intensive consciousness. Phenomenal core consciousness involves polysensory awareness of ongoing activity, or what Neisser (1988) termed the *ecological self.* This capacity might be served by a neural map of the animal moving about its environment that is found in the modestly named optic tectum and its cortically reentrant circuitry (Merker, 2007). The visual field is experienced as one monocular field emanating from the front of the head, and this visual field is automatically perceived as closer to the forelimbs than the hind limbs. Localized sound is neurally mapped on this model of the local world. How does this organization of perception arise? In the optic tectum, neural maps of the retinal fields communicate with deeper cellular levels, putting other senses in registration to organize, by orderly connection, that neural map of the animal behaving within its life space (Butler & Hodos, 2005; Merker, 2007). The insular cortex, related nuclei, and broad transcortical communication also comprise a system in which senses, both intero- and extero-, come together with emotional awareness (Simmons et al., 2012).

Working memory-intensive consciousness might involve the inner monologue of language-based self-awareness, and other chunks assembled on the mental workbench, served by processing in the dorsolateral prefrontal cortex. Awareness of emotional feeling and the self- reflective aspects of emotional experience require engagement of this type of consciousness (Ekman, 2007; LeDoux, 1998; Lewis et al., 2008).

Pharmacological findings further connect the reality model with other sciences. Hallucinations deal with sensory systems, which have significant serotonergic modulation. The serotonergic (5-HT) indoleamine system is a deeply evolutionarily conserved neuromodulatory system that can regulate information flow (Spoont, 1992). Many hallucinogens, such as LSD-25, exhibit marked indoleamine system activity, allowing unusual sensory function. Some cannabinoid receptors have sensory effects as well. Long-term use of dopamine agonists such as amphetamines and cocaine is also associated with hallucinations, often after extensive sleep deprivation. Delusions of persecution often result from heavy amphetamine use. Another relationship of dopamine signaling to psychosis is the fact that classic antipsychotic agents block dopamine autoreceptors—molecules on dopaminergic cells that allow the cell to regulate itself. These dopamine agonists, covered again in the resource acquisition system section, are also involved in delusions—fixed beliefs at sharp variance with reality (Morrison & Murray, 2009).

As we turn from this cognitive reality modeling system to other proposed ROS systems, we draw attention to the fact that several other systems are EPIC emotion systems. However, in the intact human, the full experience of emotion involves the interaction of EPIC systems with this cognitive reality modeling system. The self-conscious emotions (Lewis et al., 2008), such as shame, intrinsically involve both EPIC emotion systems and the reality modeling system.

Short-Term Danger Detection

Three of the five major adaptive systems we propose for a clinical ROS are EPIC emotion systems. We illustrate general features of EPIC emotion systems by describing the immediate danger detection system, contained in detailed accounts such as those of Ekman (2007) and Frijda (2006). Figure 3, schematically depicting features of the danger detection system, also illustrates some general properties of EPIC emotion systems. The portion of the system that responds to immediate danger is the fear component. The accelerating signature of predator approach, loss of support, reptilian features (Öhman & Mineka, 2003), rage in others (Hansen & Hansen, 1988), loud and bright events, as well as pain and injury (Rhudy & Meagher, 2001) are well-prepared triggers for the system. On the output side, the right side of Figure 3, there is typically an increase in blood pressure and heart rate, increased flow of blood to the legs, intense cognitive focus on the threat, a characteristic facial expression, possible vocalization, the action tendency to flee (or depending on predator cues, fight or freeze), and in some cases, fear. This raises a critical point: In the operation of an EPIC emotion system, the feeling is just one optional output.

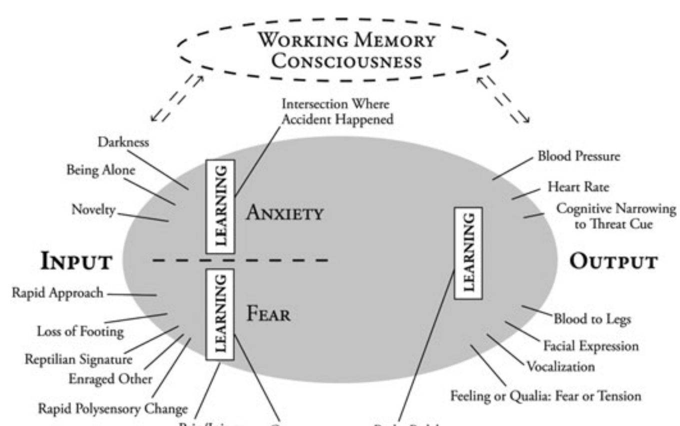


FIGURE 3.—Short-term danger detection system.

According to LeDoux (1998), consciousness of fear depends on the availability and deployment of working memory and consciousness, which has a limited capacity. In the midst of a crisis, when action to avert disaster is still possible, there might not be enough excess capacity to be conscious of the feeling. Panksepp (1998) disagreed with this perspective and considered the qualia or feeling state to be a primary part of the output of the system.

Although the evolutionary function of the system involves organizing a response to immediate danger, an additional part of the system detects cues to danger, rather than immediate danger itself. For a social primate with arboreal origins, and wonderful daytime color vision, a number of visual cues signal increased dangerousness: novel situations, rapidly approaching (looming) stimuli, being alone, darkness, strangers, and possibly treeless expanses. Such cues signal increased levels of danger and potentiate the fear system, hence the well-established phenomenon of fear-potentiated startle. Thresholds drop, and there might be output from the system without any identifiable external danger. This can lead to misattribution to internal danger—reading the increased heart rate as a signal of heart attack, as is commonly seen in panic disorder, for example.

LeDoux (1998) greatly furthered the neuroscience of the immediate danger detection system. His work showed that, certainly for auditory stimuli, there are two routes to the input side of the system. There is a quick subcortical input from the thalamus that can perform minimal stimulus analysis, which LeDoux called the low road. The high road involves more studied input from the cortex. Both roads lead to the lateral and basal nuclei of the amygdala. This input is then processed and the central nucleus coordinates output to specific downstream nuclei responsible for hypothalamic activation of the autonomic features, nuclei organizing facial output, increased startle, feedback to the cortex for stimulus focus, and so on. A tremendously important implication of the low road versus high road distinction is that an emotion system can begin to respond and steer consciousness even before there is any conscious awareness of the stimulus. This theoretical viewpoint differs radically from the typical cognitive clinical theory in which emotions are seen predominantly as downstream result of cognitive appraisals (e.g., Lazarus, 1982).

Another critical aspect of EPIC emotion systems is that they have onboard subcortical learning systems. These are illustrated by three boxes labeled *Learning* in Figure 3. Subcortically, the fear system can learn new triggers (Ekman, 2007), the anxiety system can learn new cues and contexts, and the output side can learn new responses. Consider a person who has had an accident who experiences a priming of the system as she approaches the intersection where the accident happened. As a passenger, she might even attempt to press the imagined brake pedal to slow the approach.

Some anxiety onboard learning involves a structure of the extended amygdala (Heimer, 2003), the bed nucleus of the stria terminalis. Memory for contextual cues is subserved by connections with the hippocampus and is integrated by cells of the bed nucleus (Davis, 1998; Walker et al., 2009). Onboard learning, at the level of the extended amygdala, differs from generic cognitive cortical learning, although these systems routinely interact.

Although it is conjectured that each EPIC emotion system can be brought into action by low-road fast subcortical analysis of a specific class of stimuli in the external environment, Ekman (2007) detailed a number of other ways in which each system can be activated. Certainly, the high road of cognitive appraisal is another route. Thus reflection and memory of emotional events can set off systems. Ekman further contended that making the facial expressions associated with an emotion can raise the activity of an EPIC system.

Although fear and anxiety represent two divisions of the danger detection system, they work together to detect and anticipate (over the short term) danger. Fear and anxiety are associated with largely different (a) patterns and durations of autonomic arousal, (b) neural signal pathways, (c) sets of triggers, (d) behavioral patterns, and (e) brain areas of activation (Sylvers, Lilienfeld, & LaPrairie, 2011). Additionally, psychometric studies of trait anxiety and trait fear demonstrate that they load on different higher order personality dimensions (negative emotionality and constraint, respectively) and are only moderately related ($r = .32$; Sylvers et al., 2011).

Individual differences in the danger detection system: PSY–5 negative emotionality. Negative emotionality involves individual variation in the stable parameters of systems detecting imminent threat (fear system) and the processing of correlated cues to impending danger (anxiety system). Individual differences can also arise because each adaptive system has an onboard learning capacity feature that lies outside of cognitive deliberation. This onboard learning allows mammals to adapt to novel environments that might pose a threat. People experience different environments, which creates individual differences in how one's major adaptive systems respond to stimuli. Classical conditioning could be explained by examining this onboard learning. For instance, the danger detection system is activated when an individual experiences a trauma. Although a parking garage might not have originally caused the system to be activated, after experiencing a trauma in one, the system incorporates that trigger into its memory, or trigger bank. When the person enters another parking garage, the system will be reactivated, giving rise to a renewal effect of fear (Bouton & Bolles, 1979).

Danger detection system in the history of psychology. Classical conditioning using aversive unconditioned stimuli engages the danger detection system. The ability of the nervous system to learn new predictors for the unconditioned stimulus entails onboard, amygdaloid-level learning. Learning to be anxious in the context of prior danger involves hippocampal activity and the extended amygdala circuitry of the bed nucleus of the stria terminalis. Extinction appears to require new inhibitory learning involving the ventrolateral-prefrontal cortex. In Taylor's (1953; later well-known as Janet Taylor-Spence) work, anxiety was explored as a potential modulator of aversive learning. Pavlovian reduction of discriminating cues in avoidance learning gave rise to an early connection between experimental psychology and psychopathology: experimental neurosis in dogs.

Danger detection system and psychopathology. Although the danger detection system is a highly functional major adaptive system, fear and anxiety are central players in the history of psychopathology. However, as signs or symptoms, they have often been divorced from the functionality of the system. This is because the system operates in environments very different from the environment of evolutionary adaptedness (e.g., mile-long bridges, closed-in caves, aluminum tubes flying at 35,000 ft, speaking to crowds of 100 or more persons, living alone; see Barlow, 2002). Eberly, Harkness, and Engdahl (1991) proposed that exceptional trauma often resets the danger detection thresholds in posttraumatic stress disorder.

The topics of specific fears and anxiety related to crowds, flying, reptiles, isolation, and the appreciation of mortality have long been central concerns in psychopathology. Layering the study of these phenomena on top of deep understanding of the normal functioning of the major adaptive system for danger detection would advance the study of psychopathology.

Danger detection system and the connection to other sciences. Much has been learned about between-cell signaling in the danger detection system, from enzymes that synthesize transmitters, to releasing mechanisms, to variations of postsynaptic receptor molecules, to reuptake molecules, and breakdown enzymes that terminate signals. Although it also serves as a hormone in the hypothalamic-pituitary-adrenal axis, corticotropic-releasing factor (CRF) or hormone (CRH) acts as a synaptic transmitter in this system. It is now well known that many central cells in the danger detection system are rich in a type of $GABA_A$ receptor, an inhibitory receptor responsive to benzodiazepines such as Diazepam (Valium).

Long-Term Danger and Benefit Projection System

Description of long-term danger and benefit projection system. Humans experience the world not just in three dimensions of space; they also classify experience into past, present, and future. The long-term danger and benefit projection system constrains some individuals because of what could happen in the future. Although much of the adaptation in evolution is local adaptation to the here and now, organisms that can generate accurate predictions of future conditions and conform present behavior to future danger or future benefit often gain some competitive advantage. However, this advantage can only be realized if the organism survives the present. Evolution will always weight adaptation to the here and now over adaptation to long-term future projections, if only because the threats in the former tend to be more certain. This propensity, which is only probabilistic, gives rise to a potent individual differences variable.

Individual differences in long-term cost–benefit projection system: PSY–5 disconstraint and DSM–5 *disinhibition.* Tellegen (1982) conceptualized constraint as a broad higher order dimension comprising control versus impulsiveness, harm avoidance versus risk-taking, and traditionalism or rule-following versus rule-breaking. Harkness and McNulty (1994) identified this dimension emerging from personality markers in the development of the PSY–5. In measurement, constraint is closely related to Zuckerman's (1994) construct of sensation seeking, but the explanation of the construct is far different. Rather than seeking excitement or thrills, the disconstrained end of the dimension is viewed as the suite of traits that emphasize functioning in the here and now as opposed to being limited to future consequences.

Long-term cost–benefit projection system in the history of psychology. The classic case of Phineas Gage describes a man whose emotions were constrained, and who was initially able to serve as a leader in railroad construction. In 1848, he sustained severe damage to his left frontal lobe when an iron tamping rod was propelled thorough his ventromedial prefrontal cortex (VMPFC; Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994). His personality reportedly changed from that of a respectful supervisor to that of a crude individual who no longer restrained himself from abusing substances and showed little respect to others (Haas, 2001; but see MacMillan, 2002). The VMPFC controls one's ability to regulate emotions, especially about social issues, and Gage had sustained a serious wound to that area. A meta-analysis (Morgan & Lilienfeld, 2000) found reduced executive functioning abilities in antisocial and conduct-disordered populations (see also Ogilvie, Stewart, Chan, & Shum, 2011), leading to the topic of psychopathology.

Long-term cost–benefit projection system in the history of psychopathology. This system is related to the psychopathy. For instance, Lykken's (1957) classic mental maze study revealed that Cleckley psychopaths exhibit no impairment of immediate reward learning (see the section on the Resource Acquisition System). Nevertheless, they show a distinct disadvantage in avoiding a future punishment, presumably because they are deficient in anticipatory anxiety.

This long-term cost–benefit system is involved with individuals who have trouble inhibiting impulsive desires. Excessive drinking, gambling, drug use, smoking, spending, and unconstrained sexual behaviors might be currently enjoyable, but are typically purchased with extensive costs defrayed to the future. Newer brain imaging technology, such as functional magnetic resonance imaging, has shown that a negative functional interaction of the anteroventral prefrontal cortex, on the one hand, and nucleus accumbens and ventral tegmental areas, on the other, is necessary to inhibit impulsive desires. Individuals who have higher levels of interaction between these areas are more successful than other individuals during pursuit of long-term goals even when an immediate reward is in sight (Gruber et al., 2009; see also Marsh et al., 2008).

Long-term cost-benefit projection system and the connection to other sciences. Except in the last tiny fraction of human evolutionary history, there have been two major ways for humans to earn a living: as hunter-gatherers or as farmers. Agrarians are more constrained by future consequences than are hunter-gatherers. The hunter-gatherer must be willing to take risks and act in the here and now.

Biochemical switches between constrained versus disconstrained patterns are essential not only in the farmer-hunter contrast; they are also essential in male versus female reproductive patterns (Harkness, 1997). Reproductive patterns are related to differences between human sexes in the required ratio of parenting to mating effort (Buss & Schmitt, 1993). Males can have offspring with mating effort alone. Mating effort requires risk-taking, capitalizing on spontaneous opportunities, and perhaps even rule-breaking. Such effort is supported by the same suite of traits that support the hunter-gatherer, namely disconstraint. In contrast, a female must, at minimum, parent for 9 months of pregnancy to reproduce. And typically, birth heralds only the beginning of intense demand for parenting effort over an extended period for human young, who are altricial rather than precocial. Parenting effort requires sacrifice of the present for the future, hoarding resources, harm avoidance, and encouraging a rule-bound culture, a suite of traits well fitted to agrarian culture, namely, constraint (Harkness, 1997). Data show that females are on average more constrained than males, and with age, most of us become more constrained (Harkness et al., 2002; Watson & Clark, 1993).

The long-term cost–benefit system might not attend exclusively to the future. The individual differences in this system might also involve concern with the past as a means of predicting likely future consequences of one's and others' actions—given that the best predictor of future behavior tends to be past behavior (Garb, 1998). Thus, constraint might involve not only a greater readiness to project into the future, but also to reflect on the past. In this respect, disconstraint might be related to the cognitively mediated emotion of regret and the orbitofrontal cortex. During a gambling game, in which participants received immediate feedback on the value of the option that had not been chosen, patients who had a lesion in the orbitofrontal cortex and members of the control group both displayed happier emotions and larger skin conductance responses when they won than when they lost. However, participants in the lesion group did not show the same level of disappointment as did those in the control group when they learned they could have earned more (or lost less) with the alternative choice. Thus, emotional expression was intact, but the patients were less able to cognitively integrate feedback of the cost. The patients with orbitofrontal lesions did not show regret, and the author concluded they "fail to grasp this concept of liability for one's own decision that colors the emotion experienced by normal subjects" (Camille et al., 2004, p. 1169). Thus, failing to incorporate regret could contribute to disconstrained actions.

Resource Acquisition System

Description of resource acquisition system. The resource acquisition system receives input from homeostatic systems and detects resource opportunities calibrated by needs. The psychological functioning of the resource acquisition system is schematized in Figure 4. The resource acquisition system can be primed by internal need states and sensory detection of resource opportunity, as in a child paging through a toy catalog. Because the resource acquisition system is subserved by the extended basal ganglia, which are also movement structures, engagement of this system primes approach-related motor behavior. Attention is focused on resource opportunity, although unlike the narrowing of focus generated by the danger detection system, seeking systems may open and broaden cognitive associations (Fredrickson, 2001; Isen, 2008), and memory access may be wider to allow creative planning for goal attainment. A primary positive feeling tone is enabled, but again, adequate cognitive resources in working memory must be available before there can be conscious awareness of positive feeling tone. Upon consummation, there can be joy experiences, in which recent behavioral sequences are reinforced by the release of endogenous opiates and characteristic facial expressions (Ekman, 2007).

Individual differences in the resource acquisition system: Introversion/low positive emotionality versus extroversion/high positive emotionality. Meehl's (1975, 1987) conjecture on "Hedonic Capacity" was an early contribution to individual differences in the capacity to experience joy. Tellegen

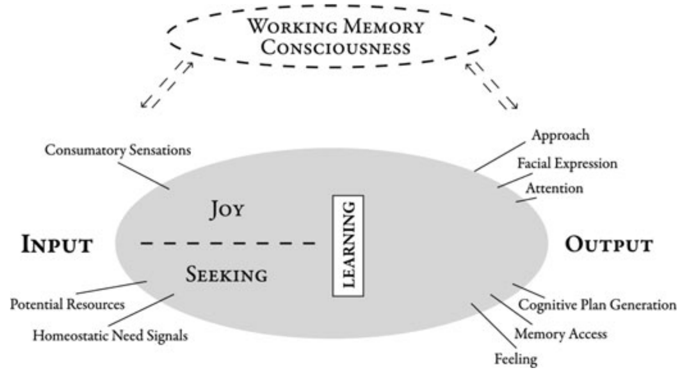


FIGURE 4.—Resource acquisition system.

(1991) developed a comprehensive picture of emotion dispositions as a central component of personality. PSY–5 individual differences in column two of Table 1 ranging from low positive emotionality to high positive emotionality are conceptualized as stable properties of the EPIC emotion system shown in Figure 4.

How this system interacts dynamically with other systems. Plans and goal-directed behavior can be rendered subservient to resource acquisition. When forebrain executive function systems have constructed plans and agendas, the anger and rage system detects frustration of those agendas, and focuses energy on the obstacle to prepare the organism to overcome it. When loved ones, health, or treasured objects are irreversibly lost, a sadness system reduces the energy that could be wasted on further attempted search or reparation, and time can instead be spent on the internal recalibration of valued objects (Gilbert, 2006; Tooby & Cosmides, 2008).

Resource acquisition system in the history of psychology. Thorndike's (1905) law of effect and the positive reinforcement of radical behaviorism involve the operation of the resource acquisition system. The confined cat in a Thorndike puzzle box, because of the Maslowian hierarchy, is highly motivated to escape. The seeking system is completely attuned to finding escape routes. Behaviors that bring about escape are highly rewarding, changing the "response hierarchy" to favor escape-providing behaviors.

Radical behaviorists strongly engaged the resource acquisition system. Rats, pigeons, and other species were dieted down to 90% of free-feeding weight or were water- deprived for 24 hr, and the reinforcer was matched precisely to the form of deprivation. These manipulations, central to the experiments, were rarely emphasized. In addition, the activation of competing adaptive systems was carefully managed: Long-term exposure to the experimental environment and sound and lightproofing were used to dampen any competing danger detection. This account is not intended to demean the many accomplishments of behaviorism. However, the results can be fully understood as the operation of the evolved resource acquisition system.

Resource acquisition system and psychopathology. Perhaps some of the most challenging patients are those who are unmotivated and uninterested. *DSM–I* (American Psychiatric Association, 1952) contained a category of "Inadequate Personality" that functioned as a catch-all for individuals with low levels of energy and poor social skills, but who might have been largely hypothymic and anhedonic. At the other end of the dimension, the hyperthymic, hypomanic, and manic become highly energized by possibilities. Here the mixture of the seeking system (starting projects) to the joy system (obtaining the culminating satisfaction) becomes critical. High seeking of joy might result in starting many things but never finishing them, a propensity often seen in patients prone to the manic phases of bipolar disorder (Fulford, Johnson, & Carver, 2008), whereas high motivation for satisfaction might result in short-circuiting the system for opiate satisfaction.

Resource acquisition system and connection to other sciences. The resource acquisition system allows organisms to seek out pleasurable resources such as food, water, and social interaction. The basal ganglia are composed of central cell body collections that subserve movement, especially the control of approach behavior. The nucleus accumbens, in the ventral pallidum, is a critical extension of the basal ganglia and an important termination point of dopaminergic fibers that subserve seeking, or incentive motivation (Heimer, 2003). The outer shell of the nucleus accumbens is rich in μ-opiate receptors, and is thought to play a central role in the positive experiences and reinforcement that accompany consummatory behavior (Depue & Lenzenweger, 2006; Patrick & Bernat, 2006).

Agenda Protection System

Description of agenda protection system. Humans learn quite a bit of culture; they are taught to do many things, such as working together to meet goals. Yet unless they are monozygotic twins, they share only 50% of their polymorphic genes with their closest, first-degree, relatives. Thus, their personal agenda, in evolutionary terms, trumps collective agendas, unless the two are aligned. Simply put, the susceptibility to cultural or social indoctrination is balanced by a system that protects one's personal agendas. The most basic outputs of the agenda protection system are anger and rage. An early example of rage is seen when a baby's arms are pinned and movement is prohibited, which in healthy infants results in a mighty struggle. The agenda protection system allows persons to overcome social and environmental obstacles that inhibit them from reaching their goals.

Although a major portion of the agenda protection system is an EPIC emotion system, the agendas are products of rostral extensions of the motor system—plans that range from the immediate motor movements of the next milliseconds to the long-term plans of the adult. This mixture of frontal lobe agenda generation and its protection by an EPIC emotion system make up a hybrid system.

Individual differences in agenda protection system: PSY–5 aggressiveness. Attempts to change our agendas bombard humans constantly—whether it is a parent attempting to control a child, a confidence artist trying to bilk a person, a teacher trying to refocus a child's attention, or a boss asserting priorities. The agenda protection system can respond with irritation or frank anger, intensifying energy and focusing cognition on the obstacles to one's agenda (Lang, Bradley, & Cuthbert, 1998). Individual differences in the use of angry offensiveness to dominate and control others lie at the core of the aggressiveness personality dimension. On one end of the dimension is submissiveness and passivity, a low capacity for assertion or agenda protection. At the other end is the readiness, and perhaps even enjoyment, of the use of threat and violence to protect or achieve one's agenda (Carver & Harmon-Jones, 2009). Although individual differences are prominent, gender differences point to a potentiating role for androgenizing steroid hormones.

Agenda protection system in the history of psychology. After the hideous spasm of death in the trenches of World War I, Freud (1922) went "beyond the pleasure principle" to describe a death drive (thanatos) that opposed the life drive (libido). As opposed to the life drive that produces life through the libido, according to this theory, the death drive seeks destruction and an escape from the buzzing sensory bombardment of life and a return to the nihilistic quiet of nonexistence. Soldiers who returned from war angry and fixated on the violence (then called war neurosis) or clients who repeated past violent relationships (trauma neurosis) seemed to Freud to provide evidence of an attraction to death—the conjectured death drive. This construct again illustrates the problem of scientifically isolated, symptom-oriented, and nonfunctionalist explanations. This theory was unappealing to experimental psychology because of its lack of falsifiability. It was also unappealing to ego-oriented psychoanalysts because of its unrelenting pessimism. Instead, experimental psychology and subsequently, social psychology examined the frustration-aggression hypothesis, central to our proposed ROS.

Dollard, Doob, Miller, Mowrer, and Sears (1939) proposed that being frustrated in one's goals could lead to aggressive behavior. Aggression can be used to overcome the obstacle that is creating the frustration. Aggression rooted in sexual jealousy functions in keeping the partner for oneself. Aggression can also result from the deflation of narcissistic individuals (Baumeister, Bushman, & Campbell, 2000), in part because it threatens their grandiose agendas.

Agenda protection system and psychopathology. In many cases, resistance to obstruction is healthy. However, the instrumental aggression used to protect one's agenda can become a problem when control systems are overtaxed. If one is fatigued, mentally occupied, or emotionally aroused, it is harder to regulate aggression and outbursts can result. Dysregulation of agenda protection might be a common factor in so-called Cluster B PDs, particularly borderline, narcissistic, and antisocial PDs, intermittent explosive disorder, and in some cases, the manic phase of bipolar disorder. Linehan's astute reconceptualization of borderline PD as a primary result of emotional dysregulation (Linehan & Dexter-Mazza, 2008), allows an understanding of how aggression might become extreme and destructive when emotion systems are not well regulated and one is kept from achieving a goal. The result can be yelling, physical violence, stalking behavior, and suicidal gestures in an attempt to achieve one's agenda.

Agenda protection system and connection to other sciences. It has long been known that anatomically distinguishable systems in mammals serve different patterns of aggressive behavior (Flynn, 1967; Panksepp, 1998). When cornered and under attack, defensive or reactive aggression can emerge. Fiber systems connecting to regions of the periaqueductal gray are thought to influence selection among types of aggression

(Blair, 2010; Panksepp, 1998), and in turn, several areas of the prefrontal cortex, such as ventromedial regions play an important role in regulation aggression and its different forms. When hunting is involved, a quiet, sneaky, predatory aggression, often termed proactive or instrumental aggression in humans, can emerge. However, when one's goals, needs, and plans are frustrated, rage-related aggression can emerge. The displays and systems of angry, or rage-related aggression, can also be used instrumentally to frighten and dominate others to achieve one's ends, often resulting in a blurring between these two forms of aggression (Bushman & Anderson, 2001).

General Summary

We have argued that a crisis in clinical description has resulted from the dominance of atheoretical approaches. We contend that clinical psychology and psychiatry would benefit from functional theory directly connecting pathology to the evolved major systems allowing adaptation to the external environment. We provided a framework for such theory, describing the structure of psychological systems, how such systems are organized with the nervous system, and principles of dynamic interaction among systems.

We then proposed a list of five major systems: reality modeling for action, short-term danger detection, long-term cost–benefit projection, resource acquisition, and agenda protection. These real evolved systems underlie many of the great historical issues in psychology and psychopathology and individual differences in normal and abnormal personality. Using the Panksepp (2008) definition, reality modeling for action is predominantly a cognitive system (cortical processing does entail both top-down and bottom-up). Long-term cost–benefit projection involves EPIC emotion systems and the time projection capacity of the reality modeling for action. It is a hybrid. These systems offer potential control over emotion systems by reasoned abstraction and projection of future consequences. Together they are systems by which a Freudian therapeutic goal, namely, to acquire better conscious control over impulses ("where there was id, there shall ego be") can be achieved.

Short-term danger detection, resource acquisition, and agenda protection are EPIC emotion systems. Influential emotion scientists and theorists such as Ekman, Panksepp, Izard, LeDoux, Tomkins, Frijda, Öhman and many others brought the great Darwinian adaptive systems out of the shadows and onto center stage in psychology. The systems have always been there in the mammals; but in the lab, the systems have often been silently controlled out, or hidden in the procedures of the report (just as the well-intentioned Ebbinghaus controlled away meaning in memory studies). In the intact person, system interaction is the norm. For example, the full conscious experience of emotion combines the cognitive reality modeling system as well as EPIC systems, just as any big event involves all systems examined in a medical ROS.

In our short list of emotion systems, we have used systems recognized by most EPIC theorists. But there are other important systems. For example, the pain system is at the evolutionary edge between a sensory system and an EPIC emotion system. It detects a very broad class of stimuli—actual injury or tissue degradation—and prepares an initially adaptive response. Like all EPIC emotion system responses, it can also engage the cognitive reality modeling system. The engagement of cognitive working memory processes makes pain catastrophizing possible: "this will never end," "the pain means I am mortally ill or wounded."

Our short-term danger detection system, with both fear and anxiety subcomponents, is more narrow than the broad individual difference variable of negative affectivity, which involves a number of other EPIC emotion systems that are essential components for adapting to external reality. Disgust could play an important role in obsessive–compulsive disorder, certain specific phobias (e.g., fear of insects), and intimacy problems (Reynolds, 2012; Rozin, Haidt, & McCauley, 2008). Sadness, another EPIC emotion system detecting irreversible loss, might play an important role in signaling the need for social support and in recalibrating the values of remaining resources (Tooby & Cosmides, 2008). Depression might be better understood as failure modes of the sadness system, and the dynamic suppression of the resource acquisition system.

Does the resource acquisition system handle it all: lust, friendship, parental and child attachment, and appetite? Or are subsystems so distinct in terms of anatomy, neuropeptide signaling, and dynamic function that they are better seen as separate systems? We conjecture that the appearance of islands of fresh cell development in the nucleus accumbens (Heimer, 2003) might accompany some instances of "neo-cathexis." The conjecture is that the desire for a new toy, a freshly desired sexual partner, a newborn daughter, and a tasty new soup flavor are all served by new cell islands. But are all classes mixed together? If so, this might argue for a single system. If there are separate regions, if they operate autonomously, with identifiably different neuro-activity and biochemical signaling, this might argue for separate systems (Panksepp, 1998). This cross-disciplinary theory building elevates such conjectures from being arguments over definition to being data-informed theoretical discussions.

ROS, RDoCs, Should Use Theory-Laden Falsifiable Measures

Theories that can connect the sciences and generate new hypotheses cannot be constructed purely from observation-level operational definitions. To be generative, a theoretical framework lays out systems of interacting components: It is compositional. Generative theory also describes how the components interact dynamically. It then provides a way of thinking about development, and it frames the systems in terms that allow all developed sciences to engage the problem. Our proposed ROS provides such a framework. In psychology, biology, and medicine, first understanding an evolved major adaptive system, such as the visual system, has always provided a framework for understanding clinical problems. Doing so has allowed pathological concepts to be layered on top of an understanding of major, evolved, adaptive systems. As understanding of the systems advances, old theory-laden measurement operations can be falsified and give way to new measurement.

In this respect, our ROS dovetails broadly with the new NIMH RDoC initiative (Insel et al. 2010), which represents a fresh and viable alternative means of doing business in the long-ossified field of clinical description. However, the C in RDoC, standing for criteria, represents a source of concern. If the C is taken to represent some gold standard of unfalsifiable measurement operations, the field will again have returned to Baconian empiricism. Instead, C should be exchanged for falsifiable markers, because measures need to be linked to substantive theory. RDoC should be *open* on the best means of measuring these adaptive systems; though some measures might be biochemical markers, it is entirely possible that individual differences in systems are best assayed using traditionally psychological (e.g., self-report, interview) measures. We urge the NIMH to adopt the spirit of falsification found in an ROS that extends even to measures, perhaps moving from RDoCs to RDoFMs!

Unfortunately, it appears that the diagnostic classification system that is "the result of historical accretion and accident without any real underlying system or scientific necessity" (Frances, quoted in Phillips et al., 2012, p. 25) has temporarily won the day for *DSM–5*. Rather than linking clinical problems to evolved major adaptive systems, the old and comfortable approach of atheoretical, surface-level categories has gained what we consider to be a temporary reprieve.

We believe that the days of this old approach are numbered. The point is often missed by advocates of Baconian empiricism: Purely atheoretical operational criteria (operational meaning they consist only of measurement operations, not theory) can never be falsified, only misapplied. How many articles have we read claiming to falsify operational criteria sets by committee? These assertions are misleading, as the arguments are over such matters as whether the epidemiological capture rates are too high or too low. If purely operational criteria can't be falsified, then in the famous phrase of Wolfgang Pauli, they are not even wrong. Explicit measurement terms are necessary in science, but unless they are connected to falsifiable theory, they are insufficient. It will take considerably more work to flesh out the ROS, to agree on some manageable set of major adaptive systems and their measurement. Yet we believe in the inevitability of this direction.

Rather than a series of disconnected conditions, human problems derive from the functioning of evolved adaptive systems. The Darwinian viewpoint was unavailable when Platonic clinical categories were being accreted. Dennett (1995) likened Darwin's contribution to a "universal acid" that "eats through just about every traditional concept, and leaves in its wake a revolutionized world-view, with most of the old landmarks still recognizable, transformed in fundamental ways" (p. 63). We think he was exactly right: Individual differences are not just an artifact of a particular factor analysis, anxiety disorders are not disconnected diseases, the psychoses are not completely unrelated, and there are not 10 "different" personality disorders. These "old landmarks," using Dennett's image, will one day be mapped onto the operation of a series of evolved, real, and understandable adaptive systems. The ROS is the way of the future. There is no stopping the universal acid.

ACKNOWLEDGMENTS

The authors deeply appreciate the work of Claire Harkness in providing the figures for this article, as well as astute comments on an earlier draft. Kyle Simmons of the Laureate Institute for Brain Research provided invaluable comments on an earlier draft of the article. Mackenzie Ayer, Jack Burgos, Jordan Heroux, Kara Kerr, Namic Kirlic, Kelsey Parker, Samantha Overstreet, Ashley Miller, Katherine Miller, and Catherine Morison, students in Allan R. Harkness's graduate course in emotion, also provided helpful comments on an earlier draft.

REFERENCES

Allport, G. W. (1937). The functional autonomy of motives. *American Journal of Psychology*, *50*, 141–156.

American Psychiatric Association. (1952). *Diagnostic and statistical manual of mental disorders*. Washington, DC: Author.

American Psychiatric Association. (1980). *Diagnostic and statistical manual of mental disorders* (3rd ed.). Washington, DC: Author.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disroders* (4th ed., text revision). Washington, DC: Author.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

Anderson, J. L., Sellbom, M., Bagby, R., Quilty, L. C., Veltri, C. C., Markon, K. E., & Krueger, R. F. (2013). On the convergence between PSY–5 domains and PID–5 domains and facets: Implications for assessment of *DSM–5* personality traits. *Assessment*, *20*, 286–294. doi:10.1177/1073191112471141

Angell, J. R. (1907). The province of functional psychology. *Psychological Review*, *14*, 61–91.

Angier, N. (2010). A masterpiece of nature? Yuck! *New York Times*. Retrieved from http://www.nytimes.com/2010/08/10/science/10ugly.html?ref=natalieangier

Barlow, D. H. (2002). *Anxiety and its disorders: The nature and treatment of anxiety and panic* (2nd ed.). New York, NY: Guilford.

Barrett, L. F. (2011). Was Darwin wrong about emotional expressions? *Current Directions in Psychological Science*, *20*, 400–406.

Baumeister, R. F., Bushman, B. J., & Campbell, W. K. (2000). Self-esteem, narcissism, and aggression: Does violence result from low self-esteem or from threatened egotism? *Current Directions in Psychological Science*, *9*(1), 26–29.

Blair, R. J. R. (2010). Psychopathy, frustration, and reactive aggression: The role of ventromedial prefrontal cortex. *British Journal of Psychology*, *101*, 383–399.

Bouton, M. E., & Bolles, R. C. (1979). Contextual control of the extinction of conditioned fear. *Learning and Motivation*, *10*, 445–466.

Bowlby, J. (1969). *Attachment and loss: Vol. 1. Attachment*. London, UK: The Hogarth Press and the Institute of Psycho-Analysis.

Bridgman, P. W. (1927). *The logic of modern physics*. New York, NY: Beaufort Books.

Bushman, B. J., & Anderson, C. A. 2001. Is it time to pull the plug on the hostile versus instrumental aggression dichotomy? *Psychological Review*, *108*, 273–279.

Buss, D. M., & Schmitt, D. P. (1993). Sexual strategies theory: An evolutionary perspective on human mating. *Psychological Review*, *100*, 204–232.

Butler, A. B., & Hodos, W. (2005). *Comparative vertebrate neuroanatomy: Evolution and adaptation* (2nd ed.). Hoboken, NJ: Wiley.

Cabanac, M. (1971). Physiological role of pleasure. *Science*, *173*, 1103–1107.

Camille, N., Coricelli, G., Sallet, J., Pradat-Diehl, P., Duhamel, J., & Sirigu, A. (2004). The involvement of the orbitofrontal cortex in the experience of regret. *Science*, *304*, 1167–1170.

Cannon, W. B. (1929). *Bodily changes in pain, hunger, fear and rage*. New York, NY: Appleton.

Carver, C. S., & Harmon-Jones, E. (2009). Anger is an approach-related affect: Evidence and implications. *Psychological Bulletin*, *135*, 183–204.

Chebib, M., & Johnston, G. (1999). The "ABC" of GABA receptors: A brief review. *Clinical and Experimental Pharmacology & Physiology*, *26*, 937–940.

Cosmides, L., & Tooby, J. (1999). Toward an evolutionary taxonomy of treatable conditions. *Journal of Abnormal Psychology*, *108*, 453–464.

Costa, P. T., Jr., & McCrae, R. R. (1992). *NEO PI–R professional manual*. Odessa, FL: Psychological Assessment Resources.

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences*, *24*, 87–185.

Craddock, N., & Owen, M. J. (2010). Molecular genetics and the Kraepelinian dichotomy: One disorder, two disorders, or do we need to start thinking afresh? *Psychiatric Annals*, *40*, 88–91. doi:10.3928/00485718-20100127-04

Cromer, A. (1993). Uncommon sense: The heretical nature of science. *Science*, *265*, 688.

Cytowic, R. E., & Eagleman, D. M. (2009). *Wednesday is indigo blue: Discovering the brain of synesthesia*. Boston, MA: MIT Press.

Damasio, H., Grabowski, T., Frank, R., Galaburda, A. M., & Damasio, A. R. (1994). The return of Phineas Gage: Clues about the brain from the skull of a famous patient. *Science*, *264*, 1102–1104.

Darwin, C. (1979). *The expression of emotions in man and animals*. London, UK: Julian Friedman. (Original work published 1872)

Davis, M. (1998). Are different parts of the extended amygdala involved in fear versus anxiety? *Biological Psychiatry*, *44*, 1239–1247.

Dennett, D. (1995). *Darwin's dangerous idea: Evolution and the meanings of life*. New York, NY: Touchstone.

Depue, R. A., & Lenzenweger, M. F. (2006). A multidimensional neurobehavioral model of personality disturbance. In R. F. Krueger & J. L. Tackett (Eds.), *Personality and psychopathology* (pp. 210–261). New York, NY: Guilford.

Diener, E., Lucas, R., & Scollon, C. N. (2006). Beyond the hedonic treadmill: Revising the adaptation theory of well-being. *American Psychologist*, *61*, 305–314.

Dollard, J., Doob, L., Miller, N., Mowrer, O., & Sears, R. (1939). *Frustration and aggression*. New Haven, CT: Yale University Press.

Eberly, R., Harkness, A. R., & Engdahl, B. (1991). An adaptational view of trauma response as illustrated by the prisoner of war experience. *Journal of Traumatic Stress*, *4*, 363–380. doi:10.1002/jts.2490040305

Edelman, S. (2008). *Computing the mind*. New York, NY: Oxford University Press.

Ekman, P. (1992). Are there basic emotions? *Psychological Review*, *99*, 550–553.

Ekman, P. (2007). *Emotions revealed: Recognizing faces and feelings to improve communication and emotional life* (2nd ed.). New York, NY: Holt.

Ekman, P., & Friesen, W. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology*, *17*, 124–129.

Flourens, P. (1842) *Recherches expérimentales sur les propriétés et les fonctions du systeme nerveux dans les animaux vertébrés* [Experimental studies of the properties and functions of the nervous systems of vertebrates]. Paris, France: Bailliére.

Flynn, J. P. (1967). The neural basic aggression in cats. In D. C. Glass (Ed.), *Neurophysiology and emotions* (pp. 40–59). New York, NY: Rockefeller University Press.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist*, *56*, 218–226.

Frijda, N. H. (2006). *The laws of emotion*. Mahwah, NJ: Erlbaum.

Freud, S. (1922). *Beyond the pleasure principle* (C. M. Hubback, Trans., and E. Jones, Series Ed.). London, UK: The International Psycho-Analytical Press. doi:10.1037/11189-001

Fulford, D., Johnson, S. L., & Carver, C. S. (2008). Commonalities and differences in characteristics of persons at risk for narcissism and mania. *Journal of Research in Personality*, *42*, 1427–1438.

Garb, H. N. (1998). *Studying the clinician: Judgment research and psychological assessment*. Washington, DC: American Psychological Association.

Gibson, J. J. (1977). The theory of affordances. In R. Shaw & J. Bransford (Eds.), *Perceiving, acting, and knowing: Toward an ecological psychology* (pp. 67–82). Hillsdale, NJ: Erlbaum.

Gilbert, P. (2006). Evolution and depression: Issues and implications. *Psychological Medicine*, *36*, 287–297.

Goldberg, L. R. (1993). The structure of phenotypic personality traits. *American Psychologist*, *48*, 26–34.

Gould, S. J. (1991). Exaptation: A crucial tool for evolutionary psychology. *Journal of Social Issues*, *47*, 43–65.

Gruber, O., Melcher, T., Diekhof, E., Karch, S., Falkai, P., & Goschke, T. (2009). Brain mechanisms associated with background monitoring of the environment for potentially significant sensory events. *Brain & Cognition*, *69*, 559–564. doi:10.1016/j.bandc.2008.11.008

Haas, L. (2001). Phineas Gage and the science of brain localisation. *Journal of Neurology, Neurosurgery, and Psychiatry*, *71*, 761.

Hansen, C. H., & Hansen, R. D. (1988). Finding the face in the crowd: An anger superiority effect. *Journal of Personality and Social Psychology*, *54*, 917–924.

Harkness, A. R. (1992). Fundamental topics in the personality disorders: Candidate trait dimensions from lower regions of the hierarchy. *Psychological Assessment*, *4*, 251–259.

Harkness, A. R. (1997). A unified psychology of sensation seeking. *Contemporary Psychology*, *42*, 200–201.

Harkness, A. R. (2005). Essential Paul Meehl lessons for personality assessment psychology. *Journal of Clinical Psychology*, *61*, 1277–1294.

Harkness, A. R. (2007). Personality traits are essential for a complete clinical science. In S. O. Lilienfeld & W. T. O'Donohue (Eds.), *The great ideas of clinical science: 17 principles that every mental health professional should understand* (pp. 263–290). New York, NY: Routledge/Taylor & Francis Group.

Harkness, A. R. (2009). Theory and measurement of personality traits. In J. N. Butcher (Ed.), *Oxford handbook of personality assessment* (pp. 150–162). New York, NY: Oxford University Press.

Harkness, A. R., Finn, J. A., McNulty, J. L., & Shields, S. M. (2012). The Personality Psychopathology Five (PSY–5): Recent constructive replication and assessment literature review. *Psychological Assessment*, *24*, 432–443. doi:10.1037/a0025830

Harkness, A. R., & Hogan, R. T. (1995). The theory and measurement of traits: Two views. In J. N. Butcher (Ed.), *Clinical personality assessment: Practical approaches* (pp. 28–41). New York, NY: Oxford University Press.

Harkness, A. R., & Lilienfeld, S. O. (1997). Individual differences science for treatment planning: Personality traits. *Psychological Assessment*, *9*, 349–360.

Harkness, A. R., & McNulty, J. L. (1994). The Personality Psychopathology Five (PSY–5): Issue from the pages of a diagnostic manual instead of a dictionary. In S. Strack & M. Lorr (Eds.), *Differentiating normal and abnormal personality* (pp. 291–315). New York, NY: Springer.

Harkness, A. R., McNulty, J. L., & Ben-Porath, Y. S. (1995). The Personality Psychopathology Five (PSY–5): Constructs and MMPI–2 scales. *Psychological Assessment*, *7*, 104–114. doi:10.1037/1040-3590.7.1.104

Harkness, A. R., McNulty, J. L., Ben-Porath, Y. S., & Graham, J. R. (2002). *The Personality Psychopathology Five (PSY–5) scales: Gaining an overview for case conceptualization and treatment planning*. Minneapolis: University of Minnesota Press.

Harkness, A. R., McNulty, J. L., Finn, J. A., Reynolds, S. M., Shields, S. M., & Arbisi, P. (this issue). The MMPI–2–RF Personality Psychopathology Five (PSY–5–RF) Scales: Development and validity research. *Journal of Personality Assessment*.

Heimer, L. (2003). A new anatomical framework for neuropsychiatric disorders and drug abuse. *American Journal of Psychiatry*, *160*, 1726–1739.

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

Isen, A. C. (2008). Some ways in which positive affect influences decision making and problem solving. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of emotions* (3rd ed., pp. 548–573). New York, NY: Guilford.

Izard, C. E. (1989). The structure and function of emotions: Implications for cognition, motivation, and personality. In I. S. Cohen (Ed.), *The G. Stanley Hall lecture series* (pp. 39–73). Washington, DC: American Psychological Association.

Izard, C., Libero, D., Putnam, P., & Haynes, O. (1993). Stability of emotion experiences and their relations to traits of personality. *Journal of Personality and Social Psychology*, *64*, 847–860. doi:10.1037/0022–3514.64.5.847

Jablensky, A. (2010). Psychiatry in crisis? Back to fundamentals. *World Psychiatry*, *9*, 29.

Kishimoto, T., Agarwal, V., Kishi, T., Leucht, S., Kane, J. M., & Correll, C. U. (2011). Relapse prevention in schizophrenia: A systematic review and meta-analysis of second-generation antipsychotics versus first-generation antipsychotics. *Molecular Psychiatry*, *29*, 1–14.

Krueger, R. F. (2000). Phenotypic, genetic, and nonshared environmental parallels in the structure of personality: A view from the multidimensional personality questionnaire. *Journal of Personality and Social Psychology*, *79*, 1057–1067.

Krueger, R., Derringer, J., Markon, K., Watson, D., & Skodol, A. (2012). Initial construction of a maladaptive personality trait model and inventory for *DSM–5*. *Psychological Medicine*, *42*, 1879–1890. doi:10.1017/S0033291711002674

Krueger, R. F., Eaton, N. R., Clark, L. A., Watson, D., Markon, K. E., Derringer, J., … Livesley, W. (2011). Deriving an empirical structure of personality pathology for *DSM–5*. *Journal of Personality Disorders*, *25*, 170–191.

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin*, *108*, 480–498.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1998). Emotion, motivation, and anxiety: Brain mechanisms and psychophysiology. *Biological Psychiatry*, *44*, 1248–1263.

Lazarus, R. S. (1982). Thoughts on the relations between emotion and cognition. *American Psychologist*, *37*, 1019–1024.

LeDoux, J. E. (1998). *The emotional brain: The mysterious underpinnings of emotional life*. New York, NY: Simon & Schuster.

Lewis, M., Haviland-Jones, J. M., & Barrett, L. F. (Eds.). (2008). *Handbook of emotions* (3rd ed.). New York, NY: Guilford.

Lilienfeld, S. O. (2010). Can psychology become a science? *Personality and Individual Differences*, *49*, 281–288.

Linehan, M., & Dexter-Mazza, E. (2008). Dialectical behavior therapy for borderline personality disorder. In D. H. Barlow (Ed.), *Clinical handbook of psychological disorders* (4th ed., 365–420). New York, NY: Guilford.

Lykken, D. T. (1957). A study of anxiety in the sociopathic personality. *Journal of Abnormal and Social Psychology*, *55*, 6–10.

Lykken, D. (1968). Statistical significance in psychological research. *Psychological Bulletin*, *70*, 151–159.

MacMillan, M. (2002). *An odd kind of fame: Stories of Phineas Gage*. Boston, MA: MIT Press.

Marcus, G. (2009). *Kluge: The haphazard evolution of the human mind*. New York, NY: Mariner Books.

Marsh, A. A., Finger, E. C., Mitchell, D. G. V., Reid, M. E., Sims, C., Kosson, D. S., … Blair, R. J. R. (2008). Reduced amygdala response to fearful expressions in children and adolescents with callous-unemotional traits and disruptive behavior disorders. *American Journal of Psychiatry*, *165*, 712–720.

Maslow, A. H. (1970). *Motivation and personality* (2nd ed.). New York, NY: Harper & Row.

McCauley, R. N. (2011). *Why religion is natural and science is not*. New York, NY: Oxford University Press.

McNulty, J. L. & Harkness, A. R. (2002). The MMPI-2 Personality Psychopathology Five (PSY–5) Scales and the Five-factor model. In B. DeRaad & M. Peruguini (Eds.), *Big Five assessment* (pp. 435–456). Seattle, WA: Hogrefe & Huber.

Meehl, P. E. (1975). Hedonic capacity: Some conjectures. *Bulletin of the Menninger Clinic*, *39*, 295–307.

Meehl, P. E. (1978). Theoretical risks and tabular asterisks: Sir Karl, Sir Ronald, and the slow progress of soft psychology. *Journal of Consulting and Clinical Psychology*, *46*, 806–834.

Meehl, P. E. (1987). "Hedonic capacity" ten years later: Some clarifications. In D. C. Clark & J. Fawcett (Eds.), *Anhedonia and affect deficit states* (pp. 47–50). New York, NY: PMA.

Merker, B. (2007). Consciousness without a cerebral cortex: A challenge for neuroscience and medicine. *Brain and Behavioral Sciences*, *30*, 63–134. doi:10.1017/S0140525×07000891

Mikulincer, M., & Shaver, P. R. (2007). *Attachment in adulthood: Structure, dynamics, and change*. New York, NY: Guilford.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, *63*, 81–97.

Morgan, A. B., & Lilienfeld, S. O. (2000). A meta-analytic review of the relation between antisocial behavior and neuropsychological measures of executive function. *Clinical Psychology Review*, *20*, 113–136.

Morrison, P. D., & Murray, R. M. (2009). From real-world events to psychosis: The emerging neuropharmacology of delusions. *Schizophrenia Bulletin*, *35*, 668–674.

Neisser, U. (1988). Five kinds of self-knowledge. *Philosophical Psychology*, *1*, 35–59.

Ogilvie, J. M., Stewart, A. L., Chan, R. C. K., & Shum, D. H. K. (2011). Neuropsychological measures of executive function and antisocial behavior: A meta-analysis. *Criminology*, *49*, 1063–1107.

Öhman, A., & Mineka, S. (2003). The malicious serpent: Snakes as a prototypical stimulus for an evolved module of fear. *Current Directions in Psychological Science*, *12*, 5–8.

Panksepp, J. (1998). *Affective neuroscience: The foundations of human and animal emotions*. New York, NY: Oxford University Press.

Panksepp, J. (2008). The affective brain and core consciousness: How does neural activity generate emotional feelings? In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of emotions* (3rd ed., pp. 47–67). New York, NY: Guilford.

Parker, G. (2006). Through a glass darkly: The disutility of the *DSM* nosology of depressive disorders. *The Canadian Journal of Psychiatry / La Revue Canadienne De Psychiatrie*, *51*, 879–886.

Patrick, C. J., & Bernat, E. M. (2006). The construct of emotion as a bridge between personality and psychopathology. In R. F. Krueger & J. L. Tackett (Eds.), *Personality and psychopathology* (pp. 174–209). New York, NY: Guilford.

Paulus, M. P., & Stein, M. B. (2010). Interoception in anxiety and depression. *Brain Structure and Function*, *214*, 451–463.

Phillips, J., Frances, A., Cerullo, M. A., Chardavoyne, J., Decker, H. S., First, M. B., … Zachar, P. (2012). The six most essential questions in psychiatric diagnosis: A pluralogue part 1: Conceptual and definitional issues in psychiatric diagnosis. *Philosophy, Ethics, and Humanities in Medicine*, *7*, 1–29.

Piaget, J. (1951a). *The origins of intelligence in children*. New York, NY: International Universities Press.

Piaget, J. (1951b). *Psychology of intelligence*. London, UK: Routledge & Kegan Paul.

Plomin, R., Haworth, C. M. A., & Davis, O. S. P. (2009). Common disorders are quantitative traits. *Nature Reviews: Genetics*, *10*, 872–878.

Popper, K. R. (1959). *The logic of scientific discovery*. London, UK: Routledge.

Reynolds, S. M. (2012). *The development of a comprehensive disgust scale* (Unpublished doctoral dissertation). Tulsa, OK: The University of Tulsa.

Rhudy, J. L., & Meagher, M. W. (2001). The role of emotion in pain modulation. *Current Opinion in Psychiatry*, *14*, 241–245.

Ross, L., & Ward, A. (1996). Naive realism: Implications for social conflict and misunderstanding. In T. Brown, E. Reed, & E. Turiel (Eds.), *Values and knowledge* (pp. 103–135). Hillsdale, NJ: Erlbaum.

Rozin, P., Haidt, J., & McCauley, C. (2008). Disgust. In M. Lewis & J. M. Haviland-Jones (Eds.), *Handbook of emotions* (3rd ed., pp. 757–776). New York, NY: Guilford.

Schachter, S., & Singer, J. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review*, *69*, 379–399.

Simmons, W., Avery, J., Barcalow, J., Bodurka, J., Drevets, W., & Bellgowan, P. (2012). Keeping the body in mind: Insula functional organization and functional connectivity integrate interoceptive, exteroceptive, and emotional awareness. *Human Brain Mapping*. Advance online publication. doi:10.1002/hbm.22113

Smoller, J., Craddock, N., Kendler, K., Lee, P., Neale, B., Nurnberger, J., … Sullivan, P. (2013). Identification of risk loci with shared effects on five major psychiatric disorders: A genome-wide analysis. *Lancet*, *381*(9875), 1371–1379. doi:10.1016/S0140-6736(12)62129-1

Smoller, J. W., Gardner-Schuster, E., & Misiaszek, M. (2008). Genetics of anxiety: Would the genome recognize the *DSM*? *Depression and Anxiety*, *25*, 368–377. doi:10.1002/da.20492

Spoont, M. (1992). Modulatory role of serotonin in neural information processing: Implications for human psychopathology. *Psychological Bulletin*, *112*, 330–350.

Stanovich, K. (2009). *How to think straight about psychology* (8th ed.). Boston, MA: Pearson.

Sylvers, P., Lilienfeld, S. O., & LaPrairie, J. L. (2011). Differences between trait fear and trait anxiety: Implications for psychopathology. *Clinical Psychology Review*, *31*, 122–137.

Tackett, J. L., Silberschmidt, A. L., Krueger, R. F., & Sponheim, S. R. (2008). A dimensional model of personality disorder: Incorporating *DSM* Cluster A characteristics. *Journal of Abnormal Psychology*, *117*, 454–459. doi:10.1037/0021-843X.117.2.454

Taylor, J. A. (1953). A personality scale of manifest anxiety. *Journal of Abnormal and Social Psychology*, *48*, 81–92.

Tellegen, A. (1982). *Brief manual for the Differential Personality Questionnaire*. Unpublished manuscript, University of Minnesota, Minneapolis. [Since renamed Multidimensional Personality Questionnaire]

Tellegen, A. (1985). Structures of mood and personality and their relevance to assessing anxiety, with an emphasis on self-report. In A. H. Tuma & J. D. Maser (Eds.), *Anxiety and the anxiety disorders* (pp. 681–706). Hillsdale, NJ: Erlbaum.

Tellegen, A. (1991). Personality traits: Issues of definition, evidence, and assessment. In D. Cicchetti & W. M. Grove (Eds.), *Thinking clearly about psychology: Essays in honor of Paul Everett Meehl* (pp. 10–35). Minneapolis: University of Minnesota Press.

Thorndike, E. L. (1905). *The elements of psychology*. New York, NY: A. G. Seiler.

Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychological Review*, *55*, 189–208.

Tooby, J., & Cosmides, L. (2008). The evolutionary psychology of the emotions and their relationship to internal regulatory variables. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.). *Handbook of emotions (3rd ed.*, pp. 114–137). New York, NY: Guilford.

Wakefield, J. C. (1992). The concept of mental disorder: On the boundary between biological facts and social values. *American Psychologist*, *47*, 373–388.

Wakefield, J. C. (1998). Philosophy of science and the progressiveness of the *DSM*'s theory-neutral nosology: Response to Follette and Houts, Part 1. *Behaviour Research and Therapy*, *37*, 963–999.

Wakefield, J. C. (1999). The concept of mental disorder as a foundation for the *DSM*'s theory-neutral nosology: Response to Follette and Houts, Part 2. *Behaviour Research and Therapy*, *37*, 1001–1027.

Watson, D., & Clark, L. A. (1993). Behavioral disinhibition versus constraint: A dispositional perspective. In D. M. Wegner & J. W. Pennebaker (Eds.), *Handbook of mental control* (pp. 506–527). New York, NY: Prentice Hall.

Watson, D., Clark, L. A., & Chmielewski, M. (2008). Structures of personality and their relevance to psychopathology: II. Further articulation of a comprehensive unified trait structure. *Journal of Personality*, *76*, 1545–1586.

Widiger, T. A., & Clark, L. A. (2000). Toward *DSM–V* and the classification of psychopathology. *Psychological Bulletin*, *126*, 946–963.

Walker, D., Miles, L., & Davis, M. (2009). Selective participation of the bed nucleus of the stria terminalis and CRF in sustained anxiety-like versus phasic fear-like responses. *Progress In Neuro-Psychopharmacology & Biological Psychiatry*, *33*, 1291–1308. doi:10.1016/j.pnpbp.2009.06.022

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

Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking*. New York, NY: Cambridge University Press.