Toward a Consilient Science of Psychology

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From its inception, psychology has been characterized by conceptual fragmentation and slow scientific progress (Henriques, 2004; Meehl, 1978). In contrast, the natural sciences have achieved in recent decades a remarkable degree of *consilience*—the linking of fact, theory, and method across disciplines (and subdisciplines) and across nested levels of informational complexity (Wilson, 1998). Although such consilience serves as a potent catalyst of scientific discovery, there exist several barriers to the emergence of a consilient science of psychology (e.g., the persistent influence of dualism, longstanding internecine discord, resistance to perceived reductionism, etc.). We discuss the manner in which the development of metatheoretical frameworks (including Henriques' Tree of Knowledge model) may play an important role in addressing such barriers. Likewise, we describe the hybrid interdisciplinary domain of *cognitive neuroscience*, which provides an empirically testable metatheory and a promising consilient bridge between psychology and the natural sciences. J Clin Psychol 61: 7–20, 2005.

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From its inception as a distinct discipline, psychology has been characterized by conceptual disarray (Henriques, 2004) and relatively slow scientific progress (Meehl, 1978). This is not to suggest any shortage of psychological research, as the field generates a massive empirical literature each year. Rather, we note that psychology's myriad and diverse programs of research are, as a rule, neither coherently connected to one another nor meaningfully linked to relevant lines of investigation in related scientific disciplines (Staats, 1999). The field has instead witnessed the relentless accumulation of assorted facts, findings, and theories that typically fail to find integration across rival research enclaves and theoretical factions (Ilardi & Feldman, 2001a; see also Miller, 1992; Staats, 1983). In short, psychology functions as an immature science (Kuhn, 1970).

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This contrasts sharply with the state of affairs within the natural sciences, among which it is widely assumed that "the world is orderly and can be explained by a small number of natural laws" (Wilson, 1998, p. 5). Not only does empirical investigation within natural science disciplines—physics, chemistry, biology, astronomy, geology, etc.—proceed under the aegis of a set of core tenets and shared foundational assumptions (i.e., a scientific paradigm), but there has also arisen a burgeoning matrix of theoretical and methodological interconnections *across* disciplines. In fact, disciplinary boundaries between the natural sciences are becoming increasingly porous, and in many cases they are now largely irrelevant, replaced instead by the continuous creation of collaborative interdisciplinary efforts, "hybrid domains" (p. 11) like molecular genetics, behavioral ecology, quantum cosmology, cognitive neuroscience, and so on. Indeed, most conceivable combinations of scientific disciplines (and subdisciplines) now participate in such collaborations.

This phenomenon of felicitous convergence among scientific disciplines has been termed *consilience* (Wilson, 1998)—the linkage of facts, methodologies, and theories across scientific domains and across multiple nested levels of complexity. Such consilient connections, of course, often serve as the essential precursors to discoveries of great importance. For example, by virtue of the consilient bridges that now exist across relevant medical and biochemical disciplines, a disorder such as cystic fibrosis is understood in considerable detail at numerous intersecting hierarchical levels of complexity (from the molecular to the systemic): i.e., as a syndrome of chronic respiratory infection and fibrous scarring caused by mucosal plugs in the lungs, in turn, caused by the body's production of abnormally viscous mucous, which is caused by insufficient chloride transport across pulmonary epithelial cells that is the result of a deficiency in the protein CFTR due to an autosomal recessive mutation on chromosome 7. The existence of such consilient connections across related disciplines (and across adjacent levels of complexity) make possible a depth and breadth of scientific understanding (and clinical application) that would be inconceivable in their absence.

Psychology, however, does not yet share the consilient status of the natural sciences. As a result, the field is not positioned to take full advantage of the advances in knowledge, understanding, and methodology that characterize natural science inquiry (Ilardi & Feldman, 2001a). Moreover, scientific progress within psychology has historically proceeded at a slow pace, inasmuch as the field's advances commonly lack the cumulative character of those that typify the natural sciences (Meehl, 1978). Instead, considerable time and resources are frequently squandered in pursuit of the next de novo "big idea," the useful half-life of which appears to be, on average, quite short. And even when psychological research does uncover meaningful relationships among phenomena, the work of explicating and extending such discoveries is often slowed by an unintentional duplication of effort, with several research programs simultaneously examining identical or closely related concepts under different monikers, ignorant of previous and concurrent work that would inform their inquiry (Staats, 1999).

In light of the nonconsilient status of psychological science, it is perhaps not surprising that the field is also in a state of considerable stagnation regarding the development of efficacious clinical interventions derived from basic psychological science (Ilardi & Feldman, 2001a; see also Dawes, 1994). Despite a flurry of clinical innovation in the 1960s and 1970s, culminating in the introduction of several highly efficacious and innovative behavioral interventions inspired by well-elaborated learning theories, the pace of innovation in clinical psychology has slowed considerably in recent years (Foa & Kozak, 1997). This situation is attributable, in part, to the relative shortage of other robust psychological scientific principles from which to derive clinical applications. Likewise, the field has witnessed surprisingly little progress toward the vital aim of delineating the mechanisms that mediate the effect of existing efficacious interventions (Kazdin & Nock, 2003).

Why Is Psychology in This State?

How might we explain psychology's status as an immature, nonconsilient science? Although the situation could plausibly be attributed to the field's relative "youth" as a scientific discipline (physics, for example, has a several-hundred-year head start), we do not regard this as a compelling line of reasoning. By convention, the founding of psychology is traced to the establishment of Wundt's lab in 1879, an event which took place a full two decades prior to the emergence of the fledgling science of genetics, and yet the latter discipline is already characterized by a very high degree of consilience despite its apparent temporal disadvantage. Perhaps a more compelling explanation is to be found in the fact that psychology examines phenomena that are vastly more complex than those addressed by the natural sciences (Staats, 1999). Inasmuch as human behavioral events reflect the real-time activity of roughly 100 billion neurons with an estimated aggregate information processing capacity in excess of 100 trillion operations per second (Moravec, 1998), such events are clearly more complex than those that serve as the subject of most natural science inquiry (e.g., the behavior of gas molecules). Indeed, one might even expect the rate of systematic progress in a given scientific field to vary in inverse proportion to the relative complexity of its subject matter. And, historically speaking, scientific inquiry has generally proceeded from the understanding of phenomena at basic, "lower-order" levels of organization (e.g., physics) to the subsequent elaboration of increasingly complex systems (e.g., chemistry, geology, biology, etc.), with the slowest scientific progress found at the highest levels of organization and complexity (e.g., psychology and the social sciences). In other words, achieving consilience is a typically a "bottom-up" process (Wilson, 1998).

Psychology's Culture: Whither Dualism and Reductionism?

There may also exist cultural obstacles to the creation of intradisciplinary coherence within psychology and the building of robust connections to other fields (i.e., the establishment of consilience)—inasmuch as the personal beliefs of scientists often exert a profound effect on their ability to make progress in their specified domains of research. "Scientists need to be aware of how hidden a priori philosophical assumptions can determine their scientific results" (Lakoff & Johnson, 1999, p. 552). For example, to the degree that a scientist subscribes to the still-widespread Western belief in mind–body dualism (the assumption that the mind is ultimately nonmaterial in nature), his or her ability to investigate the relationship between mental events and brain events may be compromised. As Dennett (1997) has noted "There are at least as many closet Cartesians [i.e., mind–body dualists] . . . among the scientists as among the uninitiated . . . and these scientists have something to learn from philosophy (whether they like it or not!)" (p. 176).

Psychologists (and other social scientists) appear to be even more prone than natural scientists to embrace an implicitly dualistic conception of human nature (Pinker, 2002). Although such a proclivity is undoubtedly due, in part, to the ongoing tension between the scientific and humanistic cultures in psychology (see Kimble, 1984), it may also reflect an unspoken fear that the eventual integration of psychology with the natural sciences—as implied by the anti-dualistic premise of a direct correspondence between mental events and physical events—will bring about the demise of psychology as a distinct discipline. After all, the legendary Karl Popper (1972) went so far as to predict psychology's reduction to biology in the "near future."

Perhaps not surprisingly, therefore, *reductionism* is often regarded as a verboten activity among psychologists, and we can attest firsthand to the widespread pejorative use of the term—as if merely to invoke the charge of reductionism were sufficient to convincingly demolish the position of anyone foolish enough to commit such a grievous error! We note, however, that reductionism is a hallmark of all mature science (Wilson, 1998). It refers merely to the practice of (a) investigating relatively complex phenomena (e.g., cellular events) by breaking them down into less complex (and more manageable) lower-order phenomena (e.g., chemical events), and (b) delineating the lawful principles whereby the lower-order phenomena map onto higher-order phenomena, and vice versa. As such, reductionism is a ubiquitous practice among natural scientists, and it is anything but controversial (indeed, each person who ingests an antibiotic in the hopes of recovering from an acute infection is embracing a de facto form of reductionism). Reductionism serves as a prime catalyst of scientific discovery, and makes possible the successful investigation of otherwise intractable scientific problems.

It is important, however, to distinguish between such "appropriate reductionism" (Dennett, 1995) and a much more radical and objectionable variety, so-called *eliminative reductionism* (e.g., Churchland, 1986). The latter is characterized by the claim that higher-order phenomena, once they have been mapped onto their lower-order constituents, may then be completely discarded (eliminated) with no attendant loss of scientific explanatory power. Such a claim is consistent with the position that psychology will one day be completely reduced to biology, itself reduced to chemistry, itself reduced to physics. In fact, the eliminative reductionist view of mental terms (e.g., thoughts and feelings) is that they will ultimately be dispensed with (Churchland, 1986), since they may in principle be mapped onto lower-order neurophysiological events and thus described in their entirety at that level. Noted philosopher of science Daniel Dennett (1995) has fittingly referred to this eliminative reductionist position as "greedy reductionism" (p. 396), inasmuch as it seeks greedily to arrogate to lower-order phenomena the full ontological status of all higher-order phenomena (which are thus regarded as the only "real" phenomena). Dennett also observes that (a) greedy reductionists are actually rather rare in the scientific community, and (b) no such complete reduction of a higher-order discipline to a lower-order discipline has ever occurred, nor is one likely to occur in the foreseeable future, inasmuch as the elimination of higher-order terms usually involves a loss of considerable explanatory power.

On the basis of the preceding discussion, we would like to suggest that the aversion on the part of many psychologists to reductionism is unwarranted, and it appears to be based, in large part, upon an unfortunate conflation of the appropriate and greedy varieties thereof. The former certainly need not imply the latter, fear of "slippery slopes" notwithstanding (Dennett, 1995; Kitcher, 1984). In fact, although the natural sciences have long been characterized by appropriate reductionism, these disciplines continue to retain their higher-order constructs and levels of explanation, because their elimination would entail a crucial loss of scientific explanatory power (Ilardi & Feldman, 2001a). Hence, we contend that the consilient linkage of psychology with the natural sciences—with their emphasis on appropriate reductionism—would not result in the demise of psychology as a discipline, but rather in the rapidly increased pace of discovery that inexorably follows in the wake of scientific consilience (Wilson, 1998).

Schisms in Psychology: Science Versus Practice

Another factor contributing to psychology's nonconsilient status is the fact that it has existed as a fragmented discipline since its inception. As Leahy (2000) observes, psychology was founded simultaneously on three separate fronts: (a) the study of consciousness (e.g., Wundt); (b) the study of the unconscious (e.g., Freud); and (c) the study of adaptation (e.g., James; Henriques, 2004; Yanchar & Slife, 1997). The contemporaneous study of different subject areas using vastly different theories and research methods led to a climate of entrenched partisanship, with each faction stating that it alone had a legitimate claim as the science of psychology (Danziger, 1990). The fragmentation of psychology actually grew over time, fueled by divisions along professional, epistemic, and theoretical lines (Yanchar & Slife, 1997).

Currently, psychology's balkanization is manifested in several major schisms, with one of the more important involving that between science and practice. During the nascent stages of psychology's development, psychoanalytic clinicians began applying putative psychological principles to real-world (i.e., clinical) situations without the support of a solid empirical foundation. Although there exist similar historical examples of the co-existence of a developing scientific discipline and related practical applications unsupported by rigorous science (as in the case of chemistry and alchemy), psychology had the "misfortune" of seeing its scientifically unsupported early practical applications meet with considerable perceived success (Leahy, 2000). For example, Freud's "talking cure" was widely regarded as helpful, at least in some cases, despite the absence of scientific evidence to support Freud's claims about why the process worked. A similar story may be told about the development of psychology's cottage industry in personality testing, based largely on the use of projective assessment techniques (Wood, Nezworski, Lilienfeld, & Garb, 2003). Hence, an economically sustainable applied psychological profession could develop without being linked functionally to a robust foundation of basic science or the gradual accumulation of scientific knowledge.

Applied psychologists are still able to maintain relative independence from the science of psychology. For example, despite a lack of convincing empirical support, many professionals continue to use therapeutic techniques analogous to those developed by Freud nearly a century ago. Indeed, there exist many clinical and counseling psychologists who actively challenge the claim that psychological treatments even require empirical support or validation (Garfield, 1996; Shapiro, 1996; cf. Chambless, 1996; Wilson, 1996). The rift between psychology's scientists and practitioners is so wide and contentious that, on more than one occasion, separate professional organizations have been formed for each group (Altman, 1987).

Science Versus Humanism

There also exists a rift between the scientific and humanistic cultures in psychology (Kimble, 1984). In this case, however, the tension results from disagreement over epistemic values (Yanchar & Slife, 1997). Kimble (1984) has described in detail the existence of these two separate psychological cultures, and documented their disagreement on such fundamental philosophical issues as determinism versus indeterminism, objectivism versus intuitionism, data versus theory, and nomothetic versus idiographic modes of investigation. Elaborating upon such divisions, Rychlak (1993) suggests that psychology is informed by four distinct camps that appear to correspond in their orientation to the values of physical science, biological science, cognitive science, and social science, respectively (Yanchar & Slife, 1997). Any attempts at uniting the field of psychology will have to find a way to link these disparate epistemic value systems in a manner that is satisfactory to all parties.

Behaviorism Versus Mentalism. The conflict between so-called mentalists and behaviorists is one of the deepest rifts in psychology, and it remains one of the major obstacles to unification (Henriques, 2004; Ilardi & Feldman, 2001a; Uttal, 2000). Ironically, the mentalist/behaviorist rift seems to have been initiated by a desire for consilient linkage between psychology and the natural sciences. In rejecting the primary subject matter (i.e., consciousness) and methodology (introspection) of the psychological inquiry of his day, John B. Watson (1913) wrote:

> Psychology, as the behaviorist views it, is a purely objective, experimental branch of natural science which needs introspection as little as do the sciences of chemistry and physics. It is granted that the behavior of animals can be investigated without appeal to consciousness. (p. 176)

Watson's clarion call for a natural science of behavior was answered by many, including the influential B.F. Skinner, who advanced the behavioral revolution with his richly elaborated theory of radical behaviorism (RB) (Skinner, 1953, 1974, 1987). Skinner claimed that RB: (a) provides a comprehensive theory of psychology, (b) permits the integration of biological phenomena into psychology, and (c) does away with the need for mentalist concepts in the prediction and control of behavior. In essence, it was claimed that RB enables psychology to achieve genuine consilience, characterized by intradisciplinary unity and linkage with the natural sciences. Consequently, RB exerted a profound influence upon academic psychology for over half of the 20th century.

The influence of radical behaviorism has, of course, waned considerably in recent decades, and there are many reasons for believing that Skinner overstated his case. First, RB does not fully eliminate the need for higher-order mentalistic concepts. Although it is assumed within RB that all mentalistic concepts can be fully reduced to discrete physical events in the brain without any loss of explanatory power, the attempt to explain human behaviors based merely on the physical states of the brain (i.e., without reference to the mental constructs which arise from the brain's information-processing activity) proves to be an impossibly complex task, even in principle (Ilardi & Feldman, 2001a). In other words, the combinatorial explosion of possible "brain states" (i.e., unique configurations of the brain's 100 trillion synapses—there are many more of such possible configurations than there are electrons in the universe) renders the project of mapping lower-order brain events onto behavioral events computationally intractable in the absence of higher-order informational constructs (e.g., mental states) that serve to vastly reduce the complexity involved in ordering brain-behavior patterns. Moreover, as Henriques (2004) points out, it would be impossible for an animal to coordinate the movement of its billions of constituent parts without making use of higher-order information processing algorithms. Simply put, mentalistic concepts are required not only to understand animal (and human) behavior, their existence is necessary to each organism's survival.

We also note that RB is incapable of providing a consilient bridge between psychology and the biological sciences. The latter are based on the root metaphor of *organism as machine*, whereas RB uses the metaphor of *behaving organism in context* (Plaud, 2001). Biological science attempts to discover the physiological states that mediate the connection between the environment and the behavior of an organism. In contrast, RB does not regard such inner states as causally relevant (Skinner, 1953). In fact, Skinner asserted that the environment has causal preeminence over any phenomena that occur inside the organism. Radical behaviorism thereby downplays the importance of proximal causes of behavior (i.e., physiological processes) in favor of distal causes of behavior (i.e., environmental phenomena). Accordingly, RB cannot consiliently link psychology to the biological sciences while simultaneously minimizing the importance of the latter subject matter in mediating behavior (Ilardi & Feldman, 2001b).

The use of mentalistic concepts in applied psychology has also led to some important clinical advances. For example, in the efficacious treatment of posttraumatic stress disorder, clinicians frequently make use of imaginal exposure (see Solomon & Johnson, 2002). This technique involves asking the client to create a mental image of the feared stimulus while simultaneously engaging in various relaxation techniques (e.g., progressive muscle relaxation). Eventually, the client experiences a reduction in feelings of anxiety. In fact, imaginal exposure appears to be as effective as in vivo exposure in reducing a subset of anxiety-related symptoms (e.g., Foa, Steketee, & Grayson, 1985; Richards, Lovell, & Marks, 1994). It is difficult for RB to explain this phenomenon without acknowledging the impact of the mental event (i.e., imaginal exposure to the feared stimulus). The beneficial nature of incorporating mental constructs in clinical work is reflected in the fact that the treatment approach with the most extensive empirical support, cognitive-behavior therapy, involves the combining of cognitive (mentalistic) techniques with traditional behavioral learning strategies. In light of the fact that behaviorism and mentalism have each made valuable contributions to the theory and practice of psychology, it would appear that neither legacy is fully expendable. Accordingly, if genuine consilience is to be achieved in psychology, these seemingly incompatible camps must be reconciled.

How Do We Get There From Here?

It is easy, of course, to criticize the current state of affairs in psychology, and much more difficult to map out a prescription for addressing its shortcomings. In this next section, we discuss the manner in which we believe psychology can progress toward a state of genuine consilience. The required changes have as much to do with altering the infrastructure of psychology as with changing the behaviors of psychologists themselves.

Generating and Evaluating Metatheories

One of the more important steps toward addressing psychology's status as an immature, nonconsilient scientific discipline will involve the generation of one or more compelling metatheories (i.e., overarching conceptual frameworks) with the potential for facilitating rapprochement across the field's myriad theoretical factions. The *Tree of Knowledge* (ToK) framework proposed by Henriques (2004) serves as one such candidate metatheory, although it is certainly not the first such attempt (see Anderson, 1996; Boneau, 1988; Gilgen, 1987; Kimble, 1997; Newell, 1990; Staats, 1975). Clearly, the mere creation of potential metatheories is not enough; the critical examination of each metatheory and its ancillary hypotheses will also be required as a crucial precursor to the field's identification and adoption of an overarching paradigmatic framework.

Evaluating metatheories is a difficult task, one made especially challenging by the fact that metatheories are not, by their very nature, directly empirically testable (Ford, 1975). Hence, their evaluation must focus on related qualitative and quantitative criteria, among them: (a) the reasonableness of their assumptions; (b) their soundness on logical grounds (e.g., a successful metatheory will be one devoid of implicit logical contradictions); (c) their ability to attract adherents and to generate activity within the field; (d) their ability to reconcile extant schisms within the field and those which may exist between psychology and other disciplines; and (e) their ability to produce tangible benefits, *especially with respect to generating fertile programs of scientific discovery and application*.

Although it will be a matter of time before Henriques' (2004) metatheory can be evaluated adequately, there exist some clues regarding its potential value. For example, the ToK model clarifies and makes explicit psychology's relationship to the natural (and social) sciences, and explains in straightforward fashion how mental phenomena are compatible with the assumed materialist monism (i.e., non-dualism) of the natural sciences. By virtue of its explicit delineation of psychological phenomena as "metaphysical" in nature, the ToK model may, in addition, help allay the widespread concern that psychology as a discipline is at risk of being reduced to lower-order natural science disciplines.

The ToK system also attends to many of psychology's internecine rifts at the theoretical level. For example, its construct of *mental behaviorism* (MB) deftly addresses the mentalist-behaviorist divide by conceptualizing mind as an emergent function of specific, quantifiable phenomena (neurally instantiated information-processing operations and overt behaviors), thereby conjoining two of psychology's most fruitful areas of empirical research (i.e., behaviorism and cognitive science) under a single conceptualization. Nevertheless, there is reason to believe that this definitional maneuver alone may be insufficient to bridge the mentalist–behaviorist divide. Indeed, Staats (1975, 1996, 1999) used a highly similar definitional approach in his introduction of *psychological behaviorism* nearly 30 years ago, only to discover that radical behaviorists generally adopted aspects of psychological behaviorism they liked but rejected the overarching metatheory, while nonbehavioral psychologists evidenced considerable resistance because to them "a behaviorism is a behaviorism is a behaviorism" (Staats, 1999, pp. 5–6).

It is thus perhaps difficult to overstate the importance of a receptive audience (or the absence thereof) in determining the ultimate influence of any metatheoretical proposal. Fortunately, however, there are hopeful signs of increasing receptivity among psychologists toward initiatives of intradisciplinary and interdisciplinary rapprochement (as evidenced, for example, by the appearance of these special issues of *Journal of Clinical Psychology*). Moreover, it appears that the broader culture outside of psychology is increasingly receptive to the notion that psychology may be meaningfully integrated with the natural sciences, as reflected in the popularity of such books as Wilson's (1998) *Consilience*, Dennett's (1995) *Darwin's Dangerous Idea*, Pinker's (1997) *How the Mind Works*, and Ridley's (2003) *Nature Via Nurture*. Thus, with pressure increasing from both within the discipline and without, the time may be ripe for the appearance of a metatheoretical framework with the potential to catalyze the development of a unified and consilient science of psychology.

Delivering the Goods

It has been argued that the ultimate test of a scientific theory is the extent to which it affects the real world (Laudan, 1977). And, despite the considerable efforts dedicated to generating a rational model of science based on philosophical realism (i.e., the notion that science progresses by telling us about the world as it *really is*), this *pragmatist* attitude toward scientific progress is becoming increasingly influential (Leahy, 2000). From the pragmatist's perspective, scientific theories and hypotheses are ultimately judged, neither by their conceptual elegance nor their number of enthusiastic adherents, but by the extent to which they "deliver the goods." In other words, a theory is only as good as its practical real-world impact. In this vein, Laudan (1977) contends that science is ultimately to be viewed as a problem-solving activity. Successful unifying scientific theories (i.e., metatheories) are thus the ones that, over time, solve the greatest number of problems and propose new problems that also can be addressed (Leahy, 2000). In his typically eloquent style, William James (1907) may have best summed up the pragmatist view:

> Pragmatism asks its usual question. "Grant an idea or belief to be true," it says, "what concrete difference will its being true make in anyone's life? How will the truth be realized? What

> experiences will be different from those which one would obtain if the belief were false? What, in short, is the truth's cash-value in experiential terms?" (p. 97)

Based on pragmatist principles, any theory or discipline in a field will be judged to have merit only after it demonstrates tangible payoffs. Such payoffs in psychology will include generating highly effective treatments for mental illness, providing increasingly accurate prediction of human behavior, and creating novel areas of fruitful psychological research.

At the Threshold of Consilience: The Role of Technological Development

Kuhn (1970) proposed that immature sciences are characterized by a progressive process of "natural selection," in which rival schools of thought and associated theories compete until one particular framework wins out as a result of its empirical fertility (i.e., its ability to deliver the goods). However, it is also the case that technological innovation frequently serves as a necessary impetus and precursor to scientific maturation. Specifically, scientific disciplines become better equipped to generate and evaluate rival paradigms as their methods for observing and measuring phenomena become more sophisticated and more accurate.

Technological advancement, therefore, may serve as a key rate-limiting step in the process of disciplinary maturation. For example, the ancient Ptolemaic (earth-centered) model of the solar system did not receive its mortal blow until 1609, when Galileo was able to make use of emerging telescope technology to discover Jupiter's moons, and thereby to demonstrate that not all celestial objects orbited the earth (Hawking, 1996). In other words, the advent of a new technology played a direct role in propelling the science of astronomy forward. Advances in technology likewise catalyzed the maturation of physics, chemistry, and biology (Asimov, 1966; Brock, 1993; Burke, 1996; Judson, 1995).

The development of cognitive science provides an illustration of this principle in action within a psychological domain. Conceptualizations about mental events have existed since the beginning of psychology; however, the absence of a method for reliably observing and quantifying mental phenomena enabled the behaviorist school to dominate empirical psychological research for much of the middle part of the 20th century, and the workings of the mind were largely ignored. It was not until the advent of a technology that enabled one to peer into the previously un-navigable waters of information processing that mentalist concepts were allowed to reemerge.

During World War II, Norbert Wiener was working for the military at the Massachusetts Institute of Technology on developing mechanisms for guiding anti-aircraft artillery, missiles, and airplanes (Gardner, 1985). The technological advances that resulted from this work inspired Wiener to make the analogy between engineered feedback systems and the human nervous system and to launch the field of cybernetics (Wiener, 1961). Another formative event for cognitive science occurred in 1948, when legendary mathematician John von Neumann presented a paper comparing the brain to a new invention, the electronic computer. A decade later, Von Neumann (1958) would elaborate on these thoughts in his seminal book, *The Computer and the Brain*. The computer became an important tool for cognitive science because it served as a "proof-of-concept" regarding the viability of instantiating informational (i.e., mental) constructs in observable physical mechanisms. As Gardner (1985) pointed out: "The computer made it legitimate in theory to describe human beings in terms of plans, images, goals, and other mentalistic conceptions" (p. 33). Gardner went on to conclude that it was the advent of computers that enabled scientists to begin to study the mind: "There is little doubt that the invention of computers in the 1930s and 1940s . . . were powerfully liberating to scholars concerned with explaining the human mind" (p. 40).

Thus, the advent of computers and other information technology following World War II made it possible for cognitive psychologists to begin creating working models (albeit rather crude ones) of human mental events as information processing operations (Massaro & Cowan, 1993). In similar fashion, the emergence in recent decades of powerful neuroimaging techniques (e.g., PET, SPECT, MRI, QEEG, fMRI) has made possible the examination of brain activity in real time and thereby given rise to a new multidisciplinary domain, cognitive neuroscience (CN), that evidences perhaps the greatest potential of any realm of psychological inquiry in bringing about a consilient science of psychology.

Cognitive Neuroscience as a Bridge to Consilience

Cognitive neuroscience (CN) enjoins the collaborative efforts of researchers from many disparate fields—psychology, neurophysiology, behavioral ecology, computer science, genetics, and psychiatry among them—drawn together in pursuit of answers to the fundamental question: "How do brain events give rise to mental and behavioral events?" (Tooby & Cosmides, 1995). Although the CN enterprise is of very recent provenance, it is presently witnessing a "heroic period" of scientific discovery (Wilson, 1998; see also Gazzaniga, 2000) and dramatic advances in elucidating the workings of the human mind–brain relationship at the molecular, neuronal (cellular), and higher-order neural computational levels. To take just one recent example, Goldapple and colleagues (2004) have observed that cognitive therapy for depression brings about salubrious reductions in the activity level of frontal circuits involved in the process of depressive rumination, whereas antidepressant medication appears to exert its effect principally upon the more "primitive" subcortical neural circuits that regulate mood—a finding with numerous potential clinical applications.

As described in detail elsewhere (Ilardi & Feldman, 2001a; Ilardi, 2002), CN researchers share a set of unifying tenets and metatheoretical assumptions (e.g., "All human mental events occur as the result of neural information processing" (Ilardi & Feldman, 2001a, p. 1072); cf. Pinker, 1997; Tooby & Cosmides, 1995) that together constitute a de facto scientific paradigm. Of crucial significance is the fact that the CN paradigm, by virtue of its rigorous integration of both the theory and method of biological science, is already linked in consilient fashion with the metatheoretical framework of the natural sciences (Wilson, 1998). Accordingly, CN provides an implicit consilient bridge between psychology and biology (and related natural science disciplines). Moreover, the CN paradigm, by virtue of its ability to provide a coherent conceptual account of the relationship between mental events and brain events, appears to have the potential for bringing about considerable rapprochement among at least some of the field's fragmented theoretical "enclaves," including those at opposite poles of the mentalist–behaviorist continuum (Ilardi, 2002; Ilardi & Feldman, 2001a).

It is perhaps also important to note at this juncture the striking points of convergence between the CN paradigm and Behavioral Investment Theory (BIT; Henriques, 2004), the facet of the ToK model that addresses the interrelationship of psychological and biological science. These points of theoretical overlap between CN and BIT include the shared assumptions that: (a) neural organs are evolved to represent and process information about the environment; (b) mental events are isomorphic with brain events; (c) mental events are the result of neural information processing; (d) purposeful human behavior is the result of neural information processing; and (e) gene expression is an important determinant of neuronal structure and functioning (and, by extension, of mental and behavioral responding).

Of course, a key distinction between the CN and ToK metatheories resides in the fact that only the former has emerged in the context of a highly fertile multidisciplinary program of research (one that is "delivering the goods"). However, we note that while CN provides a "bottom-up" consilient bridge between psychology and lower-order natural science domains, it does little in the way of addressing the need for consilience with disciplines that investigate higher-order social phenomena (e.g., the social sciences). In view of the bottom-up trajectory of consilient linkage that has thus far been observed across the natural sciences (including, most recently, cognitive neuroscience; Wilson, 1998), it could be argued that the establishment of lower-order consilience (i.e., between psychology and the natural sciences) will serve as a necessary precursor to the occurrence of higher-order consilience (i.e., between psychology and the social sciences). In other words, first things first! Nevertheless, because the ToK metatheory provides an account of the manner in which both higher-order and lower-order phenomena may be conjoined, we believe this model (unlike CN) has promise in providing an impetus for the necessary establishment of consilient programs of research at the nexus of cognitive neuroscience, psychology, and the social sciences.

A Vision of Psychology's Future: Consilience and Concinnitas

We are optimistic about the future of psychology, one in which it emerges as a mature paradigmatic science capable of reaping the benefits of consilient linkage with the natural sciences. And, despite fears to the contrary, it will not be subsumed under biology. Nevertheless, psychology's disciplinary boundaries will become more porous and, ultimately, more meaningless, as interdisciplinary efforts become the norm and the field becomes increasingly interwoven with related scientific domains at multiple nested levels of complexity. A heuristic roadmap to such a future is to be found in Henriques' (2004) metatheoretical framework, one which, if it proves capable of passing the pragmatist test (i.e., delivering the goods vis-à-vis novel and generative programs of research), may play a role in bringing about a consilient science of psychology.

The great Florentine architect Leon Battista Alberti used the Latin term *concinnitas* to refer to ultimate harmony: a regulating and unifying balance that reconciles opposing forms into a beautiful whole, such that nothing could be added or subtracted but for the worse. Although the term has long been reserved for describing the work of artists in their attempts to create beauty, scientific consilience (harmony achieved across opposing domains of inquiry) and artistic *concinnitas* ultimately reflect the same ideal. Psychology is, then, a science in search of *concinnitas*. For too long it has languished in a state of fragmentation, with competing professional, epistemic, and theoretical camps pulling the field in myriad competing directions, such that there is little forward movement at all. Turning this maelstrom of activity into a harmonious whole will require heroic measures of inspiration and perspiration from many. It will be difficult, but it will be achieved.

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