A Century After Freud's Project: Is a Rapprochement Between Psychoanalysis and Neurobiology At Hand?

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A CENTURY AFTER FREUD'S PROJECT: IS A RAPPROCHEMENT BETWEEN PSYCHOANALYSIS AND NEUROBIOLOGY AT HAND?

In his 1895 "Project for a Scientific Psychology" Freud attempted to construct a model of the human mind in terms of its underlying neurobiological mechanisms. In this endeavor "to furnish a psychology which shall be a natural science," Freud introduced the concepts that to this day serve as the theoretical foundation and scaffolding of psychoanalysis. As a result, however, of his ensuing disavowal of the Project, these speculations about the fundamental mechanisms that regulate affect, motivation, attention, and consciousness were relegated to the shadowy realm of "metapsychology." Nonetheless, Freud subsequently predicted that at some future date "we shall have to find a contact point with biology." It is argued that recent advances in the interdisciplinary study of emotion show that the central role played by regulatory structures and functions represents such a contact point, and that the time is right for a rapprochement between psychoanalysis and neuroscience. Current knowledge of the psychobiological mechanisms by which the right hemisphere processes social and emotional information at levels beneath conscious awareness, and by which the orbital prefrontal areas regulate affect, motivation, and bodily state, allows for a deeper understanding of the "psychic structure" described by psychoanalytic metapsychology. The dynamic properties and ontogenetic characteristics of this neurobiological system have important implications for both theoretical and clinical psychoanalysis.

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On April 27, 1895, Sigmund Freud wrote his friend Wilhelm Fliess that he was preoccupied, indeed obsessed, with a problem that had seized his mind. In what would turn out to be a creative spell, he was attempting to integrate his extensive knowledge of brain anatomy and physiology with his current experiences in psychology and psychopathology in order to construct a systematic model of the functioning of the human mind in terms of its underlying neurobiological mechanisms. In the preceding month he had completed the final chapter on psychotherapy for *Studies on Hysteria*, and at this point in time, twenty years into his professional career, he had produced over a hundred neuroscientific works. Yet in his letter to Fliess he openly admitted that "I am so deeply immersed in the 'Psychology for Neurologists' as to be entirely absorbed until I have to break off, really exhausted by overwork. I have never experienced such intense preoccupation. I wonder if anything will come of it?" (Jones 1953, p. 380).

Throughout the summer Freud continued to relay to Fliess messages of both his progress and frustration with the Project, describing his mood as alternately "proud and happy" or "ashamed and miserable." Breuer wrote to Fliess in July that "Freud's intellect is soaring at its highest" (Sulloway 1979, p. 114). In September Freud feverishly began putting his ideas in writing, and within a month he had filled two notebooks totaling a hundred manuscript sheets. He sent this draft to Fliess in early October. In a letter of October 20, commenting on his ambitious attempt to work out the direct links between the operations of the brain and the functions of the mind, he wrote: "One evening last week when I was hard at work, tormented with just that amount of pain that seems to be the best state to make my brain function, the barriers were suddenly lifted, the veil drawn aside, and I had a clear vision from the details of the neuroses to the conditions that make consciousness possible. Everything seemed to connect up, the whole worked well together, and one had the impression that the Thing was now really a machine and would soon go by itself. . . . Naturally I don't know how to contain myself for pleasure" (Jones 1953, p. 382). The state of elation and excitement would not last. A month later he admitted to Fliess, "I no longer understand the state of mind in which I hatched out the 'Psychology,' and I can't understand how I came to inflict it on you" (p. 383). In fact, he never asked for the return of the manuscript and never wanted to see it again. Fliess kept it, however, and after Freud's death it was finally published in 1950 under a title devised by Strachey, "Project for a Scientific Psychology."

Despite Freud's disappointment with this work and his repudiation of it, Strachey (1966) characterized the essay as an "extraordinarily ingenious working model of the mind and a piece of neurological machinery" (p. xvii). Ernest Jones (1953) called it "a magnificent tour de force" and concluded that the experience released in Freud "something vital in him that was soon to become his scientific imagination" (p. 384). Yet Jones also wrote that the Project "imposes more exacting demands on the reader than any of his published work; there must be very few who can apprehend its full meaning with several perusals" (p. 383). More recently, Sulloway (1979) has asserted that "no other document in the history of psychoanalysis has provoked such a large body of discussion with such a minimum of agreement as Freud's Project" (p. 118). And Gay (1989) has offered the observation that "the Project, or rather its invisible ghost, haunts the whole series of Freud's theoretical writings to the very end . . ." (p. 87).

What was Freud attempting to accomplish, and why did the seeming possibility of achieving this goal create in him an exhilaration he was hardly able to contain, yet his failure trigger a quick and seemingly irreversible repudiation? What are the contents of this controversial document that appeared at the dawn of psychoanalysis, at a point that immediately preceded the period of Freud's self-analysis, and how did they influence his subsequent thinking? How did Freud later view the possibility of a rapprochement between neurobiology and psychoanalysis, and why do the issues first broached in the Project critically relate to the current status of psychoanalysis as it enters its second centennium?

At the very outset of the Project, Freud proclaims that its essential aim "is to furnish . . . a psychology which shall be a natural science" (p. 295). He then presents, for the first time, a number of constructs that will serve as the foundation, the very bedrock of psychoanalytic theory. In this remarkable document Freud introduces the concepts of the primary and secondary processes (which Jones calls Freud's most fundamental contribution to psychology); the principles of pleasure-unpleasure, constancy, and reality testing; the concepts of cathexis and identification; the theories of psychical regression and hallucination; the systems of perception, memory, and unconscious and preconscious psychic activity; and the wish fulfillment theory of dreams.

These ideas are very familiar to us, but it should be mentioned that this seminal work also contains Freud's earliest thoughts about the essential nature of affect and motivation, two problematic concepts he would struggle with the rest of his career. In Freud's neuropsychological model of a living organism interacting with its environment, energies from the external world impinge on sensory neurons, thereby filling them with a "sum of excitation" or "quota of affect" that is proportional to the impinging energy. It is the fundamental property of each neuron, and therefore of the organism, to rid itself of excitation through a process of discharge. The organism also receives stimulation from within, from primary needs, and these stimuli too give rise to excitations that must be discharged through a motor apparatus. Affect is brought about by a sudden discharge of previously stored excitation. Freud speculates that although affect is initiated by environmental stimulation, it is supported and augmented by the resulting endogenous excitation. An affect can be precipitated also by the environmental activation of a memory that is charged with an endogenously originating load.

Freud's special interest in the problem of regulation also first appears in the Project, which in essence suggests "a model whereby excitation from various sources arising both from within and from outside the individual might be regulated by processes essentially within the individual" (Sander 1977, p. 14). Freud posits a close connection between affect and primary process, noting that memories capable of generating affect are "tamed" to the point that the affect provides only a "signal." In his later writings Freud never strayed too far from (nor really expanded upon) these basic principles of affect and its regulation. To this day, psychoanalysis stands in need of a comprehensive theory of affect.

Most important, each of these phenomena is described by Freud in a language that was familiar to him, a scientific language of cerebral physiology and physics. And each individual psychic function is presented in the context of an overall attempt to build a comprehensive neuropsychology of brain functioning. In order to construct this model of the brain mechanisms corresponding to processes central to his psychodynamic approach (Segalowitz 1994), Freud, the skilled scientist and neurologist, had to deduce the existence of certain neurobiological phenomena that were not yet discovered. For example, though he speaks of the essential function of "contact barriers," Sherrington was not to introduce the term *synapse* until two years after the Project was finished. Freud also refers to the critical activity of "secretory neurons" in the brainstem, yet the biogenic amines of the reticular core of the brain were not discovered until well into the twentieth century.

If it is true that Freud disavowed the Project, why are we so familiar with the concepts it introduced? Ernest Jones points us to the answer—it is contained in the seventh chapter of Freud's masterwork, *The Interpretation of Dreams*. On February 13, 1896, Freud wrote Fliess that he had revised the Project and formally renamed it "metapsychology." This was the same year that he would use the term *psychoanalysis* for the first time. In "On the History of the Psycho-Analytic Movement," Freud (1914) stated that *The Interpretation of Dreams*, though published in 1900, "was finished in all essentials at the beginning of 1896" (p. 22). Here, in the work that Freud publicly declared to be "the starting point of a new and deeper science of the mind," he "employed a working model of the mind very similar to the one he had in the 'Project' and also a good many of the same fundamental conceptions, *but the physiological terminology has almost entirely disappeared*" (Jones 1953, p. 395; emphasis added).

In other words, every major psychoanalytic concept introduced by Freud in the Project was originally accompanied by a model of its underlying mechanism. He initially formulated these mechanisms on the basis of his biological and neurological knowledge. He then chose to keep the mechanisms intact while leaving their neurobiological foundations implicit. "But deprived of their roots and explicitness, the mechanisms became isolated from contemporary developments in science . . . " (Pribram and Gill 1976, p. 10).

Freud's disavowal of the Project occurred at the moment of birth of psychoanalysis. It should be remembered that "at the turn of the century neuroscience had very little to offer dynamic psychology as it was attempting to localize psychological processes in discrete cortical regions" (Solms and Saling 1986, p. 411), a position that Freud (1891) had rejected in *On Aphasia*. His ambivalence about the import of achieving an overarching integration between psychoanalysis, psychology, and neurobiology is echoed throughout his later writings. In *The Interpretation of Dreams* he proclaimed, "I shall entirely disregard the fact that the mental apparatus with which we are here concerned is also known to us in the form of an anatomical preparation, and I shall carefully avoid the temptation to determine psychological locality in any anatomical fashion. I shall remain upon psychological ground . . . " (1900, p. 536). In 1916, in *Introductory Lectures on Psycho-Analysis,* he asserted that "psycho-analysis must keep itself free from any hypothesis that is alien to it, whether of an anatomical, chemical or physiological kind, and must operate entirely with purely psychological auxiliary ideas; and for that very reason, I fear, it will seem strange to you to begin with" (1916–1917, p. 21).

Yet at about this same time, in "The Claims of Psycho-Analysis to Scientific Interest," Freud (1913) stated: "We have found it necessary to hold aloof from biological considerations during our psycho-analytic work and to refrain from using them for heuristic purposes, so that we may not be misled in our impartial judgement of the psycho-analytic facts before us. But after we have completed our psycho-analytic work *we shall have to find a point of contact with biology*; and we may rightly feel glad if that contact is already assured at one important point or another" (pp. 181–182; emphasis added).

How is the Project thought of today? McCarley and Hobson (1977) argue that this work represents the source from which Freud developed the major concepts of his psychoanalytic model, and Gay (1989) declares that it "contains within itself the nucleus of a great part of Freud's later theories . . . " (p. 87). In the opinion of Solomon (1974), "What Freud attempted in the 'Project' was a monumental effort, an attempt to overcome the dualism that plagued and still plagues psychology and neurology" (p. 39). According to Sulloway (1979), Freud "never abandoned the assumption that psychoanalysis would someday come to terms with the neurophysiological side of mental activity" (p. 131). He points out that the Project is rather modern in its interdisciplinary approach. Not at all reductionistic, it "combines clinical insights and data, Freud's most fundamental psychophysicalistic assumptions, certain undeniably mechanical and neuroanatomical constructs, and a number of organic, evolutionary, and biological ideas—into one remarkably well-integrated psychobiological system" (p. 123). Most recently, Myron Hofer (1990), whose work is now linking psychobiology and psychoanalysis, concludes that the Project "anticipated the development of new scientific fields to a degree that gives it an air of uncanny prescience when read today" (p. 56).

In perhaps the most detailed and comprehensive analysis to date, the psychoanalyst Merton Gill, in collaboration with the neuroscientist Karl Pribram, suggests in *Freud's 'Project' Re-Assessed* that the work's "importance lies in the fact that it contains explicit formulations and definitions of many central concepts and terms of that branch of psychoanalytic theory known as metapsychology, concepts and terms that Freud continued to use throughout his life but never again defined as explicitly and comprehensively" (Pribram and Gill 1976, p. 5). These authors argue that the concrete neurobiological hypotheses in the Project are subject to testing and modification in light of new findings and alternate conceptualizations. In other words, the obscure concepts of psychoanalytic metapsychology, especially Freud's germinal hypotheses concerning the regulatory structures and dynamics that underlie the mechanisms of affect, motivation, attention, and consciousness, may be illuminated by modern neurobiology. Further, they contend, Freud felt "that ultimately this psychoanalytic science could be rejoined to its biochemical and neurological origins, but that (a) *the time was not right* and (b) this rejoining would not be a simplistic 'taking over' or 'reductive explanation' of psychoanalytic knowledge in biochemical or neurophysiological terms" (p. 168; emphasis added).

THE CURRENT SITUATION

At this moment, in what is widely hailed as "The Decade of the Brain," can a rapprochement between psychoanalysis and neurobiology be at hand? Let me state straight out that to my mind *the time is right*. Psychoanalysis, currently described as in a state of "vibrant ferment" (Wilson 1995), is perhaps more than ever ready for this rapprochement, the possibility of which poses it an essential challenge. The central core of its model of the mind, almost unchanged for most of its first century, is now undergoing a period of rapid transformation. The scaffolding of clinical psychoanalysis is supported by underlying theoretical conceptions of psychic development and structure, and it is these basic concepts that are now being reformulated, largely as a result of the vital contributions made by contemporary developmental psychoanalysis.

I will argue that the "point of contact with biology" that Freud sought is to be found specifically in the central role of right brain psychobiological processes in the organization and regulation of affect, motivation, and unconscious cognition. Although psychoanalysis has reworked many of Freud's initial conceptualizations, it is only now beginning to reevaluate his original model of emotion. Moreover, an ever increasing number of theoreticians and clinicians are now emphasizing the fundamental significance of affect regulation in both intrapsychic and interpersonal functioning. Indeed, "affect theory is increasingly recognized as the most likely candidate to bridge the gap between clinical theory and general theory in psychoanalysis" (Spezzano 1993, p. 39).

Even as psychoanalytic theory undergoes profound changes, a host of bordering disciplines, now freed from the narrow behavioral model that dominated psychology for much of this century, are actively probing questions about the internal processes of mind, questions that for too long were deemed to be outside the realm of "scientific" analysis and were addressed only by psychoanalysis. In *Affect Regulation and the Origin of the Self* (Schore 1994), I document how a spectrum of sciences—from developmental, cognitive, physiological, and social psychology to sociobiology and behavioral neurology—are now researching the covert yet essential mechanisms, especially those involving the role of emotional states, that underlie overt behaviors. More specifically, psychobiology is currently detailing the neurochemical mechanisms that mediate affective functions, while psychophysiology is now systematically investigating the bidirectional transduction of psychological and physiological processes that underlie mind-body relations. And neurobiology is elucidating the operations of the brain systems involved in the processing of emotional information, especially the limbic and cortical circuits that mediate affect and its regulation. Recent advances in the new fields of "affective neuroscience" (Panksepp 1991) and "social neuroscience" (Cacioppo and Berntson 1992), in conjunction with data from the more established area of "cognitive neuroscience" (Gazzaniga 1995), are giving us a more detailed picture of the brain structural systems that mediate the psychological and, especially, the emotional phenomena that Freud began to describe in the Project.

This work is providing important clues to the identification of psychic structure—psychoanalytic models of internal structural systems should not be reduced to neurobiology but should be compatible with current knowledge of brain structure. This means that "psychic structure" needs to be defined in terms of what is currently known about biological structure. Workers pioneering at the interface of psychoanalysis and neuroscience are now making valuable contributions to this effort (Hadley 1989; Levin 1991; Miller 1991; Reiser 1985; Schwartz 1992). Further, Cooper (1985) argues that "neurobiology can help us to understand which of our concepts are unlikely and which are congruent with biologic experimentation" (p. 1402). This brings psychology, and along with it psychoanalysis, back to biology. The integration of neurobiological with psychological perspectives, of structure-function relationships, Freud's starting point in the Project, is absolutely essential to future advances in contemporary psychoanalysis, whose primary focus is now being described by Langs and Badalamenti (1992) as "human emotional development and functioning" (p. 163). Indeed, in their latest works, Modell (1993), Gedo (1991), Lichtenberg (1989), and others are now turning to neuroscience to identify the components and dynamic properties of psychic structures.

Let me return now to where we began, to the issues first raised in the Project. Pribram and Gill (1976) contend that "the *Project* is specific in detail as to how the neural structures that regulate behavior—i.e., the organism's motivational structures—come to be" (p. 48). If Freud's metapsychological theories of psychic structure are inadequate or elementary, then what can modern neurobiology tell us about the anatomical nature and functional properties of the brain systems that regulate the intrapsychic mechanisms that mediate adaptive psychological (especially emotional), motivational, and social functioning?

It has been known for some time that the sides of the frontal lobes between the hemispheres, as well as the pathways between and just under the hemispheres that connect the cortex with the subcortical drive and affective integrative centers, subserve unique roles in emotional processes. The work of A. R. Luria, perhaps the most important clinical neuropsychologist of this century, clearly demonstrates that the orbital prefrontal cortex acts as the essential cortical system adaptively modulating lower structures, inhibiting drive, and regulating arousal and activity states (Figures 1–2). Luria extensively documented neurological disturbances of the orbital frontal regions that elicit gross changes in affective processes in the form of lack of self-control, emotional outbursts, generalized disinhibition, and disorganization of personality. (It is interesting to note that in his youth Luria was influenced by Freud. During the 1920s he established a psychoanalytic society in Kazan and translated Freud's work into Russian.)

In fact, due to the link between impaired prefrontal activity and dysregulated states, at midcentury the ablation of the orbital regions was utilized by psychiatry to treat intractable severe psychiatric disorders. Indeed, the sectioning of the pathways between this cortex and the subcortex defines the lobotomy procedure (Hofstatter, Smolik, and Busch 1945). The disciplined study of lobotomized patients allowed researchers to determine which functions are associated with this system; indeed, psychoanalytic studies were conducted on a few of these patients. Ostow (1954), for instance, reported that these individuals

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FIGURE 1. Approximate boundaries of functional zones of the human cerebral cortex, showing the dorsolateral and orbital prefrontal areas (from Kolb and Whishaw 1990).

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FIGURE 2. Computerized reconstruction of magnetic resonance (MR) imaging of a coronal section of the human brain. Notice orbital gyri (from Damasio 1995).

lack a depth of personality, and present with a loss of the ability to create derivatives of instinctual drives, to fantasize and process unconscious wish fantasies, and to maintain a fully affective consciousness of self. Earlier, Frank (1950) had observed that patients with sectioned orbital cortices show impairments in the preconscious functions of internalization and symbolic elaboration; he concluded that a loss of orbitofrontal activity leads to an "emotional asymbolia." It is important to note that in the 1950s the first extensive anatomical studies of the orbitofrontal regions were reported. Much of this early work was conducted by Karl Pribram, who wrote works not only with Merton Gill but also with Luria, a fellow pioneer of modern neuroscience.

It is only within this decade that experimental studies have began to provide more detailed anatomical and functional information about this relatively unexplored area of the brain. The orbital frontal cortex (so called because of its relation to the orbit of the eye) is "hidden" in the ventral and medial surfaces of the prefrontal lobe (Price, Carmichael, and Drevets 1996). In addition to receiving multimodal input from all sensory areas of the posterior cortex and relaying to the motor areas in the anterior cortex, this cortical system uniquely projects extensive pathways to other limbic structures in the temporal pole and amygdala, to subcortical drive centers in the hypothalamus, to arousal and reward centers in the midbrain, and to vagal nuclei and autonomic centers in the medulla oblongata (Figures 3–5). These connections with both the cortex and the subcortex allow the system to act as a "convergence zone," one of the few brain regions that is "privy to signals about virtually any activity taking place in our beings' mind or body at any given time" (Damasio 1994, p. 181). But the system is responsive also to events in the external environment, especially the social environment. Studies demonstrate that orbitofrontal neurons fire in response to emotional expressions of the human face (Thorpe, Rolls, and Maddison 1983) and that this structure is functionally involved in attachment processes and in the pleasurable qualities of social interaction (Steklis and Kling 1985).

The orbital prefrontal area is situated at the hierarchical apex of the limbic system, the brain system responsible for the rewarding-excitatory and aversive-inhibitory aspects of emotion (Figure 6). It also functions as a major center of CNS control over the energy-mobilizing sympathetic and energy-conserving parasympathetic components of the ANS that are involved in emotional behavior. Its stimulation elicits, in addition to

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FIGURE 3. Lateral view of the human right hemisphere. Note the position of the orbital sulci (28) and gyri (29) in the frontal undersurface (from Nieuwenhuys, Voogd, and van Huijzen 1981).

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FIGURE 4. Photograph of the base of the human brain showing orbital gyri and sulci at sites labeled B (from Watson 1977).

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FIGURE 5. Relationships of brainstem structures to the orbital surface of the right hemisphere (from Smith 1981).

alterations in biogenic amines in the reticular formation, changes in neurohormonal levels in the hypothalamus, pituitary, and adrenals. The brain and body state changes produced by these biochemical activities are phenomenologically experienced as the onset of an emotion. Most significantly, in the cortex *the orbitofrontal region is uniquely involved in social and emotional behaviors, and in the homeostatic regulation of body and motivational states* (Schore 1994, 1996).

Its position at the interface of higher and lower brain structures enables the orbital system to play an essential adaptive role. At the orbitofrontal level, cortically processed information concerning the external environment (e.g., visual and auditory stimuli emanating from the emotional face of the object) is integrated with subcortically processed information regarding the internal visceral environment (e.g., concurrent changes in the emotional or bodily self state), thereby enabling incoming information about the environment to be associated with motivational and emotional states. Neuroanatomists describe that the function of this system as involved with the internal state of the organism and as "closely tied to the synthesis of object-emotion relationships in a behavioral context" (Pandya and Yeterian 1990, p. 89). Orbitofrontal areas subserve memory and cognitive-emotional interactions and are activated during the mental generation of images of faces. These areas are specialized to participate in the encoding of high-level psychological representations of other individuals (Brothers and Ring 1992). This system thus possesses the operational capacity to generate an internalized object relation—that is, a self-representation, an object representation, and a linking affect state (Kernberg 1976), or a Representation of Interactions that have been Generalized (RIG) (Stern 1985). Similarly, Edelman (1987) describes the brain's creation of models of environment, images of a context, which consist of the internal state of the brain as it responds to certain objects and events in the world.

The orbital prefrontal region is especially expanded in the right cortex, the hemisphere responsible for regulating homeostasis and modulating physiological state in response to both internal (i.e., visceral) and external (i.e., environmental) feedback. Because the early maturing (Chiron et al. 1997) "primitive" right cortical hemisphere has extensive reciprocal connections with limbic and subcortical regions (more so than the left), it is dominant for the processing, expression, and regulation of emotional information (Joseph 1988; Porges, Doussard-Roosevelt, and Maiti 1994). This prefrontal region comes to act in the capacity of an

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FIGURE 6. Midsagittal view of the right cerebral hemisphere, with brainstem removed. The limbic association cortex is indicated by the dotted region. Note the orbital gyri (from Martin 1989).

executive control function for the entire right cortex, the hemisphere that modulates affect, nonverbal communication, and unconscious processes. Most intriguingly, the activity of this "nondominant" hemisphere, and not the later-maturing "dominant" verbal-linguistic left, is instrumental to the capacity of empathic cognition and the perception of the emotional states of other human beings (Voeller 1986). The right hemisphere contains an affective-configurational representational system that encodes self- and object images in a manner uniquely different from the lexical-semantic mode of the left brain (Watt 1990). According to Hofer (1984), internal representations of external human interpersonal relationships serve an important intrapsychic role as "biological regulators" that control physiological processes.

The orbitofrontal system, "the thinking part of the emotional brain" (Goleman 1995, p. 313), is an essential component of what Langs (1996) calls "the emotion-processing mind, . . . the cognitive mental module . . . responsible for human adaptations in the emotional realm" (p. 106). The system plays a major role in the internal state of the organism (Mega and Cummings 1994), the temporal organization of behavior (Fuster 1985) and the appraisal (Pribram 1987; Schore 1997b) and adjustment or correction of emotional responses (Rolls 1986)—that is, affect regulation. The system acts as a recovery mechanism that efficiently monitors and autoregulates the duration, frequency, and intensity of both positive and negative affect states. This allows both for the ability to use affects as signals and for a self-comforting capacity that can modulate distressing psychobiological states and reestablish positively toned ones. The essential activity of this psychic system is the adaptive switching of internal bodily states in response to changes in the external environment that are appraised to be personally meaningful. This orbitofrontal function mediates "the ability to alter behavior in response to *fluctuations in the emotional significance of stimuli"* (Dias, Robbins, and Roberts 1996, p. 69). In its unique position at the convergence point of right cortical and subcortical systems, it critically influences the superior role that the nonverbal right brain plays in the control of vital functions supporting survival and enabling the organism to cope actively and passively with stress and external challenge. Recall that Freud's structural model (1923) theorizes a system that regulates the individual's adaptation to the environment.

Further, this neurobiological system is identical to the internalized structure described by Stolorow, Brandchaft, and Atwood (1987) that modulates and contains strong affect. That structure is a central component of a brain system, detailed by Fraiberg (1969), that generates the complex symbolic representations of evocative memory and allows the individuals experiencing a negative state to evoke the image of a comforting other. The system thus enables the individual to recover from disruptions of state and to integrate a sense of self across transitions of state, thereby allowing for a continuity of experience in various environmental contexts. These capacities are critical to the operation of a self system that is both stable and adaptable. Damasio (1994) also concludes that the orbital prefrontal cortex plays an essential adaptive role in the bioregulatory and social domains. His neurological studies reveal that this homeostatic system is an essential component of what he terms "the neural self" that generates "somatic markers" expressed as emotions. In convergent findings in the psychoanalytic literature, Modell (1993) concludes that "the continuity and coherence of the self is a homeostatic requirement of the psyche-soma," a finding that suggests to him "the frontier between psychoanalysis and biology" (p. 48).

IMPLICATIONS OF INTERDISCIPLINARY RESEARCH FOR PSYCHOANALYSIS

This returns us again to our starting point, the interface of psychoanalysis with the other sciences. To my mind, the borderland between disciplines gives us entry to domains of science yet to be explored, including the conscious and unconscious realms of the human mind that is engaged in this exploration. An important benefit of interdisciplinary approaches to the study of internal processes is that they allow us to reframe metapsychological hypotheses about affect, motivation, consciousness, and psychic structure in a manner that renders them heuristic and "falsifiable" (Popper 1962). Grünbaum (1986) has asserted that "if there exists empirical evidence for the principal psychoanalytic doctrines, it cannot be obtained without well-designed extra-clinical studies of a kind that have for the most part yet to be attempted" (p. 217). That endeavor is now under way.

With reference to the hundredth anniversary of Freud's attempt to create a biological psychology, Krystal (1992) concludes that "the more we learn and the more we check our views against the new developments in other sciences, the more we can solve our hitherto insoluble problems, and we are more able to refine our views and approaches" (p. 409). In that spirit, let me cite some examples of how interdisciplinary integrations can help us clarify a number of metapsychological conundrums long unresolved. First I will focus on theoretical psychoanalysis, presenting current findings from other sciences that relate to the concepts of (1) drive, (2) internal representations, and (3) consciousness, awareness of emotional states, and dreaming. Then I will briefly discuss the relevance of current research for clinical psychoanalytic conceptions of psychopathology and treatment.

Theoretical Implications

Drive. Neurobiological studies show that the orbitofrontal cortex and its cortical and subcortical connections critically participate in the adaptive functions of mediating between external environment and internal milieu, in balancing internal desires with external reality, and in modulating drive excitation and drive restraint. This system is therefore uniquely and centrally relevant to psychoanalysis, since its operational capacities define Freud's internal mechanism, first outlined in the Project, that regulates excitation from sources within and without the individual. The system is also identical to a controlling structure, described by Rapaport (1960), that maintains constancy by delaying press for discharge of aroused drives, states of psychic excitation that impel the individual to activity geared at alleviating it (Freud 1920). "In Freud's most widely used definition," write Greenberg and Mitchell (1983), "drive is a concept at the frontier between the psychic and the somatic, an endogenous source of stimulation which impinges on the mind by virtue of the mind's connection with the body" (p. 21). As Holzman and Aronson (1992) have recently written, "In acknowledging the powerful role of anticipations and planning in the emerging reality principle, [Freud] might have had some interest in contemporary neuropsychological studies of the frontal lobes in providing the organic infrastructure for channeling drives" (p. 72).

In *Descartes' Error*, Damasio (1994) argues that emotions are "a powerful manifestation of drives and instincts" and emphasizes their motivational role: "In general, drives and instincts operate either by generating a particular behavior directly or by inducing physiological states that lead individuals to behavior in a particular way . . ." (p. 115). Descartes' error, carried forward into present-day psychological and medical sciences, is specifically the separation of the operations of the mind from the structure and operation of a biological organism, the body. In the psychoanalytic literature, Deri (1990) reminds us that the ego functions within the context of a total psychobiological organism; she warns of "the danger of a purely psychological model that disregards the unavoidable psychosomatic oneness of a functioning human being" (p. 518). Recent psychobiological and neurobiological studies thus strongly indicate that *the concept of drive, devalued over the last twenty years, must be reintroduced as a central construct of psychoanalytic theory.*

Internal Representations. Multidisciplinary findings can clarify another metapsychological construct central to clinical psychoanalysis, the concept of internal representation. Freud introduced the term *object representation* in *On Aphasia*, his neurological treatise of 1891. His first discussions include not only ideas about the nature and formation of representations but also speculations on the underlying brain mechanisms. He notes specifically that the physiological correlate of a representation is "something in the nature of a process" (1891, p. 55). Freud thus concludes that neither the psychological representation nor its physiological correlate can be localized in a structure, and yet later theorists have confused structure with function, asserting erroneously that representations *are* structures. In 1991, exactly one hundred years after *On Aphasia*, Pribram concludes, in *Brain and Perception*, that a representation is not "an immutable structure" but rather "a process" (p. xxvii).

After Freud, our understanding of the concept of internal representations was greatly advanced by Hartmann, who argued that the concept of self-representation was a logical extension of Freud's object representation, and by Jacobson and Kernberg, who emphasized the affective linkages between object representations and self-representations. Loewald (1970) stressed the important principle that what becomes internalized are not objects but relationships and interactions. In developmental work, Beebe and Lachmann (1988) have shown that affective experiences with the early social environment are mentally stored in the form of interactive representations of the self emotionally transacting with significant objects. There is now evidence that the development of parental representations and the development of self-representations occur in synchrony (Bornstein 1993) and that internal representations of self and other evolve in hierarchical stages and encode templates that influence the child's expectations, perceptions, and behavior vis-à-vis the interpersonal environment (Horner 1991). Most important, the current interdisciplinary research on affect regulation strongly supports

Schafer's assertion (1968) that internalization is fundamentally a transformation of external regulations into internal ones.

Meanwhile, the concept of mental representations has been accepted and absorbed into developmental, social, and cognitive psychology, as well as into neurobiology. The neuroscientist Eric Kandel (1983) has written that "by emphasizing mental structure and internal representation, psychoanalysis served as a source of modern cognitive psychology" (p. 1281). As mentioned earlier, studies in these fields now indicate that internalized representations of relationships act as "biological regulators." My own integrative work suggests that the same interactive representations are distributed in the orbital cortex and its cortical and subcortical connections, and that they act as templates guiding interpersonal behavior. They contain information about psychobiological state transitions and encode strategies of affect regulation that are accessed in order to switch internal bodily states in response to changes in the external environment that are appraised to be emotionally meaningful.

Thus, a century after Freud outlined his concept of representation, science is now able to use it heuristically. Recent interdisciplinary research has validated and expanded upon the concept, as now the fundamental function of representations is best described as not mental but psychobiological. Current neurological thinking holds that the brain represents the outside world in terms of the modifications it causes in the body proper (Damasio 1994). This might appear to be a significant departure from Freud's original conception, but is it? In *On Aphasia* Freud clearly states that what is represented in the cortex is "the periphery of the body" (p. 51) and that all object representations are related to bodily representations.

Consciousness, awareness of emotional states, and dreaming. Studies have shown that the orbitofrontal system plays a fundamental role in preconscious functions (Frank 1950), in the processing of emotion-evoking stimuli without conscious awareness (Wexler et al. 1992), and in controlling the allocation of attention to possible contents of consciousness (Goldenberg et al. 1989). These covert processes are now being studied by modern imaging techniques that allow us to image function as well as anatomy, to literally visualize "images of mind" (Raichle 1994). These techniques offer valuable data to psychoanalysis, which essentially is a theory of mind. For example, a recent PET study demonstrates the important role of the orbitofrontal cortex in emotional-cognitive processes (Pardo, Pardo, and Raichle 1993). When normal subjects silently fantasize dysphoric affect-laden images of object loss, such as imagining the death of a loved one, increased blood flow and activation is recorded specifically in the orbital prefrontal areas. Interestingly, the PET scans of females show orbitofrontal activity in both hemispheres, while those of males show only unilateral activation, and more females than males experienced tearfulness. Another PET study shows that women display significantly greater activity in this affect-regulating structure than do men, especially in the right hemisphere (Andreasen et al. 1994). These data indicate gender differences in the wiring of the limbic system and relate to differences in empathic styles or capacities of processing nonverbal affect between the sexes.

In a functional neuroimaging study of introspective and self-reflective capacities, when subjects are asked to relax and listen to words that specifically describe what goes on in the mind (mental state terms such as *wish, hope, imagine, desire, dream,* and *fantasy*), a specifically increased activation of the right orbitofrontal cortex occurs (Baron-Cohen et al. 1994). Andreasen et al. (1995) reported a PET study showing that during focused episodic memory (the recalling and relating of a personal experience to another), an increase of blood flow occurs in the orbitofrontal areas. Right frontal activity specifically occurs when the brain is actively retrieving this personal event from the past. Even more intriguingly, this same inferior frontal region is activated when the subject is told to allow the mind to rest. In this condition of uncensored and silently unexpressed private thoughts, the individual's mental activity consists of loosely linked and freely wandering past recollections and future plans. The authors conclude that this orbitofrontal activity reflects "free association" that taps into psychoanalytic primary process.

With regard to yet another aspect of primary process activity, Solms (1995), whose work is at the interface of neurology and psychoanalysis, is now presenting neurological data indicating that the control mechanism of dreaming is critically mediated by anterior limbic orbitofrontal structures. "These regions," he concludes, "are essential for affect regulation, impulse control, and reality testing; they act as a form of 'censorship'" (pp. 60–61). Normal activity in this brain system during sleep allows for the processing of information by symbolic representational mechanisms during dreaming, while failures in regulatory functioning caused by overwhelming experiences causes disturbed sleep, a breakdown in dreaming, and nightmares. These findings support Frank's earlier observations (1950) that patients with ablated orbital cortices show a reduction in the frequency and complexity of dreams, and a dream content reflecting, like the dreams of children, direct wish fulfillment. The problem of identifying the mechanisms of dream formation and primary process was, of course, first addressed by Freud in the Project.

Clinical Implications

Psychoanalytic models of structural psychopathology. In groundbreaking interdisciplinary work, Grotstein (1986) has asserted that all psychopathology constitutes primary or secondary disorders of bonding or attachment and manifests itself as disorders of self and/or interactional regulation. This clearly implies that the orbitofrontal system, with its essential role in attachment and regulatory processes, is involved in psychiatric disturbances. My own research indicates that the orbital prefrontal areas undergo a critical period of growth at the end of the first and into the second year of infancy, and that extensive experience with an affectively misattuned primary caregiver creates a growth-inhibiting environment for a maturing corticolimbic system (Schore 1994, 1996, 1997a). Interactively generated dysregulating psychobiological events, in conjunction with genetic factors, can result in a predisposition to later psychiatric and psychosomatic psychopathologies. Indeed, there is now extensive evidence indicating that impaired function of this frontolimbic system is accompanied by affective symptomatology.

The functional indicators of impaired affect regulatory systems that are the products of developmental psychopathology are specifically manifest in recovery deficits of internal reparative mechanisms. These deficits in coping with intense affect are most obvious under challenging conditions that call for behavioral flexibility and adaptive responses to socioemotional stress. In other words, affect pathology reflects a regulatory dysfunction in the orbitofrontal structure that is centrally involved in the adjustment or correction of emotional responses. Indeed, recent imaging studies demonstrate impaired orbitofrontal functioning in an array of disorders with an early developmental etiology: autism (Baron-Cohen 1995), mania (Starkstein et al. 1990), phobic states (Rauch et al. 1995) alcoholism (Adams et al. 1995) and drug addiction (Volkow et al. 1991). Of particular interest to clinical psychoanalysis are PET studies showing orbital prefrontal deficits in depression (Mayberg et al. 1994), posttraumatic stress disorder (Semple et al. 1992), and character and borderline personality disorders (Goyer, Konicki, and Schulz 1994).

Psychoanalytic treatment. Many of these very same developmental primitive emotional disorders are now a target of contemporary models of psychoanalytic treatment. The next question is, Can the psychoanalytic therapeutic relationship alter these psychoneurobiological deficits? An answer to this comes from current brain research indicating that the capacity for experience-dependent plastic changes in the nervous system remains in place throughout the lifespan. In fact, there is now very specific evidence that the prefrontal limbic cortex, more than any other part of the cerebral cortex, retains the plastic capacities of early development (Barbas 1995). The orbitofrontal cortex, even in adulthood, continues to express anatomical and biochemical features observed in ontogeny, and this property allows for structural changes that can result from psychotherapeutic treatment. For a more detailed account of the implications of developmental and neurobiological data for psychotherapy, see the discussions of the nonverbal transference-countertransference in Schore (1994, 1997c).

There is now convincing evidence that the orbitofrontal cortex functionally mediates the capacity to empathize with the feelings of others (Mega and Cummings 1994) and to reflect on internal emotional states, one's own and others' (Povinelli and Preuss 1995). These results are relevant to both the interpersonal and the intrapsychic processes that are activated in the psychotherapeutic relationship. Most intriguingly, a PET study published last year demonstrates that as a result of successful psychological treatment patients show significant changes in metabolic activity in the right orbitofrontal cortex and its subcortical connections (Schwartz et al. 1996). These data support a growing body of literature that indicates changes in "mind and brain" occurring in psychotherapeutic treatment (Gabbard 1994).

Indeed, Spezzano (1993) now argues that the analytic relationship specifically produces changes in the patient's "unconscious affect regulating structures." Gedo (1995b) contends in a recent paper that working through involves "the actual reorganization of the relevant aspects of brain function," in which "cortex and midbrain collaborate to provide better control" (pp. 352–353). He regards working through as directed toward "the completion of development" (p. 341). This process, the core of therapy, is accomplished by "the mastery of affective intensities," and it facilitates the emergence of "new channels of intrapsychic communication" (p. 354). As a result, the patient who formerly was unable to read his/her affective-somatic signals becomes able to interpret the meanings of personal experience. Gedo further concludes that "working through must refer to the difficult transitional process whereby reliance on former modes of behavioral regulation is gradually superseded by more effective adaptive measures" (p. 344). Although he does not identify the regulatory system involved in such activities, this characterization is clearly descriptive of orbitofrontal functions (Schore 1994). In a response to commentators, Gedo (1995a) confidently states that his ideas are "congruent with Freud's usage in the 1895 Project" as well as with "the view of contemporary brain science" (p. 385).

CONCLUSION

Let me end where we began, with the question, Is a rapprochement between psychoanalysis and neurobiology now at hand? I suggest that this can occur only when psychoanalysis, which Langs (1995) redefines as "a science of emotional cognition," and the other human sciences earnestly commit themselves to the investigation of emotional processes. The neuroscientist Antonio Damasio (1995) has recently spoken to this issue:

> By the end of the nineteenth century, Charles Darwin had made incisive observations on the expression of emotions in animals and humans and had placed emotion in the perspective of biological evolution; William James had produced a scientific description of the phenomenon of emotion, thus opening the way to its experimental study; and Sigmund Freud was writing about the means by which emotion might play a role in psychopathology. Somebody freshly arrived on earth in 1994 and interested in the topic of emotion would have good cause to wonder why such groundbreaking developments did not lead an assault on the neurobiology of emotion. What could possibly have gone wrong in the intervening century? The simplest answer....is that emotion has received benign neglect from neuroscience and has been passed over in favor of the study of attention, perception, memory, and language [1995, p. 19].

In a paper in the journal *Brain and Cognition,* entitled "Personal Relevance and the Human Right Hemisphere," Van Lancker (1991) cites neuropsychological evidence to show that "the ability to establish, maintain, and recognize personally relevant objects in the environment" is an important attribute of human behavior (p. 66). This phenomenon "involves an affective interaction between subject and object," and the recognition of familiar objects requires a relationship and is accompanied by a "cognitive/affective inner state" (pp. 72, 65). Neurobiology is now moving toward embracing the concept of object relations, just as cognitive psychology has coopted the psychoanalytic concept of internal representations.

Is the time right? I suggest that the answer to this fundamental question involves much more than an objective appraisal of the match or mismatch of current bodies of knowledge, though this certainly is a part of the process. But in addition, the response of psychoanalysis will have to involve a reintegration of its own internal theoretical divisions, a reassessment of its educational priorities, a reevaluation of its current predominant emphasis on cognition, especially verbal mechanisms, as well as a reworking of its Cartesian mind-body dichotomies. This redefinition involves the identity of psychoanalysis itself, in terms both of its self-reference and its relations with the other sciences. In principle, whether or not a rapprochement takes place between two parties depends not only on the information they share in common, but on their individual willingness to enter a communicative system.

Over twenty years ago, in the final paragraph of Pribram and Gill's book on the Project (1976), the latter suggested that psychoanalysis must go its own way and that that means purging it of its natural science metapsychology; Pribram disagreed, welcoming psychoanalysis back into the natural sciences. Approximately ten years later, Reiser (1985) noted a disturbing trend in which neurobiological data were being increasingly ignored by psychoanalysts, and contemporary psychoanalytic data dismissed by neurobiologists. At about the same time, Sabshin (1984) wrote, "For a field stimulated by the author of the 'Project' to separate itself from important new developments a century later would be tragic" (p. 489). Only eight years ago, Holt (1989), in his book *Freud Reappraised,* concluded that "we must go to a nonbehavioral realm, such as neurophysiology, to test a great deal of the most distinctive parts of the clinical theory: Psychoanalysis is *not* autonomous, existing in self-sufficient isolation on an island remote from other sciences. No science can do that, and it was a great mistake for psychoanalysis to have cut its ties to the rest of the scientific world" (p. 340).

In the December 1994 through March 1997 issues of *Psychoanalytic Abstracts*, which covers articles published in forty different psychoanalytic journals, as well as books and chapters in books, the annual subject index contains not a single title referring to affect, emotion, or motivation, nor to psychoanalytic research or to the brain.

Analysts might do well to heed the words of Arnold Modell (1993): "All sciences are autonomous, yet must share concepts that lie across their frontiers" (p. 198).

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