

## Psychotherapy and the Brain: The Dimensional Systems Model and Clinical Biopsychology

Robert A. Moss

*Bon Secours St. Francis Hospital*

The dimensional systems model explains cortical processing on the basis of cortical column interactions, leading to a clinical biopsychological model which involves brain-based psychotherapy integration. The current paper provides a detailed explanation of the interface between these models in relation to psychological treatment. A specific discussion of certain psychotherapy treatment approaches is provided with suggestions on what cortical areas are being impacted. In reference to negative emotional memories there are specific, theoretically based suggestions on how to most effectively neutralize the continuing impact on a client's current psychological functioning. Loss-related depression is explained on the basis of opponent-process theory as related to the brain model. It is hoped that this paper can generate interest among neuroscientists and clinicians to fully evaluate the value of these theoretical models.

Keywords: psychotherapy, cortical column, emotional restructuring, memory

In search of an understanding of how the brain codes, processes, and stores information, two massive projects are in process. The European Union's Human Brain Project (Markram, 2012) and the proposed United States' Brain Activity Map (Alivisatos et al., 2013) both suggest there can be major improvement in treating psychological disorders such as depression and posttraumatic stress disorder if the code is discovered. Both projects emphasize the use of new and better technologies, such as super computers and nanotechnology, to search for the elusive neural code involved in memory and learning. However, neither project description offers any specific theory, or even the level (e.g., molecules, neuron, modules, etc.) of where to look, for the neural code.

William James (1890/1950) was one of the first psychologists to note the fundamental assumption in psychology that neurophysiological mechanisms

underlie both adaptive and maladaptive psychological phenomena (Cacioppo and Berntson, 1992). Sigmund Freud was trained initially as a neuroanatomist and tried to link psychodynamic concepts to neuronal mechanisms in his *Project for a Scientific Psychology* in 1895, although the work was never published during his lifetime since Freud considered it a failure (Northoff, 2012). Despite such early interests, approaches to conceptualizing and treating psychological problems largely developed and remain independent of neurophysiological factors.

In their excellent review on the history on the study of the brain, Kandel and Squire (2000) note the original perspective of psychology was that a neural approach to mental processes seemed too reductionistic. These authors trace the emergence of cellular neuroscience to the 1800s with the work of Santiago Ramón y Cajal and Charles Sherrington. Kandel and Squire (2000) believe that the cellular studies of the 1950s represented the most fundamental advance since the work of Cajal in understanding the organization of the brain. These studies provided evidence of how much neuroscience derived from psychology, as well as illustrating how much psychology could inform neuroscience. In relation to the influential work in the 1950s, Kandel and Squire specifically mention the research of Mountcastle (1957) on the cortical column as one that was instrumental. As will be discussed, the current paper is based on the view that the column is the basic unit in the cortex.

In relation to individual psychotherapy, Greenberg (2002) posits three basic approaches have provided clinical guidance. These are psychodynamic, humanistic/experiential, and behavioral/cognitive-behavioral. There have been some recent attempts to relate these basic approaches to the brain. For example, Northoff (2012) discusses neuropsychanalysis as using a “function-based approach.” In this regard he says that neuropsychanalysis “aims to link specific psychodynamic mechanisms to the neuronal activity in particular regions of the brain” (p. 2). However, such correlational studies provide little insight into how brain regions may lead to the observed “psychodynamic mechanisms.”

The United States Congress declared the 1990s to be the decade of the brain which was followed by American Psychological Association’s (1998) declaration of the 2000s as the decade of behavior. These declarations provided implications that dramatic changes in the understanding of psychological problems were at hand. However, the rather sobering article by Miller (2010) on systematic mistreatment suggested that we remain far from such a realization. Miller clearly emphasized that we do not know how psychology-biology causation works and that there are serious costs at the intellectual, clinical, and policy levels by pretending that we do. As he argued, “. . . recent cognitive/affective/clinical neuroscience literature routinely offers interpretations of data with respect to psychological-biological relationships that are not even remotely adequate accounts” (p. 717).

Perhaps the best known brain structure used in conversations by clinicians is the amygdala. This is done often with the failure to articulate the several distinct groups of nuclei in each amygdaloid body that are bilaterally present (i.e.,

paired structures). The role of the amygdala in psychological phenomena such as fear conditioning has clear support (LeDoux and Phelps, 2010). Although subcortical structures play a significant role in many psychological problems, caution is needed not to make the leap in reasoning that complex sensory memories are stored in the amygdala or at some other subcortical level. If such memories were to exist subcortically, this certainly would not bode well for psychotherapy. In other words, how can therapy which is done at the cortical level impact subcortical memory storage? If subcortical negative emotional memory storage actually exists, it is a boon for psychopharmacology since this would realistically appear to be the most effective way of impacting such memories. However, as LeDoux and Phelps (2010) note, both the fast route from the sensory thalamus and the slower route from the sensory cortex converge at the same locations in the lateral amygdala. The involvement of the sensory cortex as both the location of negative emotional memory storage and the source by which activation of the lateral amygdala occurs upon activation of that memory is consistent with the theoretical model discussed in the current paper.

Bassett and Gazzaniga (2011) provided a detailed discussion on the complexity in the investigation of the mind and brain interface. A question posed at the conclusion of their article is "What theories need to be developed to guide further research?" (p. 208). It has been suggested (Moss, 2006; Moss, Hunter, Shah, and Havens, 2012) that the theory needed is one which identifies the manner in which cortical processing occurs and memories are stored. This requires the identification of the code used by the cortex. If the code is based on a binary unit (bit), then it would be possible to theorize how the interconnection of those information units (i.e., the brain) can lead to higher cortical functions (i.e., the mind). If accurate, this theory can then be applied to psychopathology and its treatment.

The current paper provides a brief discussion of a brain model based on the cortical column as the bit involved in all cortical processing and memory. This is followed by a discussion of an applied clinical model which has the potential for providing a brain-based understanding of the development of many aspects of psychological disorders. Based on this model, a specific discussion of some psychotherapy treatment approaches follows with suggestions on what cortical areas are being impacted. In reference to negative emotional memories, a discussion ensues on how to best impact the memories in treatment. Finally, depression tied to loss issues is discussed as related to an inability to stimulate previously stored positive emotional memories.

### **Dimensional Systems Model**

Largely influenced by a Lurian view (see Luria, 1966) of higher cortical functions, Moss (2001, 2006) proposed the dimensional systems model. In relation to cortical processing and memory, five systems were identified. The sensory

input system focuses primarily on tactile, auditory, and visual input as being the most influential in higher functions and results in the manner by which processing occurs in specific cortical areas. The arousal system involves the power supply to the cortex necessary for processing and memory storage which can be selectively influenced based upon ongoing biological needs and emotions. The attention–memory system involves the structures and mechanisms by which incoming sensory information is selected and subsequently stored in memory at the cortical level. The cortical system involves the means by which the columns interact to provide processing, analyses, and responses. Finally, the motor system describes the output level of the system by which environmental manipulations occur. Of key relevance to the clinical applications of the model is that all memory storage occurs at the cortical level and that increased arousal leads to enhanced memory storage.

In an update of the cortical aspects of the model, Moss et al. (2012) discussed the supporting data which had emerged since the 2006 paper and revised certain aspects. A physiological definition of memory was provided as follows:

A formal definition of memory formation is the strengthening of synaptic connections in any given circuit of cortical columns. The strengthening occurs due to ongoing reactivation of the circuit with resultant increased probability of downstream synaptic activation initially being the result of neurochemical factors (e.g., ionic concentrations, neurotransmitter stores), followed by gradual synaptic structural growth (i.e., increased axonal boutons and dendritic spines). Forgetting is the result of weakened synaptic connections with failure to activate downstream columns in any given circuit. In this case, the probability of a column's activation by one or more other columns fails to be maintained. However, with structural changes such as axonal sprouting and increased dendritic spines between neurons of columns, then the likelihood of “forgetting” is greatly reduced. (pp. 144–145)

There are several important aspects tied to the definition. First, it defines all memory at the cortical level and all memory involves the same mechanisms. Therefore, explicit (i.e., declarative) memory and implicit memory are both circuits of columns, with the qualitative distinction being whether the verbal “interpreter” (Gazzaniga, 2002) has direct access to the memory. As will be discussed, the left lateral ventral frontal area is the purported location of self-talk, or internal verbal dialogue, and is what defines declarative memory (i.e., being able to verbally explain what is being remembered) and allows verbal schemas (Moss, 2001, 2007).

Subcortical enhancement of memory occurs as a function of the activation of the cortical circuit which in turn strengthens the synaptic connections of the involved columns. Increased general arousal via the reticular activating system and increased selective arousal, such as with the amygdala, increase cortical arousal which strengthens the columnar connections. The hippocampus serves to maintain a hippocampo–thalamo–cortico–hippocampo circuit with the goal being strengthening of the synaptic connection among columns. Moreover,

the cortical memories can in turn project to subcortical structures involved in emotions. Thus, when significant emotional sensory memories activate at the cortical level, there is increased activation in associated subcortical structures receiving cortical projections. Since each cortical hemisphere projects ipsilaterally to its own subcortical structures, then the laterality of activation of subcortical structures would correspond to the laterality of the cortical memory.

An important aspect of the current discussion is that emotional memories are stored at the cortical level despite the fact that fMRI studies may not show observable cortical activation following learning and during memory recall. In relation to learning and cortical metabolism as measured by functional magnetic resonance imaging (fMRI), it has been noted (Moss, 2006) in several studies that there is increased activity in frontal and posterior regions in the early stages of learning followed by decreased activity over time. For example, Hempel et al. (2004) monitored cerebral activation associated with a visual spatial memory task during and after four weeks of training. The right inferior frontal gyrus and intraparietal sulcus showed activation increases with improved performance after two weeks of training followed by decreased activation at four weeks. Similarly, long-term cortical negative emotional memories may not result in apparent changes in metabolism when activated although the interconnected subcortical areas would show increased activity. In like manner, novel learning associated with a psychotherapy treatment may lead to measurable increased activity in the cortex around the involved columns only during the acquisition phase with no observed activity change when the columnar connections are well consolidated. These points will be further addressed in the discussion of treatment in relation to the interpretation prior studies.

Moss et al. (2012) suggested several cortical dimensions in relation to the information being coded in a particular column. The medial cortical columns code stimulus information that is internal and self-referential while the lateral cortex codes for external stimuli. Intermediate or transitional zones code for combinations of both. In relation to proximal versus distal to the body stimulus coding, the central sulcus is considered the most proximal cortical location. The post-central sulcus parietal cortical area would code for somatosensory (i.e., body sensation) stimuli. Both vision (occipital lobe) and audition (temporal lobe) involve distal sensory information. The pre-central sulcus primary motor strip involves the body directly while anterior prefrontal processing involves information manipulation largely independent of the body. The parietal, temporal, and occipital lobes contain all receptive, or sensory, information while the frontal lobes code for all action-related information. Ventral cortex processes in a sequential manner and dorsal cortex in a simultaneous manner, with intermediate areas using both modes of processing. Receptive information progresses from less-organized, or lower-order, information to more-organized, or higher-order, information (i.e., coding) as the stream moves away from the primary sensory

receiving areas (i.e., bottom–up processing). On the other hand, the frontal action columns progress in a rostral to caudal more-organized, or higher-order information to less-organized, or lower-order information (i.e., decoding) as the stream goes toward the premotor and primary motor areas. The frontal action columns' control of posterior lobe receptive columns is also present (i.e., top–down processing). Each cortical hemisphere acts as a separate, albeit interconnected, processing unit which means that each of the aforementioned dimensions is contained within each hemisphere. However, there are fewer columns from the time of sensory input to the response level in the right hemisphere. This means that the right cortex can process information faster, but with fewer details. The reader is referred to Moss et al. (2012) for a more complete understanding of these and other aspects of the dimensional systems model. However, these aspects are briefly mentioned here to support the applied clinical model that is now discussed.

### Clinical Biopsychological Model

#### *Overview*

The clinical biopsychological model was first described in a treatment manual (Moss, 2001). Moss (2007, 2010) subsequently discussed the theoretical aspects of the model as related to negative emotional memories. The studies used in support of the model given in the previous articles will not be repeated and the reader is referred to those articles for those details. Based on the dimensional systems model, the hemispheres are viewed as capable of independent stimulus processing and behavioral responses which means both are equally conscious, though not equally verbal. However, the faster, less detailed processing of the right hemisphere means this side is the best in analyzing non-detailed indices of emotional expression by others, such as facial expressions and voice intonations. It is also the quickest in analyzing and responding to potentially dangerous or threatening external and internal stimuli, particularly along the dorsally located simultaneous information stream. Both positive and negative emotional memories involve the same columns that were used in original processing. The right cortex is expected to have only very limited verbal ability, being mainly related to words associated with the strong expression of emotion (e.g., profanity) and some lyrics housed within music. This restricts the right side to a limited repertoire of independent verbal responses to emotionally related stimuli. Therefore, the right hemisphere is basically restricted to one of three behavioral response patterns. The right cortex can freeze, it can problem solve or attack to overcome the precipitating problem, or it can escape and avoid. I will return to this particular dynamic in relation to interhemispheric congruence and poorly regulated emotional expressions later, as well as in reference to treatment.

The left cortex also has the ability to activate its own connected subcortical structures involved in both positive and negative emotions. This means it has equal ability to activate subcortically-based autonomic responding, as well as the mesolimbic dopamine pathway. However, it processes more detailed aspects and can make responses involving greater complexity, particularly in the verbal realm via the left lateral ventral frontal cortex. The interconnections with the verbal interpreter allow the action columns to directly manipulate the associated posterior cortical receptive columns, providing inhibitory control of affectively undesirable columnar activation and activation of alternative sensory columns (i.e., logical analysis and alternative interpretation or explanation). This same verbal interpreter area is also where the expressed words used in labeling emotions are processed and stored. Of particular importance is this region's role in allowing for an internal verbal dialogue. Based on the dimensional systems model, any action can be done only by the associated frontal columns. Since our verbally thinking to ourselves is an action, it must theoretically occur in the left lateral ventral frontal region. As noted by Gazzaniga (2002), the "interpreter" attempts to make sense of things. He considers it a device, system, or mechanism that seeks explanations for event occurrence. He saw the advantage of an interpreter as allowing more effective coping with similar future occurring events. Notably, Gazzaniga viewed it as only one of the cortical modules that exist. Moss (2001) went one step further and described it as being involved in all verbal-thinking. This could be as simple as reading words in a text and as complicated as writing a detailed theoretical paper. This is not to mean that the sensory processing and memory storage of the words does not occur in the left posterior cortical region; only that when one is actively using the words, it is done in the left lateral ventral frontal area.

Why is the specification of the location of the verbal interpreter so important? From a clinical standpoint, it means that only information being processed cortically that directly interconnects can be recognized and manipulated by this area. Thus, left intrahemispheric processing is much more likely to interconnect to the verbal interpreter than would right interhemispheric processing. In fact, the only direct interhemispheric projections to the left lateral ventral frontal area would be from the right lateral ventral frontal area. If, as has been suggested (Moss, 2007), the non-detailed aspects of emotional memories are located in the posterior regions of the right cortex, there is no means by which verbal-thinking can directly access, label, and influence these memories due to the absence of direct connections. Thus, based on this theoretical model, the left verbal labeling of emotional experiences of the right hemisphere is actually educated guesswork based on experience.

Another relevant factor is tied to excitatory and inhibitory cortical processing. The receptive information in the posterior lobes would logically be excitatory in a feed-forward manner. This would also mean that interhemispheric posterior

lobe communication is always excitatory. In contrast, the frontal lobes have the capacity to provide inhibitory effects on behavior. Given the fact that columnar efferent activity appears to be excitatory (i.e., glutamatergic), there must be a mechanism to otherwise allow this to occur. The basal ganglia appear to be the logical source for such inhibitory effects. This would suggest that the frontal columns involved with any learned action, no matter how concrete or abstract, rely on basal ganglia involvement, as does interhemispheric communication. For example, coordinated movement of both hands in a task requires selective activation and inhibition of each side's motor program. A "braking-system" theory has proposed that the basal ganglia's method of coordinated control is maintaining inhibition of competing motor responses and disinhibition of focal desired motor responses (Mink, 1996). Since motor responses are simply one form of action controlled by the frontal columns, a reasonable extension of Mink's theory is that all other action responses follow the same manner of functioning.

As has been mentioned, each frontal column forms based on the mode of operation of the associated posterior column. Since the posterior column development first involved relatively unorganized information close in proximity to the primary receiving areas, associated frontal columns form in close proximity to the central sulcus. The more complex the information reflected in a posterior column, the further away from the central sulcus will be its frontal column and the higher-order frontal column is interconnected with its previously formed lower-order columns. Just as the posterior columns are excitatory, so would the frontal columns be excitatory. However, by simultaneously circuiting each developing posterior and associated frontal columns' efferent output to the basal ganglia, this could logically allow the necessary inhibitory control. Additionally, the posterior and frontal columns have reciprocal connections to the thalamus. Such a connection pattern would result in a given higher-order frontal column sending output to the basal ganglia's inhibitory (i.e., gamma-aminobutyric acid) circuitry which provides inhibitory output to the thalamic nuclei which in turn provide excitatory input to the initiating frontal columns' lower-order interconnected columns. For the frontal lower-order columns to activate, the basal ganglia inhibitory output to the thalamus must be selectively removed.

From a neuropsychological perspective, this would explain the findings that damage to frontal cortex or damage to the interconnected basal ganglia results in some similar deficits. In this case, the frontal cortex contains the short-term (including working memory) or long-term memory (i.e., columns) for the assessed behavior. Damage to the frontal higher-order column means there is no indirect inhibition (via basal ganglia) or direct excitation to the associated frontal lower-order columns. With sensory input, the uninhibited lower-order frontal columns are activated which leads to the behavior controlled by those columns. For example, on the Stroop color-word inhibition test, rostrally located



higher-order columns are necessary to override the pre-potent color naming response. Damage to those rostral columns prevents the necessary inhibition to override the lower-order columns which involve the well-learned color naming response when presented with the color stimuli. Similar effects can result from damage to the interconnecting frontal column to basal ganglia fibers, or the basal ganglia nuclei themselves. This results in loss of the inhibitory control of the lower-order columns and associated problems in inhibiting the pre-potent color naming response. In relation to psychological problems such as compulsive behaviors and obsessional thoughts, similar problems in inhibition can occur either with dysfunction of frontal higher-order columns, the basal ganglia, or frontostriatal connections.

Based on the dimensional systems model, the hemisphere which can best respond to a given situation is the one that assumes control of the response. This means that the controlling frontal lobe must be capable of inhibiting the other frontal lobe which is capable of producing a competing, incompatible response. Since direct interhemispheric communication is presumably excitatory, the basal ganglia must be responsible for inhibition. Although there can be interhemispheric communication among basal ganglia structures controlling the process, there is evidence that in relation to the nucleus accumbens (ventral striatum) shell there are both ipsilateral and contralateral projections from the ventral medial prefrontal cortex (mPFC; Bossert et al., 2012). Contralateral projections would be particularly attractive as an explanation for interhemispheric inhibitory control since it would account for the quickest possible direct inhibitory mechanism limiting the effects of frontal columns in the contralateral cortex. The Bossert et al. study involved context-induced reinstatement of heroin-seeking following extinction. Of particular interest to the current paper was their discussion of results within the context of their previous research. They state:

These results suggest that only a small minority of context-encoding mPFC neurons mediate context-induced reinstatement. We speculate that this putative context-encoding mPFC “neural ensemble” is comprised of neurons that project to both ipsilateral accumbens shell and contralateral accumbens shell. (p. 4988)

The dimensional systems model (Moss, 2006) suggests that the “neural ensemble” is a cortical column encoding the contextual information. Regardless of the exact connections and mechanisms, interhemispheric inhibitory control leads to several relevant conclusions tied to psychological symptoms in negative emotional states.

The rapid processing in the right hemisphere allows faster response patterns. With situations creating negative emotional responses, the right frontal area would be quickly activated, with potential inhibitory influence on the left frontal lobe. In situations resulting in inhibition of the left lateral ventral frontal

activity, the perceived symptom would be impairment in one's verbal-thinking ability. This can result in problems accessing verbally-based information (e.g., test phobics knowing the material but being unable to access it due to anxiety while being tested) and impaired attention for details. It does not matter if the right hemisphere's excitatory receptive sensory processing is the result of a new aversive environmental stimulus or the activation of significant sensory negative emotional memories (or both), the activation of the right frontal lobe and its inhibitory influence on the left frontal lobe would occur. If the right frontal lobe does not effectively address a situation, the slower left cortical posterior excitatory activity has been ongoing and then activates the left frontal lobe. The left frontal lobe has the ability to exert inhibitory influence on the right frontal lobe to allow it to assume control of the ongoing response. Such parallel processing allows the two hemispheres to simultaneously be involved in any given situation and to employ the most efficient and effective solution. However, there are many situations which are beyond the control of either hemisphere. In this case, such as an unexpected and uncontrollable emotionally overwhelming event, both frontal lobes receive ongoing excitatory sensory input which maintains increased inhibitory influence on the other frontal lobe. This can explain perceptions of emotional numbing and depersonalization. In this case the inhibition creates attenuation of input from the opposing hemisphere, to some degree being functionally detached. This would also account for the observed electroencephalogram pattern reported in some studies of depressed patients in which the right frontal activity is relatively greater than the left (Hecht, 2010), though both frontal lobes would be expected to have decreased activity based on reciprocal inhibition.

An important point of the dimensional systems model is that each side of the brain stores its own memories tied to the processing used. This means that non-detailed sensory emotional experiences are stored in the right posterior lobes, while the non-detailed action or response memories are housed in the right frontal lobe. Due to the fewer number of columns between sensory input and behavioral output, right cortical complete circuit reception-leading-to-action memories are formed faster than in the left. Developmentally speaking, and due to fewer connections in the circuit, the initial right hemisphere's emotional memories are formed prior to the left hemisphere's verbal memories. Depending upon whether there are early positive or negative experiences tied to relationships, these memories will be the ones activated in future situations with others. Just as individuals learn a left hemisphere native spoken language that remains for life, they learn a right hemisphere native emotional language that remains for life. Thus, the sensory emotional memories leading to the activation of positive and negative reactions (i.e., what feels positive and what feels negative to each person) in response to the behavior of others are stored in the posterior right cortex. The behavioral expression memories (i.e., one's "personality") are

stored in the right frontal cortex. Therefore, one's relationship behavior patterns are largely a function of right hemisphere processing and memory. This also serves to explain what occurs in attachment disorders in which physical and emotional closeness is paired primarily with neutral and negative outcomes. In such cases, later physical and emotional contact in relationships activates negative emotional memories and consistently fails to result in competing positive emotions due to the absence of positive sensory memories in the right hemisphere. Additionally, early attachment figures may ignore or punish negative behavioral expressions (e.g., crying) and positive behavioral expressions (e.g., smiling) shown by the infant. This leads to an absence of interpersonal engagement behaviors (i.e., circuits of action columns) since such behavior patterns were not positively reinforced or were punished.

### *Treatment Considerations*

The clinical biopsychological model indicates that there are three sources leading to negative emotional states either singly or in combination. These are ongoing situations, activation of negative emotional memories, or failure to activate positive emotional memories. However, it is also necessary to look at each of these three sources in relation to the impact on each hemisphere and the congruence of frontal activity between the hemispheres. Interhemispheric congruence simply refers to the degree to which there is consistency of the analysis and response of each frontal lobe. The greater the inconsistency, the greater the perceived internal conflict in relation to the behavioral response generated from each hemisphere and the greater the inhibitory input received from the other frontal lobe.

Based on the theoretical formulation that all receptive information processing involves a feed-forward excitatory process, the posterior lobes can be considered passive. The posterior lobes cannot control environmental sensory stimulus input and resultant processing. However, sensory cortex can directly activate subcortical structures such as the amygdala. With subcortical activation, both the sympathetic and parasympathetic systems, as well as the mesolimbic dopamine pathway, can be influenced. Thus, passive does not mean that the posterior lobe processing lacks broad ranging influence. Therefore, right posterior cortical processing can result in autonomic physiological changes (e.g., decreased blood flow to the gut, increased heart rate) without the involvement of the right frontal lobe. This leaves the left lateral ventral frontal interpreter disconnected from the processing and associated effects of the right posterior cortex. In the presence of significant negative emotional memories in the right posterior cortex, there can be both subtle (e.g., decreased gastrointestinal blood flow) and noticeable (e.g., rapid heartbeat) physical symptoms without verbal recognition or awareness of why the symptoms exist. This can account for the manner in which

anxiety and other psychophysiological symptoms can emerge in the absence of verbal “conscious” awareness.

In reference to effective psychological treatment, the frontal lobe action columns are necessarily engaged. Whether practicing relaxation or mindfulness procedures, or engaging in non-directive therapy dialogue, the action columns are responsible for producing the behavior. However, even in the same hemisphere the frontal columns do not necessarily interconnect. Recall that the developmentally earliest frontal lobe columns form in association with and are connected to the corresponding intrahemispheric posterior columns leading to the same type of information coding (e.g., medial cortex involves internal, self-referential information while lateral cortex involves externally related information). The dimensional systems model (Moss, 2006) suggests the existence of multiple frontal attention centers (e.g., dorsolateral cortex manipulating posterior lateral external information columns and anterior cingulate-medial cortex manipulating posterior medial internal information columns), referring to the fact that whichever columns are required in a given task are the ones that activate. This means that different areas in one frontal lobe are responsible for different actions, often with no connections among those areas allowing for verbal interpreter awareness even when it involves other regions of the left frontal lobe. Additionally, action column circuits code for all verbal and non-verbal behaviors, including the maladaptive behaviors observed in clients. This means that treatment based on the dimensional systems model and the clinical biopsychological model can be evaluated on the basis of which frontal columns are involved with a given approach or technique, and whether a given treatment is addressing maladaptive sensory memory processing and maladaptive action processing. Therefore, truly comprehensive treatment involves the inclusion of all relevant bilateral frontal areas.

### *Ongoing Situations*

There are limitless types of situations which can create negative emotional states. Except in early infancy, no sensory processing and associated responses can be considered independent of memory since learning begins early and continues. However, within the context of psychopathology treatment, it is possible to address a client’s response pattern to current or anticipated situations employing strategies which require no attempts to deal with past memories. The most obvious theoretical orientation in this regard involves behavioral (e.g., stimulus control, reinforcement contingencies) and cognitive-behavioral (e.g., self-talk, schemas) treatments. It is possible to consider case conceptualization as an ongoing treatment procedure in that conceptualization provides a new schema to explain the development, maintenance, and proposed treatment of a client’s problem. At face value it would appear that a conceptualization is only influencing the left cortex since a verbal explanation is involved. However, the verbal descrip-

tions may lead to visualization which can directly influence the right cortex. Additionally, as the left hemisphere recognizes logical and reasonable explanations as to why problems are being experienced, the less there will be perceived internal conflict. In this case, there is improved congruence between the hemispheres as a result of the left frontal recognition that perceived problems are logical and sensible, with concurrent reduction in inhibition of the right hemisphere.

As will be evident in the discussion of each hemisphere and interhemispheric congruence, it is not possible to ever consider either hemisphere as completely independent of the other. The smooth coordination among various intrahemispheric and interhemispheric areas happens in fractions of seconds which allows the emergence of what appears to be a uniform mind. However, the dimensional systems model and the clinical biopsychological model allow a way to dissect the components contributing to the emergent mind in psychotherapy. Verbal-thinking represents only one particular function involving the left lateral ventral frontal cortex. Although this appears to be uniquely human and a very powerful function, it should not be considered “consciousness” since this is only one of many frontal lobe actions. Instead, the term “consciousness” may be better conceptualized as referring to the outputs of cortical action columns, based on receptive column information, that allow meaningful external and internal interactions. Consistent with Gazzaniga’s (2010) view on “emergence” in defining the “mind,” this definition views all frontal circuits as equally involved in meaningful interactions. The action columns which can best address an ongoing situation are those that assume control, whether or not there is verbal-thinking control or awareness.

When confronted with novel, unexpected, or threatening situations, the right hemisphere is capable of the quickest cortically processed response. Obviously spinal reflexes (e.g., withdrawing one’s hand from a hot object) and subcortical orientation responses (e.g., looking toward the source of a sound) are the fastest behavioral patterns, but the right cortical processing allows for the rapid generalized decision of freeze, fight, or flight. Contextual cues are influential since the right cortex efficiently processes them. In relation to process variables (Rogers, 1957), therapist “warmth” is primarily processed in the client’s right hemisphere. Non-detailed therapist behaviors such as voice intonation, body position, facial expressions, and eye contact are keys in conveying warmth and acceptance.

Imagery and experience are the two basic ways of influencing the right hemisphere, though in psychotherapy this is typically prompted by therapist verbal interactions and directions with the client’s left hemisphere. Although guided imagery may immediately come to mind as a treatment approach, the use of metaphor and analogy are also ways to evoke mental pictures allowing communication with the right hemisphere. Thinking spatially involves the dorsal, simultaneous processing parietal lobes. When spatial visualization occurs, the right

parietal lobe must be involved. This is accessed in therapy when describing an overarching model to allow the client get “the big picture” or “see the forest” prior to giving each of the components. If the client later has a situation in which the model is applied, the right frontal action columns are employed. If the client later explains the model to someone else, there is right hemisphere activation and congruent left hemisphere frontal action column involvement. Herein is a prime example of the importance of the level of overall cortical involvement. If the client only pictures the model (i.e., right posterior involvement), there is no frontal activation. As a result, no impact on the client’s subsequent emotions and behavior would be expected. Upon successful application of the model in a situation there is involvement of the right frontal lobe and the client will likely feel improved understanding and control as a result. This application has its main impact in the right hemisphere and can lead to long-term improvement with continued application. In the event that the client teaches the model to someone, there is involvement of the action columns in the left hemisphere which can allow even better detailed application by the client. This would also allow improved interhemispheric congruence since both sides are in concert. Thus, the client both applying the model and verbally teaching it results in bilateral frontal lobe involvement and theoretically is expected to increase therapeutic impact.

In reference to the different approaches directed to teaching relaxation, the clinical biopsychological model suggests what areas of the cortex are involved. Examples of relaxation procedures are progressive muscular relaxation, mindfulness, and meditation. Regardless of the relaxation approach, attention (action involving the frontal columns) is typically focused on internal and external body areas in the beginning of the training procedure. Medial frontal lobe columns allow the action of focusing on internal emotional states housed in the medial parietal region, transitional regions between the lateral and medial cortices (e.g., insula) involve action and sensory visceral activities, and lateral cortex involves any direct voluntary control of the body. Direct voluntary control examples are tightening and relaxing bilateral muscle groups (involving lateral frontal and parietal regions of both hemispheres), repetition of select words or phrases (involving left lateral ventral frontal), and focusing on the sensations of breathing (bilateral frontal ventral lateral and insular, as well as parietotemporal lateral and insular regions). In relation to tensing/relaxing procedures, the premotor and motor regions of the lateral frontal cortex must occur and the sensation changes activate the posterior lateral areas. Repeating phrases or words involves the verbal-thinking region. Both word repetition and tensing would be expected to lead to less activity of the “default network” since there is an active involvement of the lateral cortex. In contrast, focusing on the sensations of breathing largely disengages lateral frontal cortex, particularly in the left hemisphere, and increases activity in the transitional lateral-medial areas

since internal-visceral activities are coded in these regions. With the emerging fMRI studies on mindfulness, meditation, etc., it is possible to theoretically predict what aspects of the procedure being examined should lead to observed cortical responses. If accurate, this may at some point have prescriptive value in choosing various forms of relaxation, mindfulness, and hypnosis based on the disorder and targeted cortical regions. However, there is one important point I will repeat in this paper as it relates to new learning versus old learning. In evaluating brain activity in experienced versus matched naïve-control subjects, Brewer et al. (2011) found that medial frontal and posterior cingulate cortices were relatively deactivated regardless of meditation type. The authors suggested the differences may be related to decreased mind-wandering in experienced meditators. There is an alternative interpretation that can be crucial in avoiding potentially misleading interpretations in this and other studies in which old learning is evaluated via fMRI. In this case, well-learned behaviors will likely result in no generalized cortical activity even though the columnar memory is stored at that location.

When new cortical learning (i.e., a new circuit of columnar connections that is behaviorally efficacious) occurs, there is likely an increase in general local metabolic activity. Moss (2006) suggests this can allow the columns in the circuit to maintain activity with pronounced surround inhibition (i.e., signal) in the presence of general activation of surrounding tissue with the exception of neurons immediately adjacent to the involved columns which are inhibited (i.e., noise). As the columnar connections in the circuit strengthen, there is less generalized local activity. This not only reduces energy consumption, it likely allows the columnar circuit to further strengthen (i.e., signal) based only on the activation of that circuit. Therefore, the absence of increased fMRI activity in well-learned behaviors should not lead to the conclusion that columns in a certain region are not involved.

All psychotherapy procedures necessarily involve the left hemisphere. This is due to the reliance on verbal communication. The verbal behavior of the client is generated by the left verbal interpreter. With adequate case conceptualization which outlines treatment, the client's verbal interpreter has been provided with an organizational scheme which can be used to understand the therapy process, including expectancies of the client's own behavior. Action columns of the left hemisphere are always involved when a client logically decides to remain in a situation leading to perceived emotional distress. Perhaps the best demonstrated fMRI examples involve heightened dorsolateral prefrontal lobe activation in relation to successful fear extinction in anxiety disorders (e.g., Hauner et al., 2012). However, it is important to emphasize that any time a client finds a discussion in therapy leads to emotional distress, the voluntary choice to continue the discussion must involve the frontal action columns. Thus, the finding of frontal activation should not be considered to be exclusive

to certain cognitive-behavioral approaches. If this is accurate, then all forms of effective psychotherapy (both within session and employing techniques in the real world) involve a form of exposure therapy and similar heightened frontal metabolic activity would occur in the areas controlling the new responses (i.e., new columnar connections). This means the left lateral ventral frontal interpreter may be responsible for the decision to remain in a distress producing situation, but may not show fMRI changes since the verbal-thinking does not involve the learning of new words. Metabolic changes would be expected in the right frontal region and newly involved left frontal regions.

In support of this possibility are the data from the Hauner et al. (2012) exposure study in spider phobics. Immediately after successful treatment, there was a rise in cortical activity in the right dorsolateral prefrontal cortex. However, at the six month follow-up, this was no longer evident. The authors concluded that “up-regulation of dlPFC processing, as observed in the short term (immediately after therapy), was not essential for maintaining either long-term therapy gains or long-term amygdala/limbic responses to phobogenic images” (p. 9204). As previously discussed in relation to new versus old learning, a reasonable alternative explanation is that the initial post-treatment rise in dorsolateral prefrontal cortical metabolic activity was essential to allow the new memory consolidation. However, after the memories were effectively consolidated, there was no need for continued general activation. Importantly, this interpretation says that the dorsolateral prefrontal columns are involved in both the acquisition and maintenance of treatment effects.

When there is consistency of bilateral hemispheric information processing and analysis, perceptions of internal conflict lessen regardless of the emotional state. Thus, an individual in an emotional state who verbally thinks and emotionally feels that it is reasonable and acceptable to have that state, has a high degree of interhemispheric congruence. In relation to one of the process variables described by Rogers (1957) which is conveyed by the therapist, both the client’s right and the left posterior lobes are impacted in “genuineness.” In this case, the therapist communicates truthful and consistent verbal and emotional messages to the client, both based on verbal content and with the heartfelt aspect of the accuracy being conveyed by the therapist’s non-verbal behaviors. The result for the client is to process the receptive information in both the right and left posterior cortical columns followed by the associated frontal columns being activated. Since the frontal columns of both hemispheres have consistency, the client will experience minimal conflict. In relation to the process variable of “empathy,” the accurate verbal labeling of the client’s emotional state results in the client’s left verbal posterior processing becoming aligned with the existing right posterior sensory processing or memory activation. In this case the left posterior column activation of the connected frontal columns aligns the left frontal processing with the existing right frontal processing. In



both empathy and genuineness, there is less inhibitory input to each frontal lobe from the other frontal lobe in the client's brain. This would be expected to be perceived by the client as decreased internal conflict.

Improved congruence can result from alterations in action and receptive columns in both hemispheres. The aforementioned act of remaining in anxiety-producing safe situations until emotional distress dissipates, allows the right hemisphere to modify its patterns to align with the left hemisphere's appraisal that there is no danger. The fastest way to improved congruence in therapy appears to be providing the left posterior cortex with logical information that right hemisphere receptive processing and action are expected and reasonable. However, failure to have the client utilize the information which involves the left verbal interpreter will lead to a lack of continued congruence.

Unfortunately, there are many things therapists do which can increase hemispheric incongruence experienced by a client. For example, the all-too-frequently employed question, "Why do you allow yourself to feel that way?" [referring to guilt or some other negative state] immediately registers in the client's left hemisphere with the interpreter concluding that it should somehow have the ability to control the emotion. Based on the clinical biopsychological model, just the opposite is true in relation to right cortical processing. This is an example of how a brain-based model has the potential to identify which therapists' behaviors may have iatrogenic effects (see Moss, 2007, for a more detailed discussion).

### *Negative Emotional Memories*

Since theoretical aspects tied to negative emotional memories based on the clinical biopsychological model have been previously described (Moss, 2007), only the most salient points will be included in the current discussion. First, it is clear that all humans experience a number of situations resulting in negative emotions, but these do not necessarily lead to memories contributing to psychological problems. Therefore, there must be some aspects in relation to the situations that account for such individual differences.

The sensory aspects of negative emotions are stored in the posterior cortical lobes and the associated actions are stored in the frontal lobes. It has been proposed (Moss, 2001, 2007) that the two major situational factors tied to detrimental impact of all negative emotional memories are perceptions or feelings of loss of control and personal inadequacy or responsibility. These two aspects have been similarly noted in relation to traumatic memories by Foa and Rothbaum (1998) where they describe clients' beliefs that the world is totally dangerous and they themselves are completely incompetent. Earlier traumatic and non-traumatic events appear to be very influential in leading to psychological disorders associated with a current trauma (Moss, 2007). In this case, the memories which are formed prior to a traumatic situation are those leading to the maladaptive

client beliefs described by Foa and Rothbaum. Support for this can be taken from a study of posttraumatic stress disorder in a group of Danish soldiers before, during, and after deployment in Afghanistan. Berntsen et al. (2012) found that pre-deployment emotional problems and pre-deployment traumas, especially childhood adversities, were predictors for inclusion in non-resilient trajectories of change while deployment stress was not.

Based on the clinical biopsychological model the right cortical memories are the most influential in leading to maladaptive emotional states and behavioral reactions, yet the most difficult to access in psychotherapy. As previously noted, all psychotherapy necessarily involves the left cortical verbal-thinking region which does not have direct access and control over right posterior memories. The vast majority of all clients the current author has treated over the past 31 years, regardless of diagnosis, had prior influential negative memories, most often involving past and current relationships. Although most people have some degree of feelings of lost control when experiencing a traumatic event, those with prior relationship negative emotional memories are much more prone to experience the personal inadequacy aspect. If only the loss of control aspect is perceived tied to a traumatic event, this will likely be responsive to exposure-based therapies (Moss, 2007). However, in relation to past relationship memories, repeated detailed factual discussions of these memories in psychotherapy leads to little overall improvement and may actually increase distress. Prior to discussing the treatment of relationship negative emotional memories, a discussion of how adaptive functioning tied to memory storage and cortical processing theoretically occurs is warranted.

Only a minority of individuals exposed to trauma experience persistent psychological problems. For example, Housley and Beutler (2007) looked at combined results of three reports and found a 12-month-prevalence rate for posttraumatic stress disorder and acute stress disorder of 12% in the general population. Thus, the majority of people somehow have the resilience to handle trauma. In relation to the clinical biopsychological model, there are several factors which can explain such resilience.

In the right hemisphere, resilient individuals have few posterior cortical receptive negative emotional memories stored with the loss of control and personal inadequacy or responsibility factors. As such, the posterior cortical sensory negative emotional memories tied to past situations or events are necessarily linked to associated frontal action columns in which the situations were adequately handled. In the event of a traumatic situation, the similarity of emotions activate the posterior columns which in turn activate the frontal columns tied to past successful coping behavior. In relation to left frontal cortical memory, successfully managing the past negative emotional situations was likely a result of the logical analysis and response mediated by the verbal interpreter. There is also a strong likelihood that resilient individuals have the verbal-thinking ability

both to label accurately and accept the reasonable nature of negative emotions. In total, these cortical factors result in feelings and thoughts that one is capable of effectively coping with any situation, with the verbal interpreter initiating action to address immediate needs.

In maladaptive functioning, the frontal columns of both hemispheres lack a history of successful and socially appropriate personal control behaviors. In this case, the only right hemisphere generalized behavioral responses of the action columns are to attack, freeze, escape, or avoid. If this is the case, the left verbal-thinking area necessarily lacked a means of effectively dealing with similar situations in the past. Why? Had the left verbal-thinking led to effective control in similar past situations, the left posterior receptive columns would activate when presented with the current event and immediately activate the associated action columns. Based on this theoretical formulation, the right hemisphere is most likely to assume control over responses in those lacking a history of adequate verbal-thinking behaviors.

Given its lack of extensive verbal abilities, the attack response of the right frontal cortex is characterized by loud voice, profanity, or physical assault. If this behavior is observed, there must be a history of at least limited success. However, despite possible immediate success in terminating a negative stimulus, there are obvious longer-term social consequences to such behavior. Although there may be less chance for a loss of control feeling with aggressive behavior, there is unlikely to be a feeling of personal adequacy. The other action responses of freeze, escape, and avoid lead to both loss of control and feelings of personal inadequacy. "Personality" is considered to be the right frontal action column-related behaviors based on the receptive columns (and their associated positive or negative emotional response) which activate in response to relationship behaviors of others. Therefore, "personality disorders" can be defined the same with the only addition being that the relatively stable pattern of behavior is considered maladaptive. Overly manipulative (i.e., aggressive or controlling) action column behavior are characteristic of antisocial, narcissistic, borderline, and obsessive-compulsive patterns. The freeze, escape, and avoid action column behavior are characteristic of avoidant or dependent patterns.

The importance of engaging emotion directly in psychotherapy has been noted by Greenberg (2010). His approach, called emotion-focused therapy, employs experiential techniques which primarily impact the right cortex as based on the current theoretical model. The use of imagery in therapy has also been noted to be of importance for many years (e.g., Lang, 1977). Moss (2001, 2007) advocates for a structured assessment in identifying all potentially relevant relationships (e.g., parents, siblings, school peers, spouse, etc.) since all can contribute to a client's current emotional functioning and a structured treatment approach (i.e., emotional restructuring) to deal with each. This structured treatment includes abundant imagery, as well as role playing and reversals. It is

possible for many clients to experience dramatic changes in both their perceptions and feelings tied to the discussed relationship in a one-to-two-hour session, with immediate impact on current functioning. The impact on current functioning is viewed as the right posterior lobes' receptive columns tied to the prior or current relationship, which are activated by a number of ongoing situations, leading to the activation of new action column memories stored in the right frontal cortex. The newly formed action column memories are associated with perceptions of control and personal adequacy.

Prior to the role reversal and imagery components, the client is provided a description of one of two relationship behavior patterns. The description of the target individual (e.g., mother, spouse, boss) is based on the aforementioned storage of receptive memories in the right hemisphere which determines what feels positive versus negative. The associated right frontally based behavioral strategies to increase positive and decrease negative emotions involve either giving or taking of power, control, attention, or material things in the relationship. A full discussion of the patterns is beyond the scope of the current paper, but is mentioned here in relation to theoretical impact. The verbal interpreter is given a new schema which is sensible, allowing for an alignment of verbal-thinking of the left cortex with the long-standing non-detailed emotional memories of the right hemisphere. Once the pattern is understood, it serves as the basis for assuming the role of the target individual in the role reversal. If the client is successful in assuming the role, there is a reported shift in feelings such that there is a feeling that the target individual is responsible for the problems, not the client. Anxiety declines and anger increases. In this case, the newly formed action column circuits tied to the new schema in the left cortex and the newly formed action column circuits tied to the role-played behavior in the right cortex are consistent.

The imagery is designed to allow release of anger and increase self-nurturance. In most cases, the release of anger involves a described physical assault on the target individual in which the client knows the target individual is incapacitated. This aspect is typically not received well by either seasoned or novice therapists when it is first described. However, it is critical for the best therapeutic outcome. As explained to therapists learning the emotional restructuring process, if one can give the client a described scene lasting less than a minute that can result in permanent improvement in that client's psychological functioning, how is it possible to justify not doing so? Immediately after the anger release imagery scene, the client next receives a description of a funeral in which he realizes that it was not the target individual who died. Instead, the client sees himself in the casket, and then proceeds to engage in a dialogue while hugging the deceased. The conclusion of the imagery scene is the deceased returning to life and expressing gratitude to the client for finally recognizing the reality of what occurred. The typical report of the client at the end is that the anger

is gone and there is a feeling of relief. The final aspects involve providing further information to the client that the target individual was incapable of different behavior due to his own emotional memories, setting up the role play of stated forgiveness which completes the session.

This is obviously only a skeleton version of what is involved, but it is sufficient to apply the theoretical model to each of the imagery components. The visualization of an actual past situation in which the client failed to assert himself is typically used. With the visualized physical assault there are new action column circuits in the bilateral frontal lobes of the client, activated by the new verbal descriptions given to the client's left temporal lobe. These action columns in turn activate associated (i.e., top-down processing) receptive columns in the parieto-occipital region allowing the visualization. In many cases, the client's experience with the target individual has been that any assertive behaviors in response to inappropriate behavior of the target individual results in subsequent problems, thus never truly feeling in complete control. Logically speaking, the only way the right hemisphere can experience feelings of control without fear of retaliation is to physically overcome the person. The experience of the anger expression is perceived by clients as positive in nature. The funeral scene also results in activation of both left lateral ventral frontal columns associated with the nurturing dialogue and the right frontal columns controlling the visualization of caring for the externalized self in the coffin. In total, this allows a mechanism which addresses both loss of control and personal inadequacy tied to the influential memories.

In relation to negative emotional memory treatment, the applied theoretical model has value in evaluating the various procedures currently employed and the degree to which each can effectively engage the frontal lobes bilaterally. This can facilitate communication among therapists with varying orientations since there is a common ground to understand how the brain is being affected.

### *Positive Emotional Memories*

Failure to activate positive emotional memories leads to predictable patterns of reactions. Moss (2001) proposes that an effective way to conceptualize the reactions for the client is based on opponent-process theory (Solomon, 1980). In this regard, an initial positive (or negative) affective state tied to a recurring stimulus shows a gradual reduction in the perceived level of the positive (or negative) affect over time. An opposing affective state is hypothesized to gradually strengthen over time and reduce the experienced level of positive (or negative) affect. If the stimulus is withdrawn, only the negative (or positive) opponent affective state remains. As adapted to explain loss-related depression, the perceived emotional state can be viewed as the summation of the output of both the positive and negative "emotional centers." It is the same as adding a positive

and negative number together. For example, adding a +5 to a -4 leads to a sum of +1. In this case, +1 would still be a positive state, though greatly reduced from the initial +5 state. The most readily apparent logical reason for the existence of an opponent-process system is to ensure the organism continues to engage the environment so that all survival needs are met. In other words, nothing can remain so positive or negative that it interferes with the organism's motivation to engage other aspects of the environment necessary to meet all needs.

Upon the loss of any particular stimulus that has previously been positively rewarding there is deactivation of the positive affective state and only the opponent negative emotional state remains. If the stimulus cannot be restored, the negative emotional state continues over time. There would be a gradual lessening of the negative emotions over time due to the fact that the negative affective state's purpose was simply to off-set (thus, being powered by) the positive state; with the positive center deactivated, there is no means to keep the negative center activated. Eventually, the emotional state tied to the loss of the positive stimulus would return to neutral.

Clients may make a voluntary choice to avoid something considered detrimental despite its associated positive emotions (e.g., addictive substance) or the loss may be involuntary (e.g., death of a loved one). Regardless, the general emotional reaction pattern would be the same when the positive emotional memories are not activated tied to the lost stimulus. Although there is no progression in a smooth and complete fashion from one "phase" to another, the overall pattern is first denial, then dysphoria, then anger, and finally acceptance. Denial refers to a logical, verbal acknowledgement of the loss (left hemisphere) in the absence of extreme negative emotions. This may be related to the previously discussed emotional numbing via left frontal inhibition of right frontal activity in more traumatic events, but can also happen in situations where the full impact has not been fully processed experientially (e.g., getting a diagnosis of spinal cord injury, being told one has lost a job). As an individual participates in the typical daily situations with the loss being evident, the right hemisphere experiences the loss and the left hemisphere can fully assess the detailed changes, at which point the depressive symptoms occur. If the loss is fully accepted as permanent in nature, over time the severe dysphoria lessens and anger feelings emerge. It seems logical that the anger emerges as a function of right frontal action column circuit activation and is important in allowing the establishment of a perceived control aspect (i.e., active responding as opposed to passive acceptance) and attribution of blame for the loss outside of oneself. Both the depression and anger continue to gradually lessen and the individual finally returns to a much more neutral state. In dealing with life loss issues which are permanent in nature, Moss (2001) suggests that education of the client on the normal and expected emotional patterns is very beneficial in allaying anxiety, as well as allowing a realistic evaluation of the limited impact of various treatments (e.g., psychopharmacology).

If complex memory storage occurs only at the cortical level, this is the level at which the opponent-process is triggered when there is loss of a previously rewarding stimulus. However, the involvement of the basal ganglia and limbic structures, such as the amygdala and septum, are also expected. Mink (2008) notes that the ventral striatum receives input from limbic and olfactory cortex, including the amygdala and hippocampus. The ventral striatum (including nucleus accumbens) has reciprocal connections with the ventral tegmental area (part of the mesolimbic dopamine pathway). The ventral pallidum receives input from the ventral striatum and amygdala, with its output going to the dorsomedial nucleus of the thalamus which projects back to limbic cortex. The exact nature of the overall system's role in emotion is not known, though Mink suggests that the inhibitory output of the ventral pallidum may act to suppress or select potentially competing limbic mechanisms. Suppression or selecting competing limbic mechanisms are certainly functions consistent with an opponent-process.

In relation to cortical memories tied to significant loss, there are numerous emotional memories involving the external (lateral cortex) and internal (medial cortex) sensory columns. Specific objects and places memories involve the sequential (ventral cortex) information stream while spatial and contextual memories involve the simultaneous (dorsal cortex) information stream. In the presence of association memories the medial temporal cortex is involved. The loss of positive affect with an ongoing positive stimulus would necessarily involve output from external and internal action columns, though the internal columns (e.g., medial frontal, orbitofrontal) are likely those projecting to the aforementioned ventral basal ganglia system.

Loss can be considered extinction of prior association memories tied to the previously rewarding stimulus. In this case, the various stimuli (e.g., locations, time of day) previously associated with the absent object are experienced. Theoretically, extinction refers to the weakening of synaptic connections that allowed the formation of the temporal cortical columns (i.e., association memories) connected to the lost object's columnar circuit and the associated stimuli (e.g., locations) columns, as well as corresponding frontal action columns tied to the lost stimulus. The exact connections among all columns are only guesswork at this point, but the final result following extinction would be the lack of activation of the medial and orbitofrontal columns connected to the ventral striatum and limbic structures. The end result is that the primary affective state tied to the lost object fails to activate, leaving only the opponent affective process. There will likely be increased generalized metabolic activity (due to this being new learning related to the absent stimulus, or actually "unlearning") around the involved columnar circuits. The generalized activity in the absence of the prior column activation would simply weaken association column activation (i.e., only noise in the absence of the signal). In the case of loss of a previously rewarding stimulus, this would account for any observed metabolic increases in activity in various cortical regions.

Support for distributed cortical effects was provided in two studies on grief (Gundel, O'Connor, Littrell, Fort, and Lane, 2003; O'Connor, Wellisch, Stanton, Eisenberger, Irwin, and Lieberman, 2008). O'Connor et al. compared individuals with complicated grief versus those with noncomplicated grief. Complicated grief is considered present in an individual experiencing excessively prolonged grief which includes recurrent pangs of painful emotions with intense yearning for the loved one. The authors' goal was to elucidate the neural mechanisms associated with both complicated and noncomplicated grief. The independent variables involved a single photograph of the deceased individual versus a stranger and 15 idiosyncratic grief-related words versus 15 neutral words across 60 trials. Composites of each of the photographs and each of the words served as the presented stimuli. The dependent variables involved fMRI measures in regions of interest. There were several pain processing areas (i.e., dorsal anterior cingulate cortex, insula, periaqueductal gray) activated in both groups related to pictures of the deceased individuals and the grief words. However, the only brain area showing relatively greater activity in the complicated grief individuals to the grief related words was nucleus accumbens. Although there was no difference between groups in response to photographs of the deceased, the authors were sensitive to the likelihood of habituation (i.e., new versus old learning) since the same photograph was used in all trials. They then compared groups on the basis of the first third of the trials and found results in which complicated grief participants showed greater nucleus accumbens activation. When the increased nucleus accumbens activation was observed, it was correlated with self-reported yearning for the deceased. No correlation was found between nucleus accumbens activity and length of time since death, participant age, or general positive or negative affect.

The results of the O'Connor et al. study can be used to show the potential of a brain-based theoretical model in psychotherapy. Moss (2001) previously suggested that complicated grief is best conceptualized as a traumatic event phobic-type response, while the loss aspects follow an opponent-process pattern. In this regard, the circumstances of the death represent the trauma and the complicated grief client finds the activation of the traumatic memory painful. The client actively avoids situations, thoughts, and conversations which activate the memories of the loss, including many pre-death memories. Conceptually, these traumatic memories are characterized primarily by loss of control without the personal responsibility aspects and are responsive to exposure procedures. In treatment the client goes through two to three detailed descriptions of the events beginning when the client was notified of the death through the time of returning home after the funeral. Across the one-to-two-hour session, anxiety dissipates and there is improved recollection of details. This generally leads to immediate and dramatic improvement following the client engaging in a brief role play at the end of the session saying "good-bye" to the deceased. Similar



procedures have been described as effective by others (Shear, Frank, Houck, and Reynolds, 2005).

The O'Connor et al. (2008) study shows that nucleus accumbens is involved in response to cortically processed stimuli, both visually and verbally, and appears to be associated with yearning. The yearning is certainly one aspect of what clients report during the dysphoria phase of grieving. For uncomplicated grief, individuals face the environmental stimuli (thereby activating the associated cortical columns) leading to recollection of the deceased, including the reality of the death, on a frequent basis. Consistent with an opponent-process theory, there is gradual deactivation of the associated ventral striatum areas. By avoiding the cortical activation of memories associated with the deceased, the deactivation does not fully occur. In complicated grief subjects in the O'Connor study, with as few as 30 picture presentations, there was an indication of decreased ventral striatum activation tied to that one specific stimulus. Although such a restricted exposure to a single stimulus likely had little therapeutic effect, it can be used to support the brain effect of exposure procedures in the presence of complicated grief. It can also be used to support the value in educating clients on the normal process which is typical of natural reactions to significant loss of any kind (e.g., loss of health, loss of job). In this case, the depressive symptoms are considered normal and the client can be encouraged to be realistic in facing and accepting the loss with the understanding that the depressive symptoms will gradually dissipate over time.

### *Conclusions*

In closing, the current paper has been an attempt to bridge the conceptual divide between a neurophysiological theory and an applied clinical model. The dimensional systems model involves a whole brain model in which the cortical column is the basic unit involved in learning and memory. Based on the purported organization of columns and connection patterns, specific suggestions have been made as to how psychological problems may develop and be addressed in treatment. This has been done to show how applying the neuroscience level dimensional systems model leads to a clinician-level applied clinical biopsychological model which can be used at the client-level of conceptualization and treatment. There have been speculations made here which cannot be proven based on the current literature. However, it is believed there is enough evidence at all levels to support these as viable theoretical models which can be evaluated. It is hoped this can generate interest among neuroscientists and clinicians in fully evaluating the value of these theoretical models.

## References

- Alivisatos, A.P., Chun, M., Church, G.M., Deisseroth, K., Donoghue, J.P., Greenspan, R.J., et al. (2013). The brain activity map. *Science*, 339, 1284–1285. doi: 10.1126/science.1236939
- American Psychological Association. (1998). APA launches decade of behavior. *Monitor on Psychology*, 29(2).
- Bassett, D.S., and Gazzaniga, M.S. (2011). Understanding complexity in the human brain. *Trends in Cognitive Sciences*, 15, 200–209. doi:10.1016/j.tics.2011.03.006
- Berntsen, D., Johannessen, K.B., Thomsen, Y.D., Bertelsen, M., Hoyle, R.H., and Rubin, D.C. (2012). Peace and war: Trajectories of posttraumatic stress disorder symptoms before, during, and after military deployment in Afghanistan. *Psychological Science*, 12, 1557–1565. doi: 10.1177/0956797612457389
- Bossert, J.M., Stern, A.L., Theberge, F.R.M., Marchant, N.J., Wang, H., Morales, M., and Shaham, Y. (2012). Role of projections from ventral medial prefrontal cortex to nucleus accumbens shell in context-induced reinstatement of heroin seeking. *Journal of Neuroscience*, 32, 4982–4991. doi: 10.1523/jneurosci.0005-12.2012
- Brewer, J.A., Worhunsky, P.D., Gray, J.R., Tang, Y.Y., Weber, J., and Kober, H. (2011). Meditation experience is associated with differences in default mode network activity and connectivity. *Proceedings of the National Academy of Sciences*, 108, 20254–20259. doi: 10.1073/pnas.1112029108
- Cacioppo, J.T., and Berntson, G.G. (1992). Social psychological contributions to the decade of the brain. *American Psychologist*, 47, 1019–1028.
- Foa, E.B., and Rothbaum, B.O. (1998). *Treating the trauma of rape: Cognitive-behavioral therapy for PTSD*. New York: Guilford.
- Freud, S. (1895). *Project for a scientific psychology*. London: Hogarth Press.
- Gazzaniga, M.S. (2002). Consciousness. In V.S. Ramachandran (Ed.), *Encyclopedia of the human brain* (Volume 2, pp. 31–35). New York: Academic Press.
- Gazzaniga, M.S. (2010). Neuroscience and the correct level of explanation for understanding mind: An extraterrestrial roams through some neuroscience laboratories and concludes earthlings are not grasping how to best understand the mind-brain interface. *Trends in Cognitive Sciences*, 14, 291–292. doi:10.1016/j.tics.2010.04.005
- Greenberg, L.S. (2002). Integrating an emotion-focused approach to treatment into psychotherapy integration. *Journal of Psychotherapy Integration*, 12, 154–189.
- Greenberg, L.S. (2010). The clinical application of emotion in psychotherapy. In M. Lewis, J.M. Haviland-Jones, and L.F. Barrett (Eds.), *Handbook of emotions* (pp. 88–101). New York: Guilford.
- Gundel, H., O'Connor, M.F., Littrell, L., Fort, C., and Lane, R.D. (2003). Functional neuroanatomy of grief: An fMRI study. *American Journal of Psychiatry*, 160, 1946–1953.
- Hauger, K.K., Mineka, S., Voss, J.L., and Paller, K.A. (2012). Exposure therapy triggers lasting reorganization of neural fear processing. *Proceedings of the National Academy of Sciences*, 109, 9203–9208. doi: 10.1073/pnas.1205242109
- Hecht, D. (2010). Depression and the hyperactive right-hemisphere. *Neuroscience Research*, 68, 77–87. doi: 10.1016/j.neures.2010.06.013
- Hempel, A., Giesel, F.L., Caraballo, N.M.G., Amann, M., Meyer, H., Wustenburg, T., et al. (2004). Plasticity of cortical activation related to working memory during training. *American Journal of Psychiatry*, 161, 745–747.
- Housley, J., and Beutler, L.E. (2007). *Treating victims of mass disaster and terrorism*. Cambridge, Massachusetts: Hogrefe.
- James, W. (1950). *Principles of psychology* (Volume 1). New York: Dover. (Original work published in 1890)
- Kandel, E.R., and Squire, L.R. (2000). Neuroscience: Breaking down scientific barriers to the study of brain and mind. *Science*, 290, 1113–1120.
- Lang, P.J. (1977). Imagery in therapy: An information processing analysis of fear. *Behavior Therapy*, 8, 862–886.
- LeDoux, J.E., and Phelps, E.A. (2010). Emotional networks in the brain. In M. Lewis, J.M. Haviland-Jones, and L.F. Barrett (Eds.), *Handbook of emotions* (pp. 159–179). New York: Guilford Press.

- Luria, A.R. (1966). *Higher cortical functions in man*. New York: Basic Books.
- Markram, H. (2012). The human brain project. *Scientific American*, 306, 50–55. doi: 10.1038/scientificamerican0612-50
- Miller, G.A. (2010). Mistreating psychology in the decades of the brain. *Perspectives on Psychological Science*, 5, 716–743. doi: 10.1177/1745691610388774
- Mink, J.W. (1996). The basal ganglia: Focused selection and inhibition of competing motor programs. *Progress in Neurobiology*, 50, 381–425.
- Mink, J.W. (2008). The basal ganglia. In L. Squire, D. Berg, F. Bloom, S. Du Lac, A. Ghosh, and N. Spitzer (Eds.), *Fundamental neuroscience* (pp. 725–750). New York: Academic Press.
- Moss, R.A. (2001). *Clinical biopsychology in theory and practice*. Greenville, South Carolina: Center for Emotional Restructuring.
- Moss, R.A. (2006). Of bits and logic: Cortical columns in learning and memory. *Journal of Mind and Behavior*, 27, 215–246.
- Moss, R.A. (2007). Negative emotional memories in clinical treatment: Theoretical considerations. *Journal of Psychotherapy Integration*, 17, 209–224. doi:10.1037/1053-0479.17.2.209
- Moss, R.A. (2010). Clinical biopsychology: Could a grand theory actually exist to allow true psychotherapy integration? *Independent Practitioner*, 30, 67–71.
- Moss, R.A., Hunter, B.P., Shah, D., and Havens, T.L. (2012). A theory of hemispheric specialization based on cortical columns. *Journal of Mind and Behavior*, 33, 141–172.
- Mountcastle, V.B. (1957). Modality and topographic properties of single neurons of cat's somatosensory cortex. *Journal of Neurophysiology*, 20, 408–434.
- Northoff, G. (2012). Psychoanalysis and the brain — why did Freud abandon neuroscience? *Frontiers in Psychology*, 3, 1–11. doi: 10.3389/fpsyg.2012.00071
- O'Connor, M.F., Wellisch, D.K., Stanton, A.L., Eisenberger, N.I., Irwin, M.R., and Lieberman, M. D. (2008). Craving love? Enduring grief activates brain's reward center. *Neuroimage*, 42, 969–972. doi: 10.1016/j.neuroimage.2008.04.256
- Rogers, C.R. (1957). The necessary and sufficient conditions of therapeutic personality change. *Journal of Consulting Psychology*, 21, 95–103.
- Shear, K., Frank, E., Houck, P.R., and Reynolds, C.F. (2005). Treatment of complicated grief: A randomized controlled trial. *Journal of the American Medical Association*, 293, 2601–2608.
- Solomon, R.L. (1980). The opponent-process theory of acquired motivation: The cost of pleasure and the benefits of pain. *American Psychologist*, 35, 691–712.