Toward a Neural Circuitry of Engagement, Self-Awareness, and Pattern Search

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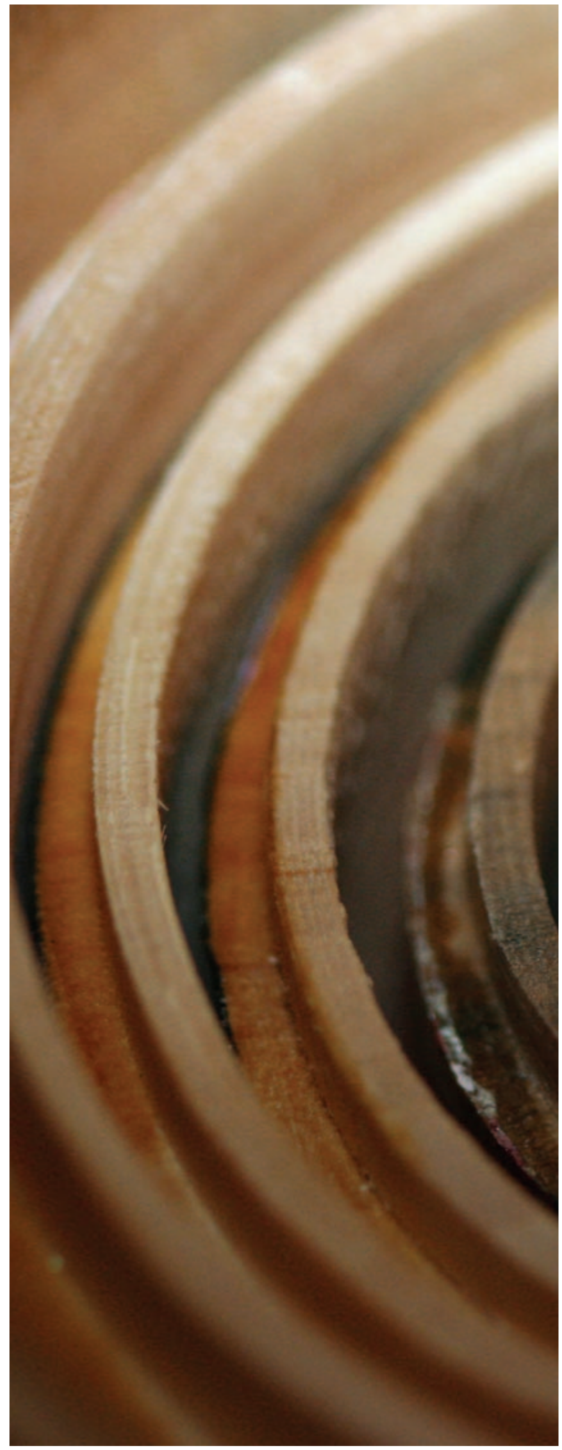

Authoritative reviews[1,2] and meta-analyses[3,4] demonstrate that no psychotherapy is superior to any other, although all are superior to no treatment. These bodies of research also suggest that a core set of features shared by all therapies account for a significant portion of client symptomatic improvement. Process researchers are demonstrating that the most effective therapies are customized to individual patients.[5]

These findings imply that psychotherapy should no longer be considered a collection of disparate schools but rather a single entity described from many perspectives. Much like blind men inspecting different parts of an elephant, theorists have proposed that the whole enterprise of psychotherapy can be described in terms of unidimensional conceptualizations such as cognition, behavior, the unconscious, emotions, interpersonal relationships, or systems formulations. Like the holistic view of the elephant, however, psychotherapy has a basic structure defined by a set of core processes,[6] among which are engagement (the establishment of the working alliance), self-awareness, pattern search, change, termination, transference, countertransference, and resistance. This definition of core processes aids the task of mapping psychotherapy onto the brain by simplifying the cacophonous professional terms currently used to describe the psychotherapeutic process. This article seeks to link core psychotherapeutic processes to specific circuits in the brain through describing the neural substrates that support the critical functions of engagement, self-awareness, and pattern search.

ENGAGEMENT

The strength of the working alliance has been the most studied process variable, shown to positively correlate with psychotherapeutic outcome.[7,8] In fact, the working alliance, "the collaborative and affective bond between therapist and patient," may be considered the therapeutic "quintessential integrative variable."[9]

When a therapist first encounters a patient, he or she immediately infers the patient's emotional state by observing facial expression, verbal output, and bodily demeanor. Work by Rizzolatti and colleagues[10] has shown that a critical neural processing step must occur, however, prior to observation being transformed to inference. Before the meaning of bodily movements and emotional expressions can be understood, these observations are modeled in the therapist's brain.[10] An array of "mirror" neurons found in the primate premotor region and in the superior temporal sulcus become activated when the actions

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and expressions of others are modeled internally.[10] The "meaning" of that which we sense both physically and emotionally when observing others is therefore an amalgam of actual observations and their internal transformation. The ability to be empathic and to accurately identify what a patient is "feeling" depends completely on the adequacy of the therapist's own limbic and cognitive circuitry. As such, the training of psychotherapists is, in great part, a tuning of brain circuitry to permit the accurate neural modeling of clinical observations and subsequent extraction of their "meaning."

As a therapist considers the patient's brain, the therapist can search for the neural source of the patient's emotional state. Imaging studies suggest that the patient's outward signs of anxiety — sweaty palms, quivering voice, motor agitation —- are the result of activation of the neural circuits that detect risk and prepare the body to take appropriate ac-

Figure 1. Graphic depiction of limbic (lower brain figure) and cortical (upper brain figure) influences on mood and behavior. Many people in psychotherapy begin the process with excessive limbic activation (Mayberg, see page xxx). As psychotherapy progresses, cortical regions are engaged and are able to restore limbic activity to a normal level. (Brain images ©2001 3B Scientific GmbH. Excerpted from NEUROteacher™. Used with permission.)

tion (Figure 1, see page xxx).[11] Risk-detection circuitry is centered in the amygdala and orbitofrontal cortex.[11,12] Both of these structures contain genetically pre-programmed information about natural "punishers": sensory perceptions (eg, bitterness or pain) that throughout the evolutionary history of humans have been connected with unpleasant outcomes.

In addition, the amygdala and orbitofrontal cortex contain a record of the unpleasant experiences encountered throughout the person's lifetime. These are in the form of synaptic linkages between previously neutral stimuli associated with an unpleasant experience and the genetically determined collection of natural "punishers" that is already represented.[11] For example, human infants quickly connect the sight of a syringe with pain and show signs of distress before immunizations. Many people with hypertension paradoxically increase their blood pressure just as it is about to be measured, because the measurement process has become associated with unpleasant outcomes in the past.

The anxious patient in front of the therapist is focused intensely on his or her set of symptoms and wonders how the therapist could possibly "understand" this distress, given the therapist's privileged position of power and success. Instinctively, and without any knowledge of neurobiology, the patient senses that it will be difficult for the therapist to model the subjective components of his or her singularly unpleasant mental state internally. The cognitive uncertainties of the initial meeting with the therapist can cause even more autonomic arousal through the combined action of the dorsolateral prefrontal cortex, which represents current cognitive contents, and the cingulate gyrus, which generates autonomic tone consistent with those contents.[13]

As the therapist works toward successful therapeutic engagement, critical steps must include relief of this initial cognitive tension and communication, through cognitive and emotional signals, until the therapist is indeed capable of "understanding," or internally modeling, the patient's situation. If engagement is negotiated successfully, then the therapeutic process can proceed. Eventually, previous neutral stimuli related to the therapist may become linked to experiences of reward in the patient's brain. This also involves synaptic modifications in the amygdala and orbitofrontal cortex, in a manner similar to what was described for unpleasant experiences.[11]

As the patient continues to associate the therapist with symptom reduction and positive emotions, reward circuits and other areas in the patient's brain that represent gratifying social interactions are likely to be activated. For example, imaging studies have shown that internal representations of people perceived as "cooperative" in interactive situations elicit activation of the nucleus accumbens, which is at the center of reward circuitry (Viamontes, see page xxx and Beitman, see page xxx), as well as the orbitofrontal cortex, fusiform gyrus, superior temporal sulcus, and insula.[14] We can hypothesize that excessive activation of reward circuitry may underlie the strong emotional attachments that patients can develop toward therapists.

Within the trusting, confiding psychotherapeutic relationship, patients frequently can reflect on their emotionally laden difficulties in ways that would have been impossible outside therapy. Secure relationships such as can be achieved in therapy are associated with enhanced resiliency, as suggested by studies of traumatized children.[15] In response to major losses such as the death of a parent, divorce, or major parental illness, children who were securely attached to their mothers were more resilient and less affected by the stressors. To be resilient is to be able to recognize that the "map is not the territory," or, in other words, that neural representations of the outside world, which incorporate both external and internal contents, are not equivalent to reality.

Experimental evidence suggests that secure attachment, as extrapolated from imaging studies of romantic love[16] and mother–child affection studies,[17] is associated with reduction in amygdala firing (lessening anxiety), increases in nucleus accumbens activity (possibly related to enhanced reward representations), and lessening of orbitofrontal firing (reducing criticism of the other). Within the secure attachment achieved through basic psychotherapeutic engagement techniques, circuits associated with negative emotions, social judgment, and "mentalizing" (Viamontes and Beitman, see page xxx[WHICH ARTICLE?]) can be activated safely through verbal means and their consequences explored. This controlled activation of negative contents within the psychotherapeutic relationship helps liberate the patient from past constraints, permitting the exploration of new interpersonal concepts.[18] The common mechanism for such self-exploration is likely the activation of self-observation.[19]

SELF-OBSERVATION

Self-observation can produce knowledge about many internal states such as intentions, expectations, feelings, thoughts, behaviors, and perceived effect on others. It also can enhance the capacity for introspection and anchor the person's understanding of his or her relationship with the environment.[20] Self-observation increases the ability to "distinguish inner from outer reality, pretend from 'real' modes of functioning, and intrapersonal mental and emotional processes from interpersonal communications" (Fonagy P et al., unpublished data, 1996). Psychotherapy, and specifically the psychotherapeutic relationship, offers the opportunity to create and function within a "reflective space" that enhances power to explore current maps of reality and alter them. Self-observation is a distinct process that can be distinguished from consciousness, awareness, and self-awareness.

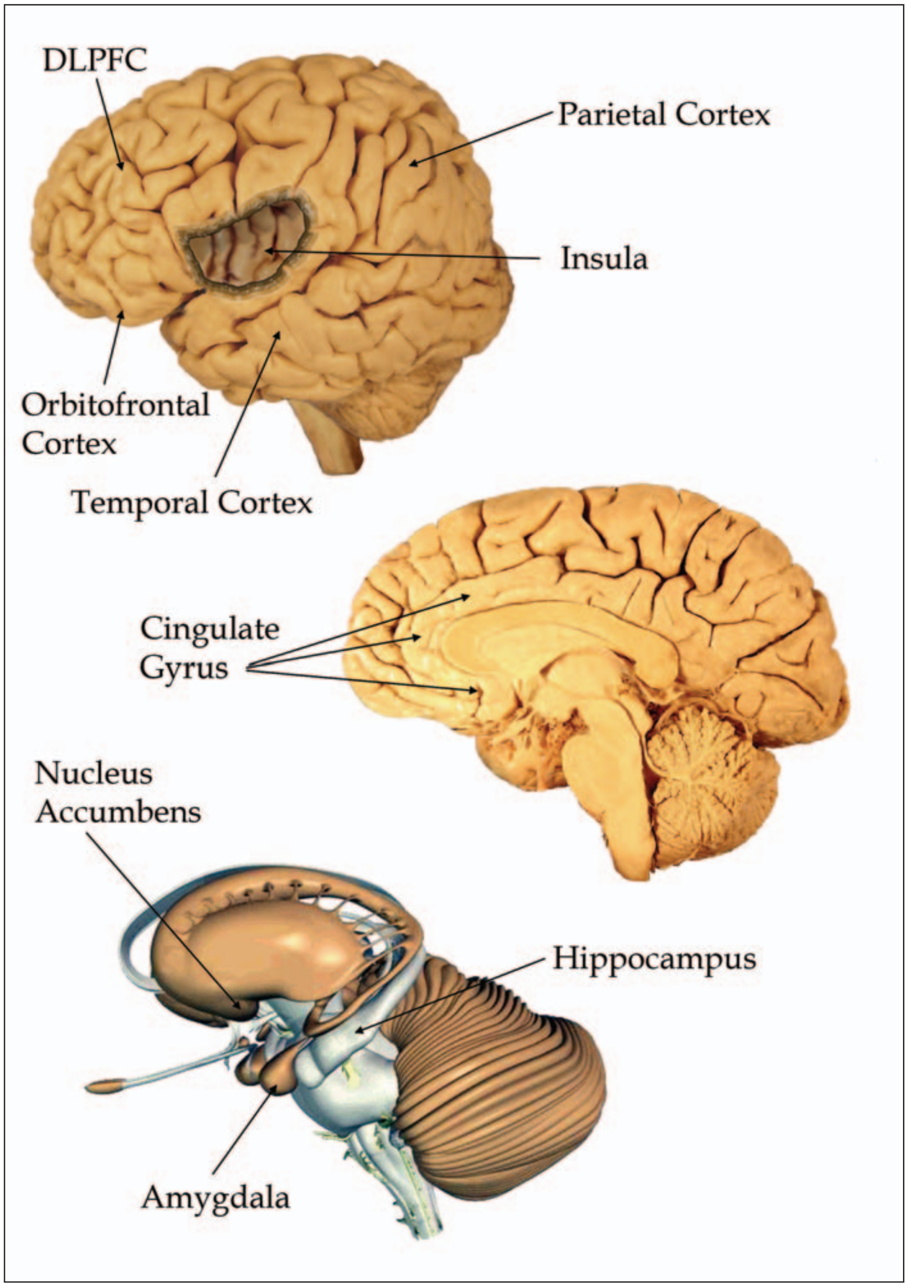

Figure 2. Composite showing some of the cortical and subcortical regions that map or integrate critical components of the self. The dorsolateral prefrontal cortex is a "master integrator" that has access to much of the information in the other mapping areas. It facilitates executive function and working memory. The parietal cortex maps spatial information. The insula contains low-level maps of internal states, including visceral sensations and autonomic arousal. The temporal cortex maps information about visually perceived objects. The orbitofrontal cortex contains data about rewards and punishers, as well as about internal and external circumstances that should be considered before initiating actions to secure potential rewards. The cingulate gyrus motivates actions that address the most salient internal and external signals by focusing attention and modulating autonomic tone. The nucleus accumbens is the functional center of the brain's reward system. The amygdala participates in emotional responses, especially fear, and contains information about potential reinforcers and punishers. The hippocampus is the functional center for the creation of episodic and semantic memories. (Upper two images © 2006 G. Viamontes. Bottom image ©2001 3B Scientific GmbH. Excerpted from NEUROteacher™. All images used with permission.

Consciousness, in the strictest neuro-

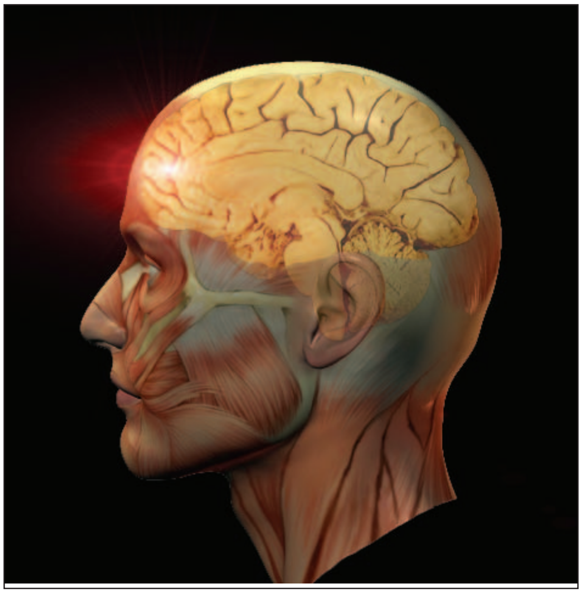

Figure 2. Neuroimaging studies have demonstrated that mentalization, or "theory of mind," operations involve activation of the anterior paracingulate cortex (illuminated in the graphic). (Figure ©2006 G. Viamontes. Used with permission.)

logical sense, refers simply to the waking state. This type of consciousness requires the firing of the reticular activating system as well as the integrity of basic homeostatic processes, such as breathing, cardiac function, and autonomic tone. It represents the "general capacity that an individual possesses for particular kinds of mental representations and subjective experiences" that are "not directed at anything."[22] One must be conscious to be aware.

Awareness, the "particular manifestation or expression" that "always has an object," implies consciousness of content, such as a cloud, another person, or a painful experience.[22] Self-awareness is a special type of awareness that is focused on the "object" of the self. The act of being self-aware encompasses the potential to observe the subjective neural representations of the self and to "model" internally an inferred representation of what others may think about the self.[23] Self-observation, in contrast, is an open-ended exploratory process that motivates the active scanning of one's inner world. In this context, observations can be made dispassionately and without criticism or evaluation.[24]

When observing oneself, attention may be focused on the totality of one's subjective reality, which includes representations of the self's experiences in the past, present, and future.[22] The broad reflective potential of self-observation allows one to marshal the resources of self-awareness to alter prediction errors.[25] This capability provides a sense of agency, an "I" who is observing, planning, deciding, and evolving toward a future goal. Most psychotherapies help clients to activate their self-observational capacities with the primary intention of altering faulty predictions and expectations.[25,26]

The ability to observe the content of one's own mind depends on the healthy functioning of many different parts of the brain (Figure 2, see page xxx). To begin the process, the person must be awake, with an intact brainstem and a functioning reticular activating system. Next, the objects of self-observation, which are neural representations in the various functional circuits that drive cognition, emotion, and behavior, must be accessed and integrated in working memory. The basic representation of the visceral self, along with a variety of internal states, can be obtained by accessing the insula; objects and space are represented in the temporal and parietal cortices; risk–reward considerations are continuously generated by the amygdala, orbitofrontal cortex, and nucleus accumbens; and episodic and semantic memories can be recalled by accessing the hippocampus and connected cortices. Cognitive considerations are generated in the lateral prefrontal cortices, and the strongest current focus of behavioral attention, whether internal or external, is represented by activity in the cingulate. Activity within regions along the border between the rostral anterior cingulate and the medial prefrontal cortex is associated with representations of mental states of the self[27] and is activated consistently during self-reflective thought[28] (Figure 3, see page xxx). The top of this functioning pyramid of self-awareness appears to be the dorsolateral prefrontal cortex (DLPFC), which potentiates executive function and working memory[22] and is capable of integrating the full range of sensory, affective and memory data.

The ability to generate a coherent self with temporal continuity depends upon the power of the DLPFC to project individuals both backward and forward in time.[22] People with damage to the DLPFC lack a temporal sense of themselves. They are unable to recall episodic representations of past experiences and are unable to project themselves into the future.[22] The DLPFC and the right parietal lobe help define the person in space and time by placing the body in the three physical dimensions as well as in past, present, and future. Without this sense, the self erodes and merges with its environment. During meditation, the right parietal lobe may decrease its activity, which can induce dissolution of the sense of self in space and time.[29] Other studies have shown that disturbances of the temporoparietal region can generate out-of-body experiences, in which a person has the sensation of floating above the ground and observing his or her body below.[30]

As part of its integrating function, the DLPFC receives inputs from a variety of internal monitors. The insula, for example,[31] monitors visceral sensations as well as emotional body-states, while the anterior cingulate can focus attention for the process of self-monitoring.[32] In a clinical context, the dysfunction of prefrontal circuits that characterizes schizophrenia is thought to play an important role in the clinical finding that many people with schizophrenia lack awareness of their disorder.[33]

The current interest in the study of mindful awareness is likely to be supplemented by an expansion of knowledge about the neural circuitry that underlies self-observation. As we continue to acquire and integrate this information, we will come to view self-observation as another brain-based skill that can be developed not only in clients but also in psychotherapists. In psychotherapy, the primary intent of self-observation is to uncover dysfunctional patterns that, if changed, will lead to relief of symptoms and improved functioning.

Figure 4. Demonstration of the amount of detail that can be encoded with different numbers of pixels, or individual encoding elements. The top picture was encoded in a matrix of 2,000 by 1,000 pixels, whereas the bottom image was encoded with a 50 by 25 matrix. (Figure ©2006 G. Viamontes. Used with permission.)

PATTERN SEARCH

A major task of the central nervous system is to organize the linkage of sensory information to adaptive responses.[34] The brain creates patterns from the huge array of sensory information that it processes to make sense of the environment in ways that optimize individual and species-survival functions, including homeostasis, reproduction, and energy acquisition and conservation.[35] Smaller brains cope with this challenge by developing inflexible bonds between sensation and action that are resistant to change. Larger brains have more flexible stimulus–response connections and therefore can have a wider range of alternative responses to specific environmental cues.[36] Smaller brains represent the world at a much coarser level of resolution (Figure 4, see page xxx), because they have fewer cortical columns to devote to each aspect of represented reality. The simplification of the brain that can result from chronic stress or illness[37] is relevant to this discussion. While such simplification conserves energy and facilitates rapid responses, it theoretically can decrease the "richness" of experiences by limiting the amount of complexity that is represented.

An important component of habitual behavior is the formation of internal patterns that can be used to organize external stimuli, determine their "meaning," and respond to them. Humans are remarkably adept at inductive reasoning, which is the ability to infer complete patterns from perception of just a small number of their elements. Even advanced computers have difficulty matching the inductive power of the brain. We can recognize a song from a few notes, a person from a few words, and a concept from a single phrase. Effective psychotherapists induce patterns from nonverbal clues, key reported events, transference behaviors, and countertransference reactions.[6] Psychotherapists can then help patients become aware of their internal patterns and drive therapeutic change by crystallizing awareness of maladaptive stimulus–response connections and how these might be altered.

Understanding the brain's mechanisms for pattern recognition represents a major challenge for computational and neural sciences. Among the many perplexing questions: should computational neuroscientists attempt to mimic the brain with respect to pattern recognition, or develop an entirely different set of algorithms? Important clues about the brain's ability to recognize patterns have been gleaned from studies of visual pattern recognition. The following description of this process is quite simplified, and many of the described functions are not localized but widely distributed with the named area.[38] Nevertheless, it provides important insights into pattern recognition.

Visual inputs are first transmitted to the occipital cortex, then routed to the lateral inferior occipital lobe, where a "prepattern" is developed — an intelligent organization of the inputs. The data is sent to the fusiform gyrus in the ventral temporal lobe, where it is divided into at least two categories — namely, faces or objects. From the fusiform, the data continue to be transmitted rostrally. At the temporal pole, the object's identity is further clarified and integrated with limbic information. Data about the object are transmitted simultaneously to the parietal cortex, where the object is placed in three-dimensional space. Processed information about the object is sent to the entorhinal cortex, where its past significance is determined, and also to the dorsolateral prefrontal cortex, where its implications for the future are elaborated.

Our experiences are organized by the facilitated pathways for information processing that have been encoded in our brains throughout our lifetimes. These facilitated pathways organize our perceptions of reality and allow us to perform activities of daily living. These pathways or patterns in our brains create expectations: if this happens, then that will follow. A remarkable corollary of these experiential encodings is that they can induce the generation of expectations from neutral circumstances. We find what we seek because we expect it to be there. For example, the expectations of a person who believes that he or she will be rejected are inevitably fulfilled, in part because the expectation itself creates the circumstances for rejection.

Behavioral patterns are deeply engrained and manifest themselves in many settings, from the therapist's office to the work environment, and certainly throughout the whole spectrum of personal relationships. Therapists also expect to find certain patterns: past–present connections, narcissistic injury, hidden anger, cognitive distortions, role-relationship conflicts, and many others. Some psychiatrists even have a "favorite" diagnosis, and a disproportionate number of their patients are identified as fitting its characteristic constellation of symptoms.

Patterns that organize perceptions and expectations in a maladaptive manner are at the core of many psychiatric disorders. In neurobiological terms, these faulty expectations are sometimes called pathological attractors, because input data are channeled toward them and they invariably lead to maladaptive behavioral outputs. Angry, impulsive, passive, or anxious excesses are the products of inputs channeled through pathological attractors that connect to excessive outputs.

Consider the black-and-white thinking characteristic of many patients, such of that of those with borderline personality disorder. How might experience create black-and-white attractors? One possible model involves the hippocampus, which may shrink in size with trauma,[37] although some controversy remains about this claim. The simplification of brain structures can have adaptive value in chronically stressful situations, as it conserves energy and shortens the stimulus to response interval. However, it also limits function.

If traumatic experiences do indeed cause hippocampal simplification and patients with borderline personality disorder suffer numerous traumatic events, then the functions of hippocampal circuitry are likely to be affected in these people. Specifically, simplification of CA3 may reduce dendritic and axonal aborization, fostering excessive compression and simplification of information. In addition, damage to the dentate gyrus limits new cell production, which in turn may hinder the process of encoding new, differentiated memory patterns.[39]

SUMMARY

Psychotherapeutic treatment relies on special combinations of brain circuits for the implementation of each of its core components, including engagement, self-observation, and pattern search. By linking basic psychotherapeutic processes with their underlying neural substrates, psychotherapists can acquire the ability to refine the theory and practice of their discipline on empirical grounds, while further legitimizing the status of psychotherapy as a scientifically based process.

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