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The Neuropsychological Connection Between Creativity and Meditation

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Prior investigations into a creativity–meditation connection involving diverse meditation strategies, proficiency levels, and creativity measurement instruments presented mixed results. These results are explained through evidence (primarily from EEG studies) supporting the hypothesis that meditation training variously enhances creative incubation and illumination via *transcendence* and *integration*, neuropsychological mechanisms common to both processes. Transcendence surpasses informational limits; integration transforms informational boundaries. In this respect, increased low-alpha power reflects reduced cortical activity and detached witnessing of multimodal information processing; theta indicates an implicit affect-based orientation toward satisfaction and encoding of new information; delta reflects neural silence, signal matching and surprise, and gamma indicates heightened awareness, temporal-spatial binding, and salience. Cortical intra-interhemispheric synchronization, within these EEG spectral bands, is essential to effective creativity and meditation. The relative impact on creativity of various meditation strategies (mindfulness, concentrative and combined) is discussed. *Sanyama*, an ancient yogic attentional technique embodying both transcendence and integration, provides a unique neuropsychological explanation for extraordinary creativity.

BACKGROUND

Creativity has been defined as the capacity to generate novel, socially valued products and ideas (Mumford, Reiter-Palmon, & Redmond, 1994), or as the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints) (Lubart, 1994, cited in Sternberg & Lubart, 1999; see also Ochse, 1990; Sternberg, 1988; Sternberg & Lubart, 1991, 1995, 1996). Whether creativity is perceived as problem solving (Weisberg, 2006), problem finding (Getzels & Czikszentmihalyi, 1976), or simply self expression, it generates new information that is often discrete and domain-specific, and that transcends informational boundaries, yet is integrated with existing information in a manner exhibiting value.

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The psychological basis of creativity has been described variously as the need to be different (Joy, 2004), the decision to create (Sternberg, 2003), creative attitude (Maslow, 1967), and the intention to transcend informational boundaries (Horan, 2007). In each description, some form of conscious, or subconscious, volition is involved. James (1983) declared that ‘‘volition is nothing but attention’’ (p. 424). Attention appears at all levels of information processing, including consciously directed, sustained attention (Posner, 1994) and subconscious goal-directed attention, which is intertwined with perspectivalness (the sense of being someone with a point of view; Taylor, 2001). The volition, or intention, to transcend informational boundaries and integrate the transcendent experience, valuably, within empirical reality is not exclusive to creativity. It is also the heart of meditation. The unique aspect of this article is to argue that the practice of meditation, as an attentional mechanism, supports creativity. A theoretical model is presented to explain diverse results arising from previous psychological studies on a creativity–meditation connection and to guide further investigations.

Meditation, as the systematic study and practice of managing attention for self development, probably began in pre-Aryan civilizations prior to the Rig-Veda period (1500 BCE; Feuerstein, 1989). In order to better understand meditation, it is important to understand its theoretical, pre-scientific background as well as its modern implementation. Patañjali (second century AD), a renowned meditation master and ancient Indian "psychologist," defined meditation in the *Yoga Sūtras* (Iyengar, 1993) as an attentional strategy leading to yoga, or "the cessation of movements in the consciousness" (I.2., p. 46), which allows the practitioner to "dwell in his own true splendor" (I.3., p. 48). Patañjali used the Sanskrit word *Cit* to represent consciousness devoid of mental fluctuations, a transcendent state that can be imagined by abstracting from empirical consciousness all informational limitations with only pure consciousness remaining (Woodroffe, 1993). In the Zen meditative tradition, pure consciousness is considered "the very essence of human consciousness" (Harai, 1974, p. 113). According to Patañjali (Iyengar, 1993), meditation has four primary phases: withdrawal of external sense awareness (*pratyāhārā*), concentration (*dhāranā*), unbroken concentration (*dhyāna*), and absorption (*samādhi*). Meditation involves the formulation of a conscious intention that carries into the unconscious, via absorption, until a state of pure consciousness is attained. The ultimate goal of meditation, however, is the psycho-physiological integration of pure consciousness, the transcendent state, with empirical consciousness (e.g., referred to as the union of *Atman* and *jiva,* the transcendent and immanent, etc.). Patañjali, in the *Yoga Sūtras* (Iyengar, 1993), also described an advanced meditative process called *sanyama* (i.e., union of concentration–meditation–absorption), in which the transcendent state is integrated into all states of consciousness (i.e., waking, dreaming, and deep sleep) by experiencing various psycho-physiological phenomena at their unfettered source within the mind. *Sanyama*, depending upon the phenomenon attended to, is said to elicit *sidhis,* or supranormal powers (SP), including knowledge of past and future, knowledge of other minds, psychic invisibility, and the ability to increase/decrease affects of gravitation on the body, as well as profound insight into the nature of reality (*pratibha*). Complete psychological integration in meditation is continuous, non-domain specific, and often described as a liberated, or enlightened, state of thought and action. Horan (2007, p.183) referred to this state as *vacuous*, the boundless source of both creativity and intelligence. In this sense, creative thinking, viewed as a process that overcomes informational limitations in a useful manner, can be construed as a restricted form of meditation.

The *Vijñana Bhairava* (Singh, 1991), an ancient Indian yogic text (twelfth century AD), lists over 112 attentional devices, or methods, that regulate the meditation process through mindfulness, concentrative, and combined attentional strategies. These three strategies reflect the multitude of meditation techniques available today. Mindfulness meditation (MM) involves the detached, non-judgmental witnessing of thoughts, feelings, and sensations over the entire phenomenal field. Popular systems using MM include Zen and Vipassana. Concentrative meditation (CM) entails focusing on a meditative vehicle such as certain thought constructs, mantra (a repeated sound), internal imagery, specific body sensations (e.g., the breath) and various emotions (e.g., joy). Examples of popular CM systems include Buddhist Samatha (breath), Ananda Marga (mantra) and Kriya Yoga (mantra/breath). Transcendental Meditation (TM) uses mantra, like many concentrative forms, but places importance on the absence of concentrative effort and development of a thought-free, transcendental awareness (Yogi, 1963). This differentiates TM from other CM systems; so, TM is herein defined as a combined meditative (CbM) strategy. In any case, the transcendent observer, or witness, perspective is either an explicit or implicit aspect of most meditative traditions (Goleman, 1996; Kabat-Zinn, 1990; Walsh, 1982, cited in Cahn & Polich, 2006).

Since the early seventies, the popularity of meditation in the Western world has lead to extensive research into both its physiological and behavioral effects, including creativity (Murphy & Donovan, 1997). Research into a creativity–meditation connection has had mixed results (Austin, 2006). A number of researchers found little support for this connection. Three of these studies utilized TM practitioners. Domino (1977) used three creativity measures (*Remote Associates Test, Franck Drawing Completion Test*, and *Similes Test*) to test subjects having 6 months meditation experience. The meditation group showed no increase in creativity over a relaxation response group, nor over students enrolled in a psychology of creativity class that practiced techniques related to creativity. Otis (1974) asked subjects, with 3 months meditation experience, to fill-out a physical and behavioral questionnaire. The investigators concluded that creativity and meditation are unrelated, though many individuals reported an increase in their creative ability. The study suggested that TM works only on individuals that find it worthwhile, or nondetrimental, and that expectations may play a major role in performance perceptions. It should be noted that subjects in both studies were CbM novices. Schwartz (1974) used the *Barron Welsh Art Scale* along with *Wallach-Kogan* tests on 16 TM teachers with results that meditators performed no better than controls and, in some scales, even worse. However, in another experiment measuring primary process creativity in storytelling, TM teachers scored higher than controls (Schwartz, 1973). At this time, *sanyama* training (TM-Sidhi program) was unavailable. O'Haire and Marcia (1980) studied the personality characteristics of 114 Ananda Marga (CM) meditators with varying degrees of meditation experience. One group had more than 3 years experience. Investigators tested creative thinking skills with the *Torrance Tests of Creative Thinking (TTCT)-Form B* (Torrance, 1974) and found a relationship between meditation and creativity unsupportable, although the long-term female meditators scored highest on figural originality. It should be noted that the aforementioned studies involve mantra-based CM/CbM strategies, with most subjects having under five years experience.

Cowger (1974) studied 27 students trained in *zazen*. It is not mentioned specifically whether a CM technique (e.g., koan-based, Rinzai school) or MM technique (e.g., breath-based, Soto school) was used. Koans are riddles, without cognitive solutions, which require significant practice to solve. The study indicated that meditators became "more present oriented" (p. 4734-A), so it may be assumed that a MM strategy (e.g., breath) was used. The meditators were matched to others practicing relaxation. A 4-week practice period ensued. TTCT scores indicated that neither meditation nor relaxation significantly affected creative thinking, yet meditators out-performed the relaxation group. Cowger's data was revisited some years later by Torrance (Cowger & Torrance, 1982) who noticed that the *zazen* meditators displayed unusual creative responses for college undergraduates. A re-analysis of data using updated creativity indicators on verbal and figural tests showed significant gains in heightened consciousness of problems, perceptual change, invention, sensory-based experience on the verbal tasks, expression of emotion and feeling, synthesis, unusual visualization, internal visualization, humor, and fantasy. The relaxation group showed decreases in 9 of 15 measures, with significant gains only in sensory experience, synthesis, and unusual visualization. Unfortunately, the overall sample size was small and the meditation training brief.

Orme-Johnson and Granieri (1977) found support for a creativity–meditation connection in a study of 60 subjects undergoing advanced training in the TM-Sidhi program (launched in 1976). The criterion for course entry was previous experience of transcendental awareness, a state wherein the mind remains fully alert while *content* is unbounded, empty, and silent (Arenander, 2000). The course teaches *samyama* to elicit psychophysiological integration through SP. Using the *TTCT* in pretest and posttest conditions, the researchers discovered significant increases in originality and fluency in visuo-spatial creativity. The average length of meditation practice was about 5.6 years. This study did not involve a control group. Instead, it filtered for familiarity with the tests and concluded that increases in creativity were not due to familiarity. Orme-Johnson, Clements, Haynes, and Badaoui (1977) further tested 22 TM meditators with *sanyama* training using the TTCT-Verbal Form A. Twelve subjects were classified as having some SP experience. All the creativity subscales (fluency, originality, flexibility, and novel uses) were significantly correlated with the number of SP experiences. Ball (1980) studied the effects of TM and TM Sidhis (SP) at Maharishi International University on verbal and figural creativity (TTCT) and auditory creativity (*Sounds and Images*). Although the tests performances were relatively stable, TM subjects showed greater originality in verbal scores and on the *Sounds and Images* test than control subjects in a developmental psychology class. At the time of this study, some TM subjects had perhaps practiced *sanyama* for 4 years. The significance of *sanyama* will be addressed later.

There are methodological drawbacks in all these studies. Differences in meditation strategies are largely ignored; length of practice and its affect on creative thinking is not adequately considered; longitudinal studies are absent and assumptions regarding the nature of creativity and how it should be assessed may not be valid. Hence, the case for a creativity–meditation connection appears inconclusive; however, these diverse results can be explained with empirical evidence from neuropsychological investigations into the nature of creativity and meditation, coupled with a theoretical framework describing *transcendence* and *integration* as key components common to both processes.

TRANSCENDENCE AND INTEGRATION

Kant (1781/1992) described knowledge as transcendental if it concerns the state of possibly knowing objects even before they are experienced. Horan (2007) suggested that the intentional transcendence of perceptions and ideas, as informational limitations, is the foundation of creativity. Koestler (1964), similarly, described creativity as a bisociation of previously unrelated information matrices or experience: "an act of liberation—the defeat of habit by originality" (p. 96). The actual moment of creative illumination appears as a leap across the "logical gap" presented by problems (Polanyi, 1998, p. 123) for which intention provides the required psychophysiological energy (Horan, 2007). Transcendence in creativity is further coupled with the integration, or manifestation, of new knowledge within the existent informational context.

This process is often iterative; that is, transcending a boundary redefines that boundary which, alternatively, allows for further transcendence.

Traditionally, meditation's intention is to attain liberation while living (*jivanmukta*), a sustained state of the transcendence of all mental fluctuations, a state that is, paradoxically, integrated with bodily activity and sensory and intellectual functioning (Brooks et al., 1997). In this sense, every moment of the enlightened meditator's life becomes an act of creation, the interplay of transcendence and integration. That is, surrender of the limited sense of self (transcendence), through heightened awareness, inhibits attachment to personal constructs of reality opening perception to a myriad of unforeseen possibilities and connections (integration) on a moment-by-moment basis. This highly unusual state is referred to as creating "the self from the Self in the Self" (i.e., the Self is equivalent to pure consciousness; Hughes, 1994, p. 104). Creativity, at this level, does not necessarily result in a specific contribution (Horan, 2007). The key difference between creativity, defined as problem solving, and meditation lies in the nature of the problem. Whereas the creative seeks discrete, temporary, and transcendent solutions to empirical problems (even if the "problem" is one of finding problems or forms of self-expression), the meditator seeks continuous, permanent, and transcendent solutions to the limitations of phenomenal existence, empirical problems being one of those limitations. Whereas creativity provides solutions, the present-centered focus in meditation provides a sense of well-being (Davidson, 2004; Siegel, 2007). At the neuropsychological level, however, transcendence and integration reveal similarities between both processes.

Transcendence is herein defined as a state of synchronized neural activity in which an existing informational set(s) is attenuated or surpassed; where psychological/cognitive closure is not yet in effect; and where attention is broad and sustained on explicit, or implicit, phenomena in a defocused, yet alert, witnessing mode. Synchronized neural activity (Jausovec, 2000a, 2002), broad attention (Kasof, 1997), and defocused attention (Martindale & Hines, 1975) are all associated with processing efficiency in creativity, as well as in meditation (Cahn & Polich, 2006). Integration is defined as a state of synchronized neural activity in which informational sets, both across and within explicit and implicit domains, are matched, bound, and encoded; where psychological/cognitive closure is in effect; and where attention is focused, sometimes over multiple modalities. Integration is a major brain function. It has been associated with object representation (Tallon-Baudry, & Bertrand, 1999) recognition (perception; Rodriguez et al., 1999), and multimodal conscious experience (Edelman, 1989; Edelman & Tononi, 2000). It also underlies the union of meditation-induced transcendence with the waking state (Travis, Tecce, Areander, & Keith Wallace, 2002). Both transcendence and integration allow global brain functioning, mass action, and Gestalt phenomena (Finger, 1994). Synchronization increases appear to correlate with both transcendence and integration (see Coherence). Differentiation, another key brain function, is defined by functionally segregated, localized neural activity (i.e., synchronization of diverse local cell assemblies), which is highly selective, narrowly focused and tends to separate (e.g., encode or retrieve), refine, and otherwise process more specific information. Visual cortex specialization for shape, motion, and color (Felleman & Van Essen, 1991), functional parcellation in the motor cortex (Rizzolatti, Luppino, & Matelli, 1998), and perceived, imagined, or remembered components of cognitive tasks (Frackowiak et al., 2004) are examples of differentiation. Electroencephalogram (EEG) studies of creativity, meditation, and their neurological markers appear to favor transcendence and integration over differentiation.

The EEG (Davidson, Jackson, & Larson, 2000) represents electrode-array tracings of summated cortical and subcortical electrical activity collected by applying sensors to either the scalp (noninvasive) or directly to the cortex (invasive). The cortical potentials exhibited are the average of excitatory and inhibitory postsynaptic potentials. EEG has proved to be a useful tool providing high-temporal/low-spatial resolution in diagnosing and monitoring the central nervous system for both pathological and normal conditions. EEG waveforms exist in frequency bands roughly divided into delta (0.5–3.5 Hz), theta (4–7.0 Hz), alpha (7.5–12.5 Hz), beta (13–24.5 Hz), gamma (25–42 Hz or above). (Transitional frequencies are indicated between bands.) Beta frequencies are, for the most part, excluded in this discussion because they arise in externally focused vigilant attention (Austin, 1999; Wróbel, 2000), sensory processing and sensory-motor control (Lalo et al., 2007), task processing (Pfurtscheller & Andrew, 1999), and reflect psychomotor speed in intelligence tests (Polunina & Davydov, 2006). These functions generally lack transcendence and are probably more applicable to convergent thinking in creativity's preparation and verification phases (Wallas, 1926).

It is argued that MM, CM, and CbM offer attention management strategies for enhancing the incubation and insight phases of creativity (Wallis, 1926). A fundamental assumption is that cortical maps of neuronal activity can be altered through attentional patterns via neuroplasticity, the brain's ability to reorganize by forming new neural connections. Schwartz and Begley (2002; for a neuroplasticity-attention review) made a strong case for the efficacy of attention in remapping the brain in their obsessive compulsive disorder (OCD) studies. OCD is "a neuropsychiatric disease marked by distressing, intrusive, unwanted thoughts that trigger intense urges to perform ritualistic behaviors" (p. 55). The investigators referred to it as "brain lock" (p. 72). OCD is analogous to the sort of inflexible cognitive patterns that inhibit creativity. The investigators used both mindfulness and concentration attentional strategies to defeat OCD. They demonstrated, via pre-/posttherapy brain imaging, the therapeutic impact of attention on the physicality of the brain. A further assumption, herein, is that similar neurological activity and psychological states exhibited both by creativity and meditation denote a correlation. Correlations, however, don't indicate causal direction, so the reverse may also be true: Creativity may enhance meditation. This is an area for further research.

ALPHA

The EEG signal in the alpha band was first demonstrated by Berger (1929) to increase in power over the occipital scalp upon eye closure. Alpha activity reflects low cortical arousal, as well as memory encoding and retrieval (Klimesche, 1996). Alpha activity is divided functionally into two bandwidths: alpha-1 (low-alpha, 7.5–9.5 Hz) and alpha-2 (high-alpha, 10–12.5 Hz; Danko, Starchenko, & Bechtereva, 2003). High-alpha band is most sensitive to the encoding and processing of semantic information (i.e., common knowledge by familiarity) and low-alpha is associated with internalized attention (Klimesche, Doppelmayr, Pachinger, & Ripper, 1997). The attentional mechanism reflected in low-alpha activity is considered nonselective because it does not appear to inhibit environmental stimuli (Klimesche, 1996).

The inability to filter previously irrelevant stimuli, called low latent inhibition, is associated with openness and increased creative achievement in high-IQ individuals (Carson, Higgins, & Peterson, 2003). Martindale and Hines (1975) suggested that creatives exhibit low level of cortical activation, unfocused or broad attention evidenced by an increase in alpha power, a preference for novel stimuli and oversensitivity. Their study, however, did not differentiate alpha bands. Martindale (1999) suggested that attention in creatives is a variable state that becomes defocused, allowing irrelevant information to combine when solving ill-defined problems, and focused when verifying ideas (see also Vartanian, Martindale, & Kwiatkowski, 2007). Others perceive defocused attention as a stable trait (Eysenck, 1995; Mendlelsohn, 1976).

Low cortical arousal is theoretically attributed to cortical processing efficiency reducing anxiety, which increases the ratio between cognitive effectiveness and effort, leading to better performance (Eysenck & Calvo, 1992). Creativity is often required in addressing complex, ill-defined problems. Complex concepts are processed much faster than less complex concepts (Klimesche, 1994). Klimesche (1987, 1994, 1996) used the connectivity model to explain this effect; that is, memory speed is related to the spreading activation, or integration, of semantic long-term memory codes (not episodic short-term memory) which accounts for the finding that overall alpha frequencies increase with memory performance.

Additionally, creatives process faster when distraction is minimal (Vartanian, Martindale, & Kwiatkowsky, 2007). Although high-alpha denotes the processing of semantic information, low-alpha conceivably, by providing a relaxed, defocused, or detached "witness," perspective enhances memory processing speed by permitting the bypassing, or disengaging from, the limitations of more habitual memory pathways, thereby allowing for greater flexibility and efficiency in addressing complex concepts. Simpler concepts, on the other hand, could rely on existing pathways (e.g., heuristics) and would not need the extra processing speed and consequent increased number of activated cell assemblies.

During problem solving, creatives differ from intelligents, and ill-defined problems exhibit greater alpha synchronization than well-defined problems (Jausovec, 2000a, 2002). Creatives solving divergent production problems (e.g., name all uses for a brick) demonstrate greater neural synchronization in low-alpha with de-synchronization in high-alpha; intelligents show the reverse. Desynchronization in the low-alpha (noted in intelligents) is associated with external attention processes such as vigilance and expectancy (Klimesche, 1999). Intelligents, however, in solving dialectic problems (e.g., design an experiment to test the hypothesis that apes can speak), which are more difficult than divergent production problems, exhibit decoupling in high-alpha, suggesting that they use semantic processing to solve these problems, yet creatives rely on attention (e.g., low-alpha) and episodic memory (Jausovec, 2000a, 2002). Episodic memory reflects subjective information such as context, expectancy, emotion, and autobiographical experience (Klimesche, 1996). It is related to the theta frequency (see Theta). Increased event-related low-alpha synchronization in the right hemisphere is related to increased originality (Grabner, Fink, & Neubauer, 2007).

Creatives display a higher percentage of alpha waves during inspiration, versus elaboration, which is attributed to automatic processing, not purposeful control (Martindale & Hasenfaus, 1978). Creatives are also less capable of controlling alpha production than average individuals, which is consistent with the notion that they are characterized by disinhibition (Martindale

& Hines, 1975). This suggests that automatic subconscious processes integrating information over multiple modalities (verbal, figural, etc.) governs inspiration. Martindale (1999) concluded that increased alpha activity in creatives involved a decrease in frontal lobe activity. The frontal lobe is the center for goal-directed cognition and has executive control over other cortices. An increase in BOLD (blood oxygenation-level-dependent) fMRI signals, at rest, in frontal and parietal lobes correlated with decreases in alpha power (desynchronization).

Conversely, increased alpha power (synchronization) is linked to deactivation of cortical structures involved in attention related to goal-directed cognition and behavior (Laufs, Kleinschmidt, et al., 2003a; Laufs, Krakow, et al., 2003b). Increased low-alpha frontal lobe synchronization following divergent thinking training has been linked to creativity (Fink, Grabner, Benedek, & Neubaeur, 2006). Reduced frontal lobe activity exhibiting broad, defocused attention and low-alpha synchronization may speed up processing of complex concepts. It may also reduce constraints on response space (Reverberi, Toraldo, D'Agostini, & Skrap, 2005). All these neurological markers indicate transcendence.

Numerous studies (Cahn & Polich, 2006) show alpha power increases with higher basal alpha levels more prevalent in meditators over control conditions. In most of these studies, alpha bands are not differentiated; however, this may be discounted because semantic processing (high-alpha) is not usually a component of meditation (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007; Farb et al., 2007). One study did note low-alpha increases in TM practitioners (Banquet, 1973). Some reports indicate no alpha effect during meditation, but others correlate alpha activity with relaxation (Cahn & Polich, 2006). A body of evidence supports the contrary view that meditation differs from both rest and light sleep (Dillbeck & Orme-Johnson, 1987; Pagano & Warrenberg, 1983; West, 1980). So and Orme-Johnson (2001) investigated a large group of Taiwanese students, some practiced TM while others napped. The meditators demonstrated increased processing speed, practical intelligence, field independence and "whole-brained creativity" (p. 421). The results could not be attributed to either unstructured rest or light sleep. The difference lies in meditation being a unique process that leads to a "least excited self-referral state" (Areander, 1996, p. 3) wherein the mind is relaxed, disengaged from phenomena, yet highly alert. Meditation, like creative thinking, exhibits low levels of cortical activation and defocused witnessing of internal events. Neuropsychological transcendence in meditation leads to integrative qualities like mental clarity, increased energy, feelings of bliss, and a coherent sense of self (Arenander, 1996).

Harai (1974) classified four states in Zen (MM), progressing from (a) the appearance of alpha waves in the eyes-open resting state, (b) an increase in persistent higher amplitude alpha waves with eyes closed, (c) a decrease in alpha frequency, to (d) the appearance of rhythmical theta trains. Meditators with under 5 years experience exhibited only the first three states, indicating that length of MM practice may affect creative processes, especially in the theta band (see Theta). Before theta bursts appear in Zen meditators, alpha has a tendency to move frontally from the posterior cortex (Kasamatsu & Harai, 1966); yet, in TM, alpha spreads rapidly from frontal regions posteriorly (Areander, 1996). The difference is likely due to meditation strategy.

Potentially, MM displays an initial increase in alpha in the posterior attention and orientation association areas due to integration of basic interoceptive and exteroceptive sensory processes involved in present-centered awareness, followed by a hypofunction of the lateral prefrontal regions (e.g., low-alpha) supporting quietude and more self-detached transcendent awareness of the moment (Farb et al., 2007). CM and CbM, alternatively, start with narrowly-focused attention on a meditation vehicle (e.g., decreased frontal alpha power) that converts into hypofunction of the frontal cortex (the meditation vehicle leading the practitioner into a low arousal state). It carries to the posterior association and orientation areas further inhibiting distracting stimuli, eventually making task performance less effortful (Brefczynski-Lewis et al., 2007). CM and CbM meditators are consequently less responsive to external stimuli than MM practitioners (see Sensitivity).

Slow frontal alpha activity was recorded from 20 novices practicing Zen "su-soku" (breathing) CM. Frontal alpha correlated positively with novelty-seeking, as well as inhibition of sympathetic activity (Takahashi et al., 2005). Sympathetic activity includes fight–flight anxiety reactions like increased heartbeat. Heilman, Nadeau, and Beversdorf (2003) suggested that inhibition of the sympathetic system by a hypoactive frontal cortex leads to innovation. These findings support the novelty preference and low cortical arousal proposed by Martindale and Hines (1975). Dunn, Hartigan, and Mikulas (1999) discovered that MM produced more mean alpha amplitude, particularly over the central and posterior cortex, than CM. This may be due to increased suppression of narrative self-focus along the anterior cortical midline (Farb et al., 2007) coupled with enhanced responsiveness to novel stimuli in the association areas. Meditation strategies appear to affect creativity differently. MM enhances creativity faster than CM and CbM, perhaps by "releasing primary bottom-up experience from narrative top-down enslavement" (Siegel, 2007, p. 261). This could account for improvements in

MM novices' creativity (Cowger & Torrance, 1982). Low-alpha activity, synchronized over large portions of the cortex, reflects a relaxed, yet alert, witness state that may permit disengagement from strong associative thinking habits, a requirement in creative thinking (Glover, Ronning, & Reynolds, 1992). Clarity arising from quietude and a reduced signal-to-noise ratio over posterior attention and orientation areas could then conceivably activate weak or nonexistent associations leading to creative inspiration.

THETA

Theta activity appears in the hippocampal formation (Greenstein, Pavlides, & Winson, 1988, cited in Klimesche, 1996; Larson, Wong, & Lynch, 1986), an area important in novelty detection (Knight, 1996), and in imagining fictitious scenes (Hassabis, Kumaran, & Maguire, 2007). Hippocampal theta is associated with the encoding of new information and is potentially of great significance for working memory (Klimesche, 1996). The detection and encoding of new information is essential in creativity, especially for manifesting novel associations. There are two different types of theta synchronization: (a) type-1: related to an increase in power over a broad range of frequencies and exhibiting irregular oscillatory epochs, such theta dominates in slow wave or nonrapid eye movement sleep (non-REM); (b) type-2 is a selective activation of working memory and related to an increase in power within a narrow frequency band of the peak theta frequency (Klimesche, 1996). Type-1 theta is a nonselective activation and, in some studies, does not seem related to the encoding of new information. Klimesche (1999) suggested that type-1 theta may even reduce or block this capacity during the hypnogogic state (i.e., the transitional state between waking and sleep), in slow wave sleep or in demented subjects. In other studies, however, slow wave and REM sleep, of which theta frequencies are a major component, have been implicated in the consolidation of memory traces and learning (Maquet, 2001). There is evidence that novel representations arising from behavioral experience are strengthened in REM sleep (Poe, Nitz, McNaughton, & Barnes, 2000). Type-1 theta accompanies hypnogogic hallucinations (Koukkom, Dittrich, & Lehmann, 1975). It is possible that encoding, although non-selectively activated, does occur in type-1 theta. An increase in theta and decrease in high-alpha power during the hypnogogic state is representative of a decrease in external stimulation (Klimesche, 1999). It is well known that hypnogogic reverie has served many eminent creatives like Frederich Kekule, who discovered the benzine ring while envisioning, in a fire, a snake biting its tail (Briggs, 2000).

Increases in theta (e.g., type-2) is also associated with task difficulty and emotional factors (Dolce & Waldeier, 1974; Gundel & Wilson, 1992; Hankins & Wilson, 1998; Inouye, Shinisaki, Iyama, & Matsumoto, 1993; Lang, Lang, Kornhuber, Deikman, & Kornhuber, 1988; Makeig & Inlow, 1993). Theta increases appear in normal young individuals demonstrating feelings of disappointment and frustration arising after the termination of an agreeable stimulus. Theta, therefore, is correlated with scanning for *visceral pleasure* (Walter, 1959). Walter (1953) declared, "the uniform swell of theta rhythms, as pleasure fades, would represent the renewed search for other pleasures" (p. 209). Increases in theta are also found in phases of enhanced artistic creativity (Rorvik, 1970), responses to novel situations (Adey, Kado, & Walter, 1967) and various forms of training (Miller, 1991). Given that theta activity reflects encoding of new information into memory, learning, responding to task difficulty; forms part of hypnogogic reverie, REM, and slow wave sleep; and seems to be related to emotional reward, it is reasonable to assume that the general function of theta (i.e., types 1 and 2) in relation to creativity is to effect neuropsychological closure (i.e., integration), both explicitly and implicitly, in response to new (or difficult to assimilate) information coupled with an affective orientation (i.e., transcendence) toward emotional satisfaction. Psychological closure, in Gestalt psychology, is defined as "a law of organization that assumes an innate tendency to perceive incomplete objects as complete, to close up or fill in gaps in sensory inputs, and to view asymmetric and unbalanced stimuli as symmetric and balanced" (Psychological closure, 2003, p. 1182). Creative insight undergoes psychological closure as weak or nonexistent associations are integrated within awareness. Poincaré (1913), similarly, described spontaneous creative insight as reflecting low-alpha/theta-like processes: "Ideas rose in clouds; I felt them collide until pairs interlocked, so to speak, making a stable combination" (p. 387). Regarding theta, the law of psychological closure could extend to neuropsychological processes involving implicit rewards associated with transcending informational challenges. The capacity to encode new information, process challenging tasks, orient one's self autobiographically in space and time (episodic memory), consolidate partially processed information from the waking state during sleep, rest the mind in slow wave sleep, and experience the "aha" moment of creativity are all fundamentally satisfying. Theta activity, whether selective or not, appears to reflect an innate intention to achieve greater levels of affective fulfillment, or joy, which may result from man's existential inclination to be free of informational limits (i.e., transcendence) as well as his ability to adapt to new environments (i.e., integration).

In Harai's (1974) fourth stage of Zen meditation, high voltage (70–100uV) rhythmical theta trains appeared in high-achievement meditators with 20, or more, years of experience. Harai argued that these waves functionally differed from drowsiness because of larger amplitudes, increased rhythm, persistence, and less contamination by high frequency activity. The theta trains also reacted to audio click stimulus in a similar manner to alpha waves (see Sensitivity), an indication of reduced habituation or ongoing attentiveness to external stimuli. This activity may be an unusual type-2 theta, or a variation of types-1 and -2. Banquet (1973), while investigating 12 TM meditators (9 months to 5 years experience) during closed eye relaxation, observed similar stages: alpha power increase, frequency decrease, then bursts of high voltage theta (up to 100 uV) arising first in frontal areas then diffusing posteriorly. The functional nature of this unusual theta in long-term meditators (LTM) is uncertain; however, other studies provide clues. Sahaja Yoga meditation (CbM) directs internal attention toward the positive emotion of bliss. Eleven LTM (3 to 7 years experience) demonstrated increased theta synchronization between the prefrontal and posterior association cortices with a center of gravity in the left prefrontal region (Aftanas & Golocheikine, 2003), an area associated with positive affect (Tomarken, Davidson, Wheeler, & Doss, 1992). In another Sahaja Yoga study, the meditative experience of happiness correlated positively with theta power increases in frontal and mediofrontal cortical zones (center of gravity also in the left hemisphere) and negatively with the rate of thought appearances (Aftanas & Golocheikine, 2003). The search for, and experience of, positive affect seems to elicit theta. Novice Zen meditators (MM) demonstrated fast frontal theta increases correlating positively with harm avoidance (a reaction to aversive stimuli related to punishment and non-reward; Takahashi et al., 2005) providing further support. The literature indicates that meditators, generally, show levels of negative affect decreasing with practice (Astin, Shapiro, Eisenberg, & Forys, 2003). MM novices produced more mean theta amplitude in the left frontal cortex (although not the unusual theta observed in advanced practitioners) than CM novices (Dunn et al., 1999). Since seeking satisfaction through novelty, pleasure, reward, and freedom from cognitive limitations seems related to theta activity, meditative techniques that enhance this inclination may support creative incubation and inspiration. In this respect, both MM and CbM display an early advantage over CM.

According to the Vedāntic tradition (Feuerstein, 1989), the bliss of meditation arises when the practitioner enters the body of bliss (*ananda-maya kosha*). In novices, bliss appears as a feeling of contentment, or peace. Elevated bliss originates during absorption where both perceiver and object of perception are transcended (*Shiva Sūtras* 1.18; Muktānanda, 1997). Whereas the bliss of creativity arises from the satisfaction of transcending empirical problems in a useful manner, the bliss of meditation is associated with psychological integration embodying the transcendent state (Muktānanda, 1977a, 1977b). A common experience for LTM is that the "new" knowledge being encoded is, paradoxically, the experience of a thought-free state transforming all phenomena into novelty. Phenomena become new because "there is no succession of perception of this knowledge, it takes in all things simultaneously, at a glance" (Nikhilānanda, 1956, p. 203), echoing Mozart's astonishing claim to having heard his symphonies, complete, new, and all at once (Ghiselin, 1952). In both creativity and meditation, theta reflects both seeking and encoding the transcendent. The difference between creativity and meditation lies in whether the resulting integration is strictly an empirical expression, or maintains its transcendent quality. Inability to integrate the transcendent within a problem-solving space (see Insight) may account for evidence that some experienced TM meditators (O'Haire & Marcia, 1980; Schwartz, 1974) perform no better than controls on creativity tests. Further regarding theta, it is well known that creativity occurs not only in repose, but under stressful conditions. Meditation, similarly, increases sensitivity to limitation and suffering motivating practitioners to seek transcendence, bliss, and integration (Muktānanda, 1997).

DELTA

Although theta reflects the cognitive/affective *motivation* to transcend informational limits and encode new information, a mechanism is still required for the recognition of new information. Delta (1.5–3.5 Hz) and subdelta (0.5–1 Hz) frequencies are potential candidates. Delta oscillations are intrinsic neuronal rhythms with thalamocortical origins (Olejniczak, 2006). They are related to decreased functioning of the brain as seen in non-REM (NREM) sleep and pathology. They also appear in the performance of mental tasks. Vogel, Broverman, and Klaiber (1968) addressed this discrepancy by postulating two kinds of behavioral inhibition: (a) Class I inhibition refers to a gross inactivation of an entire excitatory process resulting in a relaxed, less active state, such as sleep, and (b) Class II inhibition refers to the selective suppression of inappropriate, or nonrelevant, neural activity during mental task performance. In event-related potential (ERP) experiments, the P300 response (a positive potential peaking at 300 ms) is obtained by the appearance of a novel external stimulus (the oddball response). The most prominent component of the P300 response in the human brain is delta, followed by theta (Başar-Eroğlu, Başar, Demiralp, & Schürmann, 1992). The delta component is "mostly involved in signal matching and decision making following a novel or unexpected signal and/or partial surprise" (p. 175). Delta is associated with detection of the affective significance of stimuli (Aftanas, Reva, Varlamov, Pavlov, & Makhnev, 2004), surprise being one example, and in prefrontal cognitive flexibility, such as P3a activity in task-set shifting during the *Wisconsin Card Sorting Test* (where set rules are suddenly altered; Barcelo, Perianez, & Knight, 2002). Prefrontal cortex (PFC) flexibility is important in the neuropsychology of divergent thinking (Dietrich, 2004a). Regarding Class I. delta, the slow oscillations of NREM sleep suppress, but do not extinguish, perception and mentation, even though a subject may be unconscious. They are associated with synaptic reorganization, plasticity, and waking-state information consolidation (Hobson & Pace-Schott, 2002), making them potential candidates in the recognition and decisive matching of new associations.

Recognition of novelty is crucial to creative thinking. If it is assumed that the subconscious matching/recognition of very complex informational patterns, as well as highly ambiguous, or vague, signals requires a very subtle neural mechanism with both localized and global matching capacity, then it is reasonable to assume that the closer that mechanism approaches neural silence, without inducing pathology, the more effective it becomes. Delta and subdelta frequencies are the most silent frequencies in the human brain. When globally distributed, the brain usually enters sleep. However, attention to internal processing during difficult tasks, such as calculation and memorization, increases delta power (Harmony et al., 1996). Dialectic (ill-defined) problems are complex, difficult, and require the highest level of creativity (Doerner, 1983; Jausovec, 1994) and the greatest intra- and interhemispheric cooperation between neural assemblies (Jausovec, 2000a). Solving these difficult problems requires the ability to recognize subtle, complex information. The role of delta in incubating complex problems is unknown, although signal matching is likely. However, increases in synchronized delta power are associated with the moment of creative insight (Whitton, Modolfsky, & Lue, 1978). Delta activity appears to represent a neuropsychological integration function (e.g., signal matching) that is enhanced by its transcendent (e.g., silent—*mirror-like*) qualities. The functional difference between delta and low-alpha activity, perhaps, is that delta's relative neural silence reflects the ground for recognition and surprise, whereas low-alpha reflects detached witnessing of information over various modalities and levels of processing.

Delta plays an important role in meditation. MM novices show greater frontal and posterior mean delta amplitude than CM novices (Dunn et al., 1999). This, however, may be attributed to Class I inhibition. Green (1972) observed Swami Rama, a renowned yoga master, intentionally producing delta waves. The swami was later able to repeat, verbatim, what experimenters had said in the room while he appeared to be in slow wave sleep. This mindfulness phenomenon is called yogic, or witnessing, sleep. Wilber (1999) also reported (and later videotaped) the ability to voluntarily enter a state of mental cessation with predominant delta activity while simultaneously maintaining vigilance. Advanced TM practitioners display alpha/theta activity superimposed over delta activity in Stage 4 (deep) sleep. They report "heightened self-awareness, similar to their experiences during TM practice, along with the body resting deeply" (Travis, 1994, p. 99). Travis suggested that this phenomenon is the result of anatomically distinct cortical/subcortical generators that have somehow coupled to produce self-awareness in a normally unconscious state. Mason et al. (1997) reported similar witnessing sleep in TM subjects coinciding with an unusual decrease in electromyogram (EMG) activity of the chin muscle. Decreased EMG chin activity is associated with increased brain activity during normal REM sleep. The subjects' REM activity density was also unusually high. This unusual activity indicates a higher level of awareness during slow wave sleep, thereby validating subjective reports of witnessing sleep (Austin, 1999, 2006).

Witnessing sleep is one stage in the integration of transcendent awareness into waking, dream, and deep sleep states, or what Wilber (1999) called *one taste*, the sense of transcending subject–object/perceiver–perceived duality. The witness "disappears into everything that is witnessed . . . there is crystal-clear awareness of everything that is arising, moment to moment, it's just not happening to anybody" (pp. 89–90). Individuals in this integrated state report the coexistence of silent inner awareness during the intensity of daily activity (Travis et al., 2002). Hypothetically, Travis' (1994) suggestion of an unusual coupling of anatomically distinct generators could be supported if the extraordinary experience of *one taste* occurs when the generators of frontal low-alpha activity (the perceiver) couple with the generators of global delta activity (the perceived, the ground of recognition or non-conceptual awareness; Siegel, 2007), such that the state of witnessing is, paradoxically, "recognized" by the witnessed, thereby creating a highly reflective neuropsychological feedback mechanism evoking astonishment. What actually occurs anatomically in the brain, at this moment, is unknown. Both transcendent and integrative qualities merge into a supra-state referred by some authors as enlightenment (Shear, 1999; Yogi, 1963). The neuropsychological mechanism of *one taste* is strangely mirrored in the *Pratyabhijñahrdayam*, an ancient Kashmir Shaivite philosophical text. It states that the light of awareness (*prakāśa*) and awareness itself (*vimarśa*) interact whereby the light (attention) shines upon awareness (recognition) such that awareness (recognition) is viewed as a reflection of the light (attention) upon itself. *Vimarśa* is called the ground for the act of creation; *prakāśa* provides the raw material (Shantananda, 2003). Creativity is similarly described as a manifestation of intention (attention), interacting with recognition, to transcend the limits of information (Horan, 2007). Meditation increases the intrapersonal awareness dimension of creativity (Holt, Delanoy, & Roe, 2004). The capacity to witness delta slow wave sleep may support creativity by increasing awareness of the subtle, subconscious, highly complex signal matching and decision-making processes that operate during incubation and illumination.

GAMMA

Gamma frequencies recorded at the scalp normally range from 30–70 Hz (Başar, Başar-Eroğlu, Karakaş, & Schürmann, 2001), although the lower end is sometimes set at 25 Hz (Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004). Gamma rhythms in the brain are ubiquitous (Desmedt & Tomberg, 1994). Studies of the 40 Hz gamma response have predominated because it appears to be involved in many cognitive and sensory processes ranging from simple stimulus-evoked signal detection at the cellular level to stimulus-induced responses and complex central nervous system activity such as the recognition of ambiguous figures (Başar-Eroğlu et al., 1999). Evoked gamma represents feature-binding in synchronously active neural assemblies and temporal-binding by signaling precise temporal relationships of concurrent incoming stimuli (Tallon-Baudry & Bertrand, 1999). Induced gamma reflects object representation or the activation of associative memories (Haenschel, Baldeweg, Croft, Whittington, & Gruzelier, 2000). Studies at the cellular level (Eckhorn et al., 1988; Gray & Singer, 1987) led to the suggestion that synchronous gamma activity, in spatially separated cells, is a neurophysiological correlate of perceptual binding processes like Gestalt perception (Başar-Eroğlu, Struber, Kruse, Başar, & Stadler, 1996a; Tallon, Bertrand Bouchet, & Pernier, 1995). Gamma band responses are both highly distributed, existing in parallel throughout many subsystems of the brain (Başar, Başar-Eroğlu, Demiralp, & Schürmann, 1995), and selectively distributed (Başar et al., 2001). Gamma appears to reflect the ability to bind information at varying levels of sensory-cognitive processing (Başar-Eroğlu, Struber, Schürmann, Stadler, & Başar, 1996b). In this sense, gamma activity may reflect the brain's fundamental orientation toward negative entropy, or increased complexity, an integrative phenomenon. This would account for the great variability of gamma's binding functions within sensory-cognitive processes.

Sheer (1989) interpreted the 40 Hz rhythm as indicating focused cortical arousal. Individuals who are faster at reversing multistable visual perceptions (e.g., Necker cube) exhibit increased frontal gamma activity, higher arousal, alertness, and attention (Struber, Başar-Eroğlu, Hoff, & Stadler, 2000). Arousal is considered a necessary condition for gamma activity because states of extremely low arousal like anesthesia and non-REM sleep display minimal gamma activity (Gross & Gotman, 1999; Rennie, Wright, & Robinson, 2000; Sheer, 1984). Although low cortical arousal is one indicator of creativity, so is oversensitivity (Martindale & Hines, 1975). In creatives, gamma activity may reflect sudden shifts to heightened awareness as a distributed phenomenon involving many modalities. Ghiselin (1952), after studying 38 eminent creatives, found that creative genius is often marked by spontaneous, involuntary production in a heightened state of awareness often predicated by deep states of absorption. This lucidity may enhance appreciation of nuance, a key trait of creatives (Briggs, 2000). In this sense, gamma-related heightened awareness is transcendent. Eminent creators are, much like LTM, highly absorbed in the complex problems they tackle, and often for extended periods of time (Weisberg, 2006). Heightened awareness seems to arise out of this absorption. For example, subjects solving verbal insight problems exhibited a burst of gamma (39 Hz) activity at anterior right temporal electrodes 300ms before button presses that correlated with correct solutions (Jung-Beeman et al., 2004). Investigators suggested that the gamma burst reflects "the sudden transition of solution-related cognitive processing from an unconscious to a conscious state" (p. 506). Although the process by which knowledge shifts from the unconscious state to a conscious state is thought to occur in stages (Dietrich, 2004b), it remains one of the fundamental unanswered questions in consciousness studies (Cleeremans & Jimenz, 2002; Dulany, 1997). Generally speaking, the movement from unconscious to conscious states can be considered a form of heightened awareness.

Gamma-related arousal differs from that of the slower beta rhythms, which increase bilaterally in frontal regions of low performance divergent thinkers. A great number of simultaneously activated cell assemblies in the frontal regions at the beta frequency (14–30 Hz) suggest inefficient attentional mechanisms (Molle, Marshall, Wolf, Fehm, & Born, 1999). Here, excessive mental arousal and rumination is implied, a common stress-related beta phenomenon. Beta activity, alternatively, is also found in focused states of audiovisual attention (Wróbel, 2000) and task performance (Pfurtscheller & Andrew, 1999). Razoumnikova (2000) found increased bilateral 20–30 Hz functional connectivity in centroparietal areas and ipsilaterally in the right hemisphere during increased divergent thinking performance. Conceivably, high beta (i.e., over 20 Hz) and gamma activity, if widely distributed, permit sudden highly-focused experiences of spatial-temporal binding, a complex mental singularity often attributed to the experience of flow (Dietrich, 2004b). Flow has been described as an important aspect of creative thinking (Csikszentmihalyi, 1996); however, insufficient electrophysiological studies of flow disallow conclusions concerning a gamma connection. Widely distributed gamma states emerging from low cortical arousal appear more often in meditation studies.

Das and Gastaut (1955) observed 7 Bengal Kriya (CM) yogis enter the state of absorption (*samadhi*) and elicit desynchronized 40–45 Hz gamma waves, indicating a state of temporary focused arousal that eventually returned to alpha-theta activity. Absorption is a transcendent phenomenon. A number of studies found high-frequency beta (above 20 Hz) in very rare cases of meditators achieving absorption (West, 1980). TM practitioners (CbM) also display both 20 Hz and 40 Hz activity in deep meditation (Banquet & Lesévre, 1980). Raja Yoga (CM) practitioners exhibited focused arousal at 38 Hz during the concentration (*dharana*) phase of meditation (Ray, 1988). The beta-gamma band border is subject to controversy. What some investigators call high-beta may reflect gamma activity. Lutz et al. (2004) studied 8 Buddhist meditators with 15 to 40 years experience during a state of unconditional loving-kindness and nonreferential compassion (CbM). Investigators found robust gamma activity (25–42 Hz), bilaterally over the parieto-temporal and midfrontal electrodes, as well as long-distance gamma phase-synchrony, 30 times greater than controls. Gamma baseline activity also increased over alpha/theta with years of practice. The investigators suggest gamma band synchrony "could reflect a change in the quality of moment-to-moment awareness, as claimed by the Buddhist practitioners and as postulated by many models of consciousness" (Lutz et al., 2004, p. 16373). Tolle (1999) referred to this heightened awareness as "living in the now." It is also a component of flow (Csikszentmihalyi, 1996).

D'Aquili and Newberg (1999) described active meditation (CM, CbM) as a state of maximal arousal coupled to quiescent discharge of the hypothalamus causing bilateral deafferentation of the orientation–association areas that obliterates the sense of a self–other dichotomy. This mechanism may underlie the gamma activity found in meditators. The heightened sense of presence associated with certain meditative vehicles (e.g., unconditional loving kindness) is often coupled with salience, or what James (1925) called a "deepened sense of significance" (p. 382). In pure consciousness, this becomes the splendor of recognizing the interconnectivity of all phenomena (Shantananda, 2003). To a lesser degree, gamma could appear when a talented creative (subject) is fully absorbed in, or devoted to, the problem being addressed (object); that is, gamma generators may reflect the transcendence of objects of perception, as well as their integration into something more meaningful. Not surprisingly, gamma activity involves both parallel bottom-up (sensory) and top-down (cognitive) processing (Karakaş, Başar-Eroğlu, Özesmi, Kadafar, & Erzengin, 2001) and appears to regulate cerebral phase transitions on all spatio-temporal scales (Wright et al., 2001). Gamma's sudden localized presence in insight problems may explain how subtle, bottom-up information processing at the edge of chaos becomes stabilized in conscious awareness. Much more research, however, is required to elucidate the functional correlates of gamma activity in both creativity and meditation.

COHERENCE

Two signals are said to be synchronous if, based on their temporal structures disregarding amplitude, their rhythms coincide. Coherence indicates high levels of signal integration (Varela, Lachaux, Rodriguez, & Martinerie, 2001). Coherence, according to the associationist theory of creativity, are neuronal populations applied to concepts (Camfield, 2005). Mednick (1962) suggested that creatives demonstrate a flatter associative hierarchy than noncreatives, thereby activating more highly distributed networks in the brain. In creativity, distant brain regions are linked by long cortico-cortical fiber systems that facilitate information transfer (Braitenberg, 1978; Thatcher, Krause, & Hrybyk, 1986). In a study of gifted, intelligent, creative, and average subjects (Jausovec, 2000a), creatives demonstrated more cortical intra- and interhemispheric coherence in solving creative problems than gifted individuals (i.e., creative & intelligent). Although coherence occurs in any frequency band, depending on the specific creative task (Petsche, 1996), creatives generally display greater coherence than non-creatives in low-alpha indicating reduced mental activity and greater efficiency in solving creative problems (Jausovec, 2002). Coherence changes in high-alpha reflect individual features in creative task completion (Petsche, 1996) such as semantic processing (Klimesche et al., 1997). Low frequency coupling appears to support global neural integration whereas high frequency coupling generally indicates more local integration (Petsche, Kaplan, von Stein, & Filz, 1997; Schanze & Eckhorn, 1994). Gackenbach (1992) concluded that high coherence in the alpha/theta bands represents the "neurophysiological correlate of more generalized, abstract synthetic, integrative functions of the brain" (p. 268), yet low coherence (desynchronization) coupled to high frequencies such as beta represent "more accurate, specialized functions of particular cortical areas, such as perceptual and motor functions" (p. 268). In effect, this reinforces the definitions of transcendence/integration and differentiation. Difficulty levels within creative problems affect coherence. Dialectic problems are the most challenging. They display, in high creatives, the greatest interhemispheric coherence in both alpha bands (Jausovec, 2000b). Furthermore, originality of insight problem responses correlated with alpha synchronization increases in centroparietal cortices (Fink & Neubauer, 2006). Conversely, coherence decreases in creatives at rest, but decoupling in alpha/beta bands is more prevalent than in non-creatives (Jausovec, 2000b). This supports Martindale and Hines' (1975) conclusion that creatives exhibit more arousal in the resting state.

Orme-Johnson and Haynes (1981), employing the *Unusual Uses* subtest of the *TTCT* on TM meditators, along with EEG analysis at bilateral frontal and central sites, found mean alpha coherence in both right hemisphere and bilateral frontal sites positively correlated with creativity. Creativity was also positively correlated with the mean of greatest alpha coherence. Excepting alpha coherence in bilateral frontal sites, the same pattern not only differentiated creatives from less-creatives, but proficient from less proficient meditators, providing direct evidence for a neuropsychological creativity-meditation connection. Many studies of meditation (Cahn & Polich, 2006) have observed increases in intra- and interhemispheric coherence in the alpha–theta range during practice as a trait effect at rest, or while engaged in cognitive tasks. Orme-Johnson et al. (1977) also noted high levels of alpha/theta coherence related to profound levels of creativity in the practice of *sanyama*. Interpretations of meditation phenomena based on intra- and interhemispheric coherence is challenging because transcendent-integrative experiences like bliss, unity awareness, pure consciousness, etc., are not clearly defined and studies are compounded by differences in meditative strategies. Based on evidence herein, it can be generally said that low-alpha coherence in creatives and meditators reflects the witnessing of internal cognitive-affective events, but theta coherence denotes an orientation toward bliss (satisfaction) coupled with a neuropsychological closure mechanism. Delta coherence reflects non-conceptual awareness as a basis for object recognition and surprise; gamma coherence indicates information binding and heightened perception of the object of meditation or moment of creative insight. What is not addressed in most studies on creativity and meditation is long-range synchrony between several frequency bands. The concurrence of high and low coherent frequencies indicates that different bands express different dimensions of the overall integration process (Varela et al., 2001).

SENSITIVITY

Experimental evidence reveals that creatives are highly sensitive. They exhibit more extended alpha-blocking (i.e., desynchronization evincing dehabituation) than less creative individuals (Martindale & Armstrong, 1974). They experience electric shock more painfully (Martindale, 1977). The more creative an individual is, the lower is the intensity of their maximally preferred audio tone (Nardi & Martindale, 1981). Galvanic skin response, when measured against scores for creativity (i.e., *Remote Associates Test,* Mednick & Mednick, 1967; *Alternate Uses Test*, Christensen, Guilford, Merrifield, & Wilson, 1960), indicate that creatives are markedly more sensitive to physiological stimuli, habituate very slowly, remain alert to incoming stimuli even after developing a cortical model for them, and show greater fluctuations in arousal levels than less creative individuals, suggesting that creatives are more motivated to seek novelty, not elicited by boredom or fast rates of habituation (Martindale, Anderson, Moore, & West, 1996).

Meditation training increases auditory sensitivity. Very unusual auditory brain stem responses (less than 10ms from stimulus) were evoked via binaural 5–70 dB stimuli by TM-Sidhi program *sanyama* practitioners using special mantras to sensitize the auditory system toward internal sounds (McEvoy, Frumkin, & Harkins, 1980). Additionally, a study on middle latencies (post-brain stem, 10–80 ms from stimulus) was conducted on two groups of CM practitioners, one meditating on the mantra *Om* and the other on the word *One*. Novice meditators repeating *Om* demonstrated a decrease in Na-potential amplitude; experts showed an increase in the *Om* condition but a decrease in the *One* condition (Telles, Nagarathna, Nagendra, & Desiraju, 1994). (The Na-potential is thought to arise at the midbrain-thalamic level.) CM, in the mantra experts, appeared to enhance audio sensitivity by affecting early thalamic sensory processing. Meditation also alters long latency auditory potentials (for a review, see Cahn & Polich, 2006).

Harai (1974) noted that advanced Zen practitioners (MM) exhibited consistent alpha-blocking (dehabituation), as well as theta-blocking, to auditory click stimuli even in the fourth stage of meditation, whereas controls habituated quickly. One of the Zen monks explained that he "perceives the objects, responds to them, and yet is not disturbed by them" (p. 43). Conversely, some yogic meditation strategies elicit habituation faster than Zen (Bagchi & Wenger, 1957). Yet, Beckert and Shapiro (1981) compared Zen, yoga, and TM meditators with controls and found no differences in habituation. Most evidence, however, points to greater dehabituation across meditation strategies (Murphy & Donovan, 1999).

In another study (Valentine & Sweet, 1999), MM practitioners outperformed CM practitioners on the *Wilkin's Counting Test* (Wilkins, Shallice, & McCarthy, 1987), a measure of sustained attention toward unexpected audio stimuli, but both groups outperformed controls. Length of practice in both groups led to superior performance. These results suggest that CM, through single-minded focus on the meditation vehicle, reduces reactivity to unexpected stimuli and distraction (or boredom). CM's concentration enhances withdrawal of the senses (*pratyāharā*) reducing distraction while internal state monitoring remains active (Brefczynski-Lewis et al., 2007). A similar state, induced in a flotation tank environment, demonstrated increased creativity in academic psychologists (Suedfeld, Metcalfe, & Bluck,1987). On the other hand, MM's dehabituation enhances openness to stimuli, but not to the point of distraction. Meditation, overall, is associated with openness to experience (Davidson, Goleman, & Schwartz, 1976) and empathy (Lesh, 1969), which are both related to creativity (Alligood, 1991; Carlozzi, Bull, Eells, & Hurlburt, 1995; Gallo, 1989; Kalliopuska, 1992). Increased theta activity, unsurprisingly, correlates with openness, including flexible thinking and the liberal values associated with openness (Camfield, 2005).

Visual sensitivity is enhanced by meditation. Buddhist MM novices, with 3 months training, outperformed controls in both detecting shorter light flashes and accurately differentiating between successive flashes, demonstrating heightened awareness of some of the preattentive processes involved in visual perception (Brown, Forte, & Dysart, 1984a, 1984b). Banquet and Lesévre (1980) presented a go/no-go visual task to both experienced yoga meditators (CM/CbM) and rest–activity controls who were asked to respond to all stimuli except omitted ones. After practice, P300 amplitude (elevated attention) increased in meditators but decreased in controls. Meditators exhibited shorter response times and greater accuracy than controls. The investigators suggested that long-term meditation practice increases selective visual attention capacity as well as vigilance.

Attentiveness to external stimuli is amplified through meditation. Contingent negative variation (CNV) is a measure of orientation and stimulus expectancy in which one stimulus serves to indicate an impending second stimulus (Walter, Cooper, Aldridge, McCallum, & Winter, 1964). Aged-matched groups of TM meditators, differing in length of practice and frequency of transcendental experiences, were tested using simple and distracter CNV tasks. A decrement in CNV amplitude elicited by distracting stimuli negatively correlated with the frequency of transcendental experience leading investigators to suggest that CNV amplitude increased because transcendental experience magnifies overall attentional resource capacity (Travis, Tecce, & Guttman, 2000). Meditation's heightened sensitivity and transcendent attentional capacity appears to (among other factors) broaden creativity and enhance sensitivity toward quality in artists (Wrycza, 1982).

INSIGHT

Thus far, the experimental data, as interpreted, indicate the following connections between creativity and meditation:

1. MM supports creative thinking (particularly incubation and illumination phases), even in novices, by inducing broad, open awareness in a state of low cortical arousal (e.g., increased low-alpha) enhancing sensitivity, reducing habituation to external (and perhaps internal) stimuli, increasing cognitive performance on complex problems and supporting novelty-seeking.
2. MM promotes cognitive flexibility due to its transcendent, detached witnessing effect. Strong associative thinking habits are suppressed allowing for the generation of new ideas.
3. There is no evidence to support MM as a specific creative problem-solving mechanism.
4. CM also induces vigilance in states of low cortical arousal but diminishes sensual awareness due to singular focus on a meditative vehicle. CM fosters the capacity to monitor internal states (e.g., primary process thinking) and enter the state of absorption, typically after years of practice. The capacity to remain absorbed in a problem for extended periods is important to creativity.
5. CbM strategies broaden CM's focus, subconsciously, through mindfulness thereby capturing the attentional benefits of both CM and MM.
6. Meditation-induced transcendence (e.g., hypofrontality, bliss orientation, neural silence, heightened awareness) alone appears insufficient for realizing creative solutions.
7. As transcendence is gradually integrated within waking, dreaming, and slow wave sleep states, awareness of the subtle nature and interconnectivity

of phenomena rises, potentially stimulating creative solutions to complex problems. Spontaneity in creative expression is also facilitated.

8. The presence of theta trains in MM, CM, CbM reflects an implicit "motivation" to transcend limitations, an orientation toward bliss (satisfaction) and the encoding of new information (e.g., unusual meditative experiences). Theta's transcendent/integrative presence in hypnogogic reverie appears associated with creativity.
9. Unusual delta activity generated in deep meditation is affiliated with non-conceptual awareness as ground for the recognition of subtle phenomena. It may enhance the capacity to recognize complex, subtle informational patterns that serve as novel and appropriate solutions to creative problems.
10. Increased gamma activity, following states of low cortical arousal, indicates heightened awareness, or lucidity, and salience. This condition, found in advanced CM/CbM practitioners, as well as in creatives, signals intense binding of spatial-temporal information, and possibly a strong sense of living in the moment.
11. Increased intra- and interhemispheric coherence, involving transcendent and integrative aspects of low-alpha, theta, delta, and gamma frequencies during meditation, fosters the sort of whole brain functioning that appears necessary for creative thinking.

What is not yet evident is meditation's capacity to proactively address problems in a creative manner. It is clear that some individuals are more adept at creative output than others. If factors like genetics, IQ, personality, family support, education, domain knowledge, and chance are excluded, the question remains whether certain attentional processes provide distinct advantages in creatively solving complex problems. To address this, it is essential to understand the relationship between intention and insight.

Metcalf and Weibe (1987) tested 67 subjects with both insight and noninsight problems, to determine whether insight problems are solved using *means-end* analysis (i.e., incrementally), resulting in an increase in subject warmth ratings, or intuitively and suddenly. They concluded that noninsight problems are solved incrementally, but insight problems are solved intuitively and suddenly. Bowden, Jung-Beeman, Fleck, and Kounios (2005) suggested a cognitive model for insight activation in which (a) initial processing strongly activates unrelated information, as well as weak information critical to a solution; (b) processing integrates problem elements across nondominant, or contextually nonbiased, information; and (c) the creative must actively "*switch* the focus of processing to unconscious activation and select it for consciousness and output" (p. 324).

The last point is critical. Dijksterhuis and Meurs (2006) found that incubation is an active unconscious process leading to more inaccessible and creative items than conscious thought, even with opposition from strong distractor tasks. During incubation, intention (defined as attention by James, 1983) shifts toward unconscious processes, bypassing dominant informational patterns. Subconscious, goal-directed attention has been associated with the parietal lobe (Taylor, 2001). The word *intention* derives from the Latin *intendere*, meaning "the act of stretching out." Intention can be viewed as a forceful, though not necessarily conscious, movement of one state toward another. This movement embodies psycho-physiological energy and is usually affiliated with conscious acts of will. Conscious attention manifests in the PFC (Posner, 1994), often called the attention association area. It is highly interconnected with other brain areas; supports sensory data integration; allows for concentration (e.g., removal of distractors); and provides, via the limbic system, emotional valence to cognitive processes. PFC injury can result in loss of will and the capacity to form an intention (Newberg & d'Aquili, 2000). The right PFC is related to sustained attention, a key factor in both creative thinking and meditation (Pardo, Fox, & Raichle, 1991; Roland & Friberg, 1985). PFC connections to the basal ganglia, an area critical to procedural memory (i.e., implicit motor and cognitive skills), which contributes to priming, conditioning, and habituation (Dietrich, 2004b), appear to enable certain formative processes of creativity, like memory consolidation, problem solving, and insight (Gluck & Myers, 1998). The PFC helps override conditioning and habituation (Schwartz & Begley, 2002). Many cognitive scientists agree that a major component of creative thinking is the destructuring of strong associative thinking habits for the purpose of generating new ideas (Glover et al., 1992). Heilman et al. (2003) suggested that PFC inhibition of semantic information storage networks might allow activation of weak, or unactivated, networks. The PFC and associated basal ganglia are strategically involved in control of semantic retrieval from posterior semantic memory (Fiez, 1997). Deep meditative states, like absorption, also destructure strong associative thinking habits and are possibly the result of a transient hypofrontality of the PFC, excluding its attentional network (Dietrich, 2003). MM, for example, appears to activate frontal inhibitory networks in breaking down associations between thoughts (e.g., memories, beliefs) and their accompanying body sensations (Ivanovski & Malhi, 2007). The presence of frontal low-alpha synchronization in creativity and meditation supports the hypofrontality hypothesis.

The destructuring of strong thought associations is implicated in other studies. Whitton et al. (1978) examined six unmedicated schizophrenics for intrusiveness of hallucinatory phenomena and six controls for creativity using seven tests, five from Guilford's (1967) divergent thinking classification. Placing one electrode at the vertex (Cz), they discovered during 4-second segments preceding and during hallucinations or creativity test responses that 71.7% of the schizophrenics exhibited predominant delta (0–1.99 Hz) and theta (2–6.99 Hz) power, and 78.1% of the creativity controls demonstrated a virtually identical pattern. All creativity tests involved "the eliciting of a sudden internal experience that is self-observable and reportable as the answer intrudes in one's contemplation" (p. 126). (Note their theta band overlaps with standard definitions of delta.) The investigators suggested two possibilities: (a) the intrusiveness of hallucinatory experience is phenomenologically similar to creative insight, and (b) theta (delta) increases may be correlated with an internally directed mechanism that excludes stimuli irrelevant to the current task. The author (unpublished), who has practiced *sanyama* for over 37 years, employed a 64-channel EEG while contemplating, with *sanyama,* abstract dialectic problems requiring insight. Two trials resulted in seven insight events. Surprise/salience levels emerging from each event were later recorded. After artifact removal and source analysis, averaged 3–4 second insight epochs exhibited peak subdelta coherence across most brain regions, greater intensity in the left hemisphere, particularly the anterior temporal region. Low-alpha (highly coherent) and theta predominated in the right temporo-parietal area (see Figure 1). Gamma power was elevated in the left anterior temporal and occipital polar area contrary to Jung-Beeman et al.'s (2004) bursts of right anterior temporal gamma. The author noted increases in the element of surprise/salience corresponded with increases in electrode sites displaying peak delta frequencies. This finding is consistent with delta activity reflecting subtle signal matching and surprise (Başar-Eroğlu et al., 1992) and Class II inhibition (Vogel, Broverman, & Klaiber, 1968). Increased interhemispheric delta has also been observed in the invention of stories (Petsche, 1996). The author's results imply that right hemisphere low-alpha/theta presence represents both non-judgmental witnessing and encoding of new information; gamma-related heightened awareness supports insight visualization.

Hemispherical differences appear in both creativity and meditation. Using both PET and EEG, Bekhtereva, Dan'ko, Starchenko, Pakhomov, and Medvedev (2001) found that left frontal hemisphere activity differentiates creative from noncreative tasks; the right frontal hemisphere is more activated by difficult creative tasks; and frontal interhemispheric coherence is particularly important in the solution to creative tasks. The right hemisphere seems to process more difficult creative tasks and has a more global attentional perspective (Barrett, Beversdorf, Crucian, & Heilman, 1998; Robertson, Lamb, & Knight, 1988), but the left displays a more focused attentional perspective; however, gender differences do exist (Razoumnikova, 2005). Some suggest that the right hemisphere searches for, and finds, a visual-spatial solution to a creative problem before transmitting the solution to the left hemisphere for verbalization (Newberg & d'Aquili, 2000). Others perceive reductions in left hemisphere language dominance as a function of over-reliance on unfocused right hemisphere semantic processes (Leonard & Brugger, 1998). The right hemisphere exhibits increased alpha activity in creatives (Martindale, Hines, Mitchell, & Covello, 1984). Cerebral blood flow measurements of 12 award-winning creatives, who scored high on the *TCTT* figural and verbal forms, also resulted in predominantly right hemisphere correlations (Chavez, Graff-Guerrero, Garcia-Reyna, Vaugier, & Cruz-Fuentes, 2004). However, the

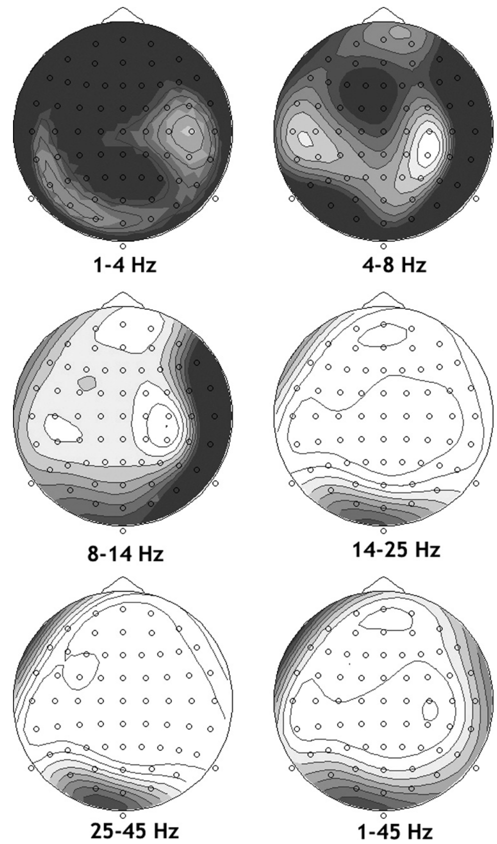

FIGURE 1 Creative contemplation insight events (FFT mean) exhibiting intra- and interhemispheric peak delta coherence with alpha/theta activity predominating in right temporo-parietal area. Gamma centers of gravity in occipital pole and left anterior temporal region.

corpus callosum, a midbrain structure that facilitates interhemispheric communication, also seems vitally important to creativity. Hoppe (1988) interviewed commisurotomy patients and found their fantasies ‘‘unimaginative, utilitarian, tied to reality and their symbolizations were concrete, discursive and rigid’’ (p. 303). Hoppe hypothesized that creativity involves transcallosal symbollexia, a neurological form of Koestler's (1964) bisociation concept. This hypothesis is supported by other investigators (Beisteiner, Altenmuller, Lang, Lindinger, & Deecke, 1994; Shemyakina & Dan'ko, 2004), some suggesting that access to complimentary hemisphere processing supports superior creative endeavor (Katz, 1986).

Jung-Beeman et al. (2004) proposed that, in verbal problems, coarsely-coded semantic integration within large overlapping information fields occurs first in the right hemisphere before being transferred to the left hemisphere for refinement. This corresponds with the yogic concept of *levels of speech* (Muktānanda, 1994). The source of all language (*parāvak*), resting undifferentiated within the unconscious, rises into a coarse, yet subtle, nonverbal form (*paśyantī*) that refines into clear thought (*madhyamā*) before verbalization (*vaikharī*). Language, or symbol, arising out of *parāvak* can be considered representative of self-identity. Dissolution of self-identity in meditation, and its reconstitution, involves symbolic representation. A study of a 59-year-old Buddhist monk revealed that the dissolution of self ‘‘into a boundless unity (emptiness)’’ and its reconstitution (Lehman et al., 2001, p. 112) appeared as gamma (35–44 Hz) activity in both right superior frontal and right middle temporal gyrii. If the ebb and flow of thought also exemplifies dissolution and reconstitution of self-representation, then *parāvak* and *paśyantī*, being coarser, represent right hemispheric functions, and *madhyamā* and *vaikharī* represent left hemispheric refinements. Strong delta coherence during creative inspiration (e.g., the author's study) may indicate blocking of strong semantic associations, subtle signal matching and surprise supporting right hemisphere processing and left hemisphere refinements of coarse concepts. Meditation's intention, according to Patañjali, is to enter the transcendent state of pure consciousness through self-surrender further integrating that state, consciously, within empirical reality (Iyengar, 1993). Similarly, creative intention strives to transcend strong problem-based associations allowing weak or nonexistent associations to be formed, subconsciously, before conscious integration with domain knowledge (see Figure 2 for this discussion). The meditative practice of *sanyama* is specifically designed to integrate the transcendent state into all states of consciousness—‘‘the Self moving within Itself’’ (Orme-Johnson et al., 1977, p. 709). *Sanyama* does this by maintaining unbounded awareness while attention focuses on a thought/object being refined to its most subtle state (Orme-Johnson & Granieri, 1977); that is, intention is sustained while perceptions of the thought/object dissolve into the subconscious mind, eventually incubating the thought/object within its own transcendent reality. This is another form of surrendering self-representation. *Sanyama* does not require seated meditation. Vivekananda (Nikhilānanda, 1956) described *sanyama* mastery as follows:

> When the mind has attained to that state in which it identifies itself with the internal impression of the object, leaving the external, and when, by long practice, that impression is retained by the mind, and the mind can get into that state in a moment, that is *sanyama* (p. 189).

Here lies a powerful formula for intentional subconscious problem solving. The *internal impression of the object* transcends the multiplicity of complex, subtle, weak, or even non-existent, memory-related connections embodied within the problem. Any exercise in mind-mapping confirms the multiplicity of memory points, or connections, associated with a problem (Buzan & Buzan, 2000). In creativity, problem requirements form the stimulus set determining which associations are eligible as solution components (Mednick, 1962). Both working and long-term memory associations are transcended through *sanyama's* intention to merge problem requirements within the entire set of all phenomena. Most meditation traditions declare that the set of all phenomena includes the vast potential of yet unknown knowledge, along with all existing knowledge (*veda*); therefore, the probability of paradigm-shifting insight occurrences would hypothetically increase as the boundary of phenomenal existence is reached. The downside is that the creative's comprehension of a profound insight is somewhat constrained by his or her knowledge base.

Mathematical genius Ramanujan, as a young man, developed advanced mathematical theorems; yet, his primary access to mathematics was a book describing 4,865 basic formulae without a single proof (Hardy et al., 1927). Ramanujan described his powerful mathematical insights to friends as originating from the Goddess Namakkal (Srinivasan, 1968), another way of saying that he felt they originated in the transcendent. Orme-Johnson et al. (1977) investigated the electrophysiological correlates of creativity relative to *sanyama*-induced phenomena (i.e., SP) in 12 TM meditators who also experienced the transcendental state in their usual meditation practice against controls experiencing infrequent SP. The experimental group had significant increases in delta band coherence, as well as increased alpha/theta band coherence over combined frontal, central, left and right electrode pairs. One practitioner, reporting

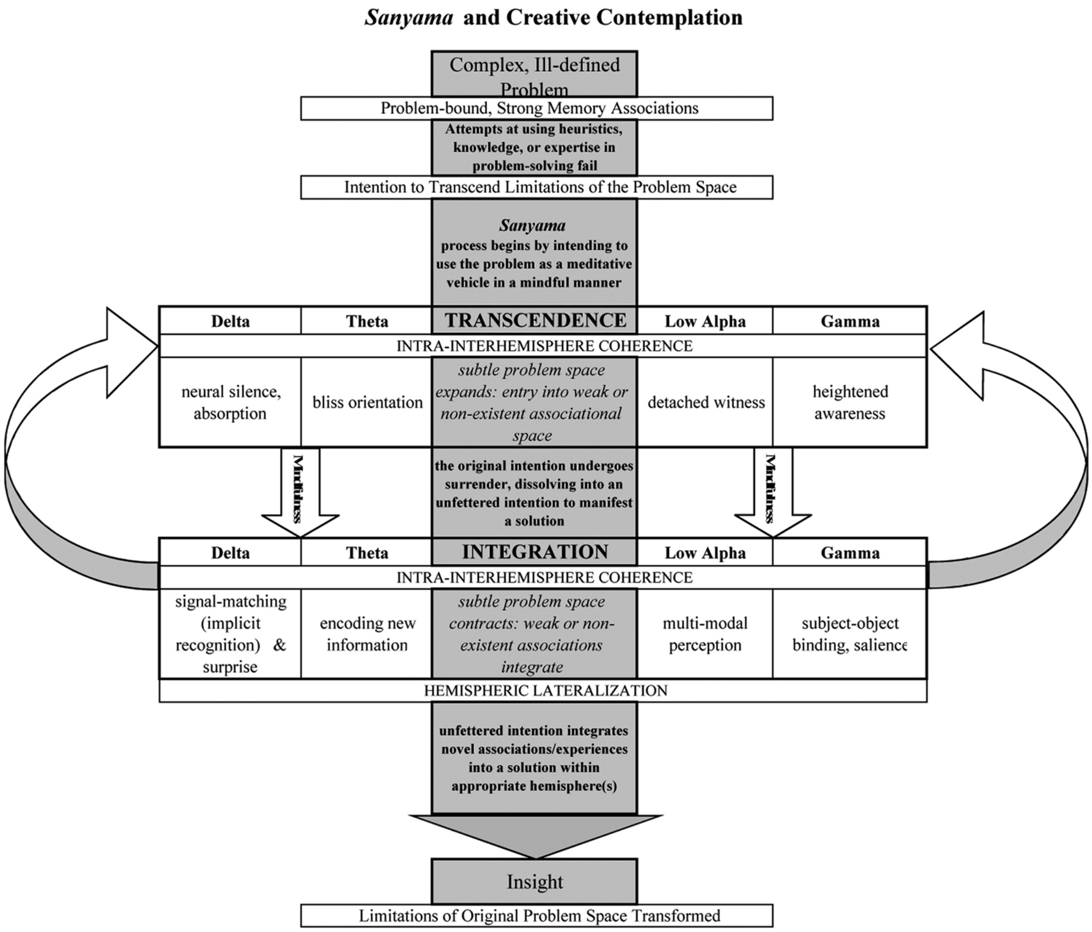

FIGURE 2 *Samyama*, a CbM strategy, uses intention to process a problem, subconsciously, via transcendence and integration as reflected in delta, theta, low-alpha and gamma bands, until insight is achieved.

transcendental experiences, SP, witnessing sleep, and describing his overall subjective state as bliss, scored 3.5 deviations above the mean in fluency of creative thought and 4.0 standard deviations above the mean on originality. The investigators associated high levels of multi-band coherence with *sanyama*-induced SP based on the neurophysiological principle of recruitment whereby many neuronal populations are enlisted on very difficult tasks through the intention of exacting a performance, or solution. A further study of 152 TM meditators with an average of 3 years and 8 months of *sanyama* practice indicated significant correlations between *sanyama* and creativity independent of the duration of TM practice (Jedrczak & Clements, 1985).

Patañjali's *Yoga Sūtras* describe various *sanyama*-induced SP; however, deep insight into the nature of reality (supreme knowledge) is considered the most important power (Iyengar, 1993). Creative contemplation is perhaps an appropriate term for *sanyama*-induced creative problem solving. The rare contemplative undergoes a *flash of illumination* (*pratibha*).

> A being who has attained *pratibha* eliminates all thoughts and experiences and so can remove the obstacles which prevent him from seeing his own nature. . . . He can fashion a new creation within himself because *pratibha* gives rise to ever-new creative abilities (Muktānanda, 1983, p. 145).

Vivekananda (cited in Nikhilānanda, 1956) further stated, "When a man has risen to a high state of *pratibha* he has a great light. All things are apparent to him. Everything comes to him naturally without practicing *sanyama*" (p. 194). This statement implies that some creatives could experience great insight without undergoing either meditation, or *sanyama,* at least in any formal sense. Creative contemplation is accomplished through intention (*sankalpa*). To intend also means *to wish, to be desirous of; purpose or resolve and to be brought about, to come into existence*, that is, *sankalpa* is both a wish and a creative force (Shantananda, 1999, p. 4). Intention lies at the root of *sanyama* (Hagelin, 1987, see note p. 80). Unlike volition that stems from normal desire, the source of will in *sanyama* is non-generated; that is, it is desireless (Hughes, 1994). Perhaps the most difficult intention to maintain is selflessness (i.e., unconditional surrender). In *sanyama*, the contemplative consciously relinquishes the desire to acquire a solution while maintaining unfettered focus on surrendering the problem to be otherwise solved, subconsciously. This "desireless" intention allows problems to be viewed with clarity while unconscious processing is free to seek unique solutions. Hypothetically, unfettered focus on a problem under conditions of very low cortical arousal could allow attention (intention) to approach, transiently, the state of a fixed point attractor (e.g., high coherence) within the brain's chaotic neural environment, thereby attracting synchronized informational patterns toward the problem set that are both novel and appropriate. Systems that attain rest, or equilibrium, become fixed point attractors. This occurs periodically in EEG waveforms. Strange attractors, on the other hand, which are deterministic and reproducible if the input and initial conditions are replicated can transition to fixed point attractors (for discussion on cortical chaos, see Başar, 1992). Conceivably, certain sustained forms of attention with high affective content can achieve unique solutions as attractors.

Similarly, according to the yogic tradition, *one-pointed attention* (*ekāgratā*) induces a state of equilibrium to which mental perturbations eventually surrender, resulting in great inspiration (Muktānanda, 1977b). One-pointed attention involves self-surrender. Ghiselin (1952) declared that the "self-surrender so familiar to creative minds is nearly always hard to achieve. It calls for purity of motive that is rarely sustained except through dedication and discipline" (p. 24). In the yogic tradition, self-surrender has an affective element called *bhakti,* or devotion. Its goal is existential freedom (Poddar, 1981; Vivekananda, 1955, 1986). Self-surrender may be linked to anterior cingulate cortex (ACC) activity which, in meditation, is reduced. The ACC is well known for its role in cognitive conflict as a mediator of processes that transcend the current mindset (Botvinick, Braver, Barch, Carter, & Cohen, 2001). The ACC is, along with the PFC, associated with selective or ongoing attention, as well as frontal theta rhythms (Asada et al., 1999). ACC coupled with PFC activity is related to creativity during insight riddle-solving (Qiu et al., 2006). The ACC is also involved in the emotionally-controlled effects of executive brain function (Lou et al., 1999) and the ventral ACC is a focal point in romantic love (Bartels & Zeki, 2000). Reduced activity in the superior occipital gyrus and ACC in LTM Zen meditators indicates a lessening of interference effects from will, or conscious intent (Ritskes et al., 2003). Conceivably, ACC/PFC activity contributes to the sort of selfless devotion (reduced willfulness), self-sacrifice, unerring dedication and intention that has led to historical creative paradigm shifts such as Einstein's theory of relativity, Copernicus' heliocentric system, Darwin's theory of evolution and Picasso's cubism, to cite a few.

Sanyama is a CbM strategy because it involves both concentration and mindfulness. During creative contemplation, the object of focus is a problem with its concomitant problem space. Unlike problem-solving where attention is drawn to using heuristics, knowledge, or expertise (Weisberg, 2006), *sanyama* concentrates on the problem without consciously attempting to solve it. The problem is surrendered from consciousness to the subconscious mind. Surrendering allows the problem space to expand significantly (i.e., neuropsychological transcendence). The intention to solve the problem creatively, however, remains unbroken. It lies at the root of the entire process. Intention is focused, yet mindful. It eventually contracts the subtle problem space, precipitating weak or non-existent associations relative to the problem set, probably in the right hemisphere, finally integrating these associations into an insight (i.e., neuropsychological integration). In *sanyama*, objects of perception are perceived as precipitated modes of pure consciousness that can be transformed through intention (Hagelin, 1987). *Sanyama* insight is known to occur, unexpectedly, when the conscious mind is otherwise occupied. *Sanyama* training, through neuropsychological transcendence and integration, appears to enhance the creative capacity of TM practitioners. This attentional mechanism may account for differences in CbM and CM studies relative to creativity. CM strategies provide concentrative support for *sanyama*, but don't appear sufficient, in themselves, to elicit creative insights until, after considerable practice, the transcendent state stabilizes within all states of the practitioner's consciousness. Additionally, most CbM training, other than the TM-Sidhi program, doesn't offer *sanyama*. In creativity, both transcendence and integration are highly interdependent, bound by a creative intention. *Sanyama* training, or *sanyama* emerging naturally in rare individuals, is a potential mechanism for eliciting unusual, intuitive, insight into complex phenomena. Additional research employing both EEG and high spatial resolution scanning equipment should be undertaken to verify this hypothesis. Confirmation could have profound impact on the education sector as well as in our understanding of the nature of consciousness.

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