Advancing Innovation and Sustainable Outcomes in International Graduate Education

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Chapter 10
Innovation, Creativity, and Brain Integration

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ABSTRACT

The heart of creative thinking is the incubation stage, in which ideas freely move on a subconscious level going beyond the limits of the problem space to create new solutions. The incubation stage might be fostered through meditation practices that lead to transcending, such as the Transcendental Meditation (TM) technique that cultures greater brain integration in which the brain functions more as a whole. Higher brain integration is seen during the TM session within a few weeks of practice, and after the TM session with regular practice over time. Higher brain integration is associated with higher creativity and greater success in life. Adding the experience of transcending to enhance incubation of creative ideas is innovation from the inside. Training in transcending could be part of forward-looking graduate programs to help their graduates thrive in an ever-changing workspace landscape, and could be a workplace skill to support better performance in many professions.

INTRODUCTION

Innovation includes two interacting processes: *Invention*, the generation of novel ideas, and *Exploitation*, the implementation of these ideas (Bledow, Frese, Anderson, Erez, & Farr, 2009; West, 2002). These two processes may alternate or occur simultaneously but the driving force of innovation is always creative thinking (Haner,

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2005). Development of creative thinking fosters innovation in the arts, sciences, technology, and political arenas to meet growing challenges (Cropley, Kaufman, & Cropley, 2011).

Creative thinking combines both focused, logical analytical thinking and undirected free flow of ideas. Wallas, a pioneer in creativity research, identified four stages of creative thinking: *preparation,* in which the problem is identified and the details of the problem are explored to understand the parameters of the problem space, *incubation*, inner silence and relaxation where ideas freely move on a subconscious level, *illumination,* the creative insight, followed by the *verification* of the insight (Botella, Zenasni, & Lubart, 2018; Wallas, 1926).

INCUBATION AND ILLUMINATION

Notice, the first and last stages of creativity involve rational thought, critical analysis and controlled processing. During the first stage, p*reparation*, one scours the existing literature and critically evaluates the designs of the study, their results and possible ramifications. The final stage, *verification*, also requires focused attention and rational thinking to implement the creative insight. *Incubation and illumination* have a different character. They are marked by transcendence, going beyond the limits of the problem space to create new solutions (Horan, 2009).

Incubation and *illumination* are the heart of the creative process. The *incubation* stage is essential to be able to think "outside the box." The proverbial box is the problem space that we explore with our rational analysis. If we remain on the level of rational thinking, the content of our thought will remain "in the box." The incubation period is when we allow task-unrelated or stimulus-independent thinking—allowing the mind to be silent and play with ideas even sub-consciously to take place (Christoff, Irving, Fox, Spreng, & Andrews-Hanna, 2016). This is thinking outside the box.

The Incubation Stage and Mind-Wandering

The *Incubation* stage is a state of mind-wandering. Mind-wandering or stimulus-independent thought is the process of being temporarily lost in a free association stream of thought, having lost track of time, place, and the current task (Christoff et al., 2016). Singer has labeled mind-wandering during the *incubation* stage as "*positive constructive day dreaming*," characterized by playful, wishful imagery (McMillan, Kaufman, & Singer, 2013; Singer, 1961).

Frequency of mind-wandering has been investigated using iphone technology in 2250 people (Killingsworth & Gilbert, 2010). Subjects were randomly texted throughout the day, and asked to answer a happiness-question, an activity-question and a mind-wandering-question. One conclusion from these data was that subjects reported being engaged in mind-wandering almost half of the time (46%). A second conclusion was that 43% of the time positive thoughts filled mind wandered, 31% of the time neutral thoughts, and 26% negative thoughts. Mind-wandering driven by negative thoughts is called rumination and is reported in clinically depressed individuals (Burkhouse et al., 2016). It destroys creativity and successful interaction with the environment. On the other hand, mind-wandering filled with positive thoughts is typically future-focused thinking called *autobiographical planning* and suggests attentional cycling between personally meaningful and external goals (Baird et al., 2012).

High levels of mind-wandering are associated with higher creativity and higher general intelligence. Participants completed a Mind-wandering Questionnaire, a test of fluid intelligence (Ravens Progressive Matrices) and a standardized test of creativity (Remote Associates Task). Those with higher levels of mind-wandering had significantly higher scores on the tests of creativity and intelligence (Godwin et al., 2017). Other research reports that mind-wandering positively supports problem solving when approaching problems with insight, but for problems requiring rational analysis mind-wandering decreased performance (Zedelius & Schooler, 2015). This presents a complex picture of creativity. If the problem-solving needs high levels of analysis, then central executive systems would yield better results. If insight is needed in solving the problem then mind-wandering will yield superior performance.

The Incubation Stage: Transcending the Thought Process

Torrance discusses the incubation stage as transcending the boundaries of sequential, controlled rational thinking and experiencing a silent awake state of inner awareness (Torrance & Hall, 1979). Functioning from inner awareness would enable the individual to transcend the limits of a rational linear analysis and explore ideas that are not yet fully formed.

This brings up the natural question: Can one learn how to cultivate the incubation stage? Can the attention be systematically de-embedded from the thinking level of the mind and brought to the feeling level, and then to the level of awake, inner silence? Since incubation is the core of creative thinking, and creative thinking is the driver of innovation, a means to foster incubation could be a valuable tool to enhance new innovations.

Transcendental Meditation: A Technique to Foster the Incubation Phase

Meditations practices are tools to explore inner subjectivity. Modern science has looked outside to identify laws that govern observed behavior of matter. Meditation practices from the Vedic, Buddhist, and Chinese traditions have looked inside to understand the laws that govern our changing thoughts and feelings, and to understand the full range of individual awareness.

The many meditations available today can fit into three categories according to level of cognitive control used in each practice (F. Travis & Shear, 2010). For instance, *Focused Attention* meditations involve strong concentration and control of the moving of the mind. Meditations in the *Open Monitoring* category involve less control—simply maintain the attitude of watching, of being mindful of moment-by-moment changes in experience. Meditations in the *Automatic Self-Transcending* category involve minimal control. These techniques teach one how to allow the mind to transcend from thinking to Being or inner silence, called pure consciousness (Maharishi Mahesh Yogi, 1969; F. Travis & Parim, 2017).

Transcendental Meditation (TM) is a technique in the *Automatic Self-transcending* category designed for transcending. Superficially, the TM technique can be described as "thinking" a mantra—a meaningless sound—and going back to it when the mantra is forgotten. This sounds like focused attention. However, on deeper analysis, TM practice is understood to be a process of transcending —appreciating the mantra at "finer" levels in which the mantra becomes secondary in experience and ultimately disappears, while self-awareness becomes more primary (Maharishi Mahesh Yogi, 1969). This is the state of pure consciousness, a state of wakefulness free from the processes and contents of knowing (F. Travis & Pearson, 2000). The "content" of pure consciousness is self-awareness. It is the source of thought and the source of creative impulses.

Nature of the Experience of Pure Consciousness

The experience of pure consciousness is qualitatively different from waking, dreaming or sleeping. A recent paper presented a 2 x 2 grid to highlight differences in self-awareness and object-awareness during these four states of consciousness (F. Travis, 2014). Figure 1 is adapted from this article.

In this figure, the lower right cell contains sleeping—there is no sense of self and no sense of the outer environment. The upper left cell contains waking—we are aware of changing objects in the outer environment and of changing thoughts and feelings. We are also aware of ourselves as directing ongoing perception and responding to outer situations. The upper right can be argued to contain dreaming.

Figure 1. Comparison of self-awareness and awareness of changing outer and inner experiences during waking, sleeping, dreaming, and pure consciousness

		Self-awareness: Yes	Self-awareness: No
Awareness of the outer environmental and inner thoughts and feelings	Yes	Waking	Dreaming
	No	Pure Consciousness	Sleeping

We are aware of changing dream images, and the sense of self, if it is there, is very fragile. That leaves the lower left cell—self-awareness without mental content. Most people, after some deep thought, might conclude that state is not possible. How can you experience yourself if you do not experience that you are the experiencer? William James (James, 1890/1950), the father of American psychology made this observation:

It is difficult for me to detect any purely spiritual element at all. Whenever my introspective glance succeeds in turning around quickly enough to catch one of these manifestations of spontaneity in the act, all it can ever feel distinctly is some bodily process for the most part taking place in my head. (pg 300)

James's conclusions are based on waking state experience, in which the sense of self is experienced along with changing content. However, the experience of pure consciousness fits into this cell. It is more than a conceptual reality but is the direct experience during TM practice. Subjective descriptions of this state support its place in this cell.

Fifty-two college students who practiced the TM technique for a few months to over 8 years were asked to describe their deepest experiences during their practice. They wrote on an average of 250 words. A content analysis of their descriptions yielded three themes—absence of time, space, and body sense. Time, space, and body sense make up the framework that gives meaning to waking experience. Note that the experience of pure consciousness was not described in relation to distorted content—strong emotions, or vivid visual, auditory, and tactile sensations, or a distorted sense of self. Rather, it was described by the absence of time, space and body sense, the customary framework that characterizes waking experience.

How Transcoding Effects Brain Functioning

Subjects quickly master TM practice. While significant differences are reported in brain patterns during meditation practice in novice and expert Buddhist meditators (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007), no significant differences are reported between novice and expert TM subjects during the meditation session, as suggested by data from a one-year longitudinal study (F. Travis & Arenander, 2006), and from two cross-sectional studies: one comparing individuals with 4-months' versus 8-years' TM practice (F. Travis & Pearson, 2000), and the other comparing individuals with 7 years' versus 32 years' TM practice (F. Travis, Arenander, & DuBois, 2004). While no differences are reported during the practice, novice/expert differences are reported during tasks *after* TM practice. Namely, the high levels of EEG alpha coherence seen during the session begins to be integrated and displayed with waking EEG after the meditation session (F. Travis, 2014; F. T. Travis, Tecce, Arenander, & Wallace, 2002).

Experience of Pure Consciousness and Creativity

The regular experience of pure consciousness during TM practice could foster the incubation phase by training the person to contact pure consciousness during meditation practice and so make that state more readily available during problem solving tasks. A matched longitudinal study found that creative performance improved with 3-months of TM practice. Forty-four matched college students—TM practice or control—were administered the Torrance test of Unusual Uses (verbal creativity) and Picture Completion test (figural creativity) before and after the 3-months of TM practice. The TM group significantly improved on the originality subscale of both the Unusual Uses and Picture Completion test (F. Travis, 1979).

Two other studies investigated the relation of the experience of pure consciousness with creativity scores on Torrance's tests of Creative Thinking. More frequent experiences of pure consciousness during TM practice was positively and significantly correlated with scores on the Unusual Uses subtest on a study with 22 subjects ($r = 0.64$) (Orme-Johnson & Haynes, 1981) and a study with 152 subjects ($r = 0.2$) (Jedrczak, Bereford, & Clements, 1985).

THE BRAIN AND CREATIVITY

The incubation phase is associated with mind-wandering—stimulus independent thinking—which has been associated with activity in the default mode network of the brain (Marron et al., 2018; Mason et al., 2007). The default mode network includes the middle of the front of the brain (ventral medial prefrontal cortex) and areas in the back of the brain (precuneus and posterior cingulate gyrus in the parietal cortex) (Raichle et al., 2001). The default mode network is associated with stimulus-independent-thought, imagination, introspective thinking, and emotional processing—all important mental components of creative behavior (Takeuchi et al., 2012). The default mode network is more active during periods of mind-wandering and during self-referential mental activity (Gusnard, Raichle, & Raichle, 2001; Vogeley et al., 2001). It is deactivated during cognitively demanding tasks (Golland et al., 2007) and goal-directed behaviors requiring executive control (Gusnard et al., 2001; Raichle et al., 2001). With focused thinking the frontoparietal network is more active (Blumenfeld, Parks, Yonelinas, & Ranganath, 2011; Curtis & D'Esposito, 2003).

When professional jazz pianists improvised, there was extensive activation of the default mode network (Limb & Braun, 2008). Improvisation involves idea generation and would be part of the incubation and illumination stages. However, the frontoparietal network became active when they edited the music that was created (de Manzano & Ullen, 2012). Research suggests that both the default mode network and the frontoparietal network are both involved in creativity thinking (Beaty, Benedek, Kaufman, & Silvia, 2015; Beaty et al., 2014; Bertolero & Bassett, 2019; Ellamil, Dobson, Beeman, & Christoff, 2012; Gonen-Yaacovi et al., 2013). The different networks are supporting different phases of the creative process (Beaty et al., 2015; Gonen-Yaacovi et al., 2013; Spreng, Sepulcre, Turner, Stevens, & Schacter, 2013)—the frontoparietal network controlling executive control during the preparation and verification stage, and the default mode network controlling free-moving associations during incubation and illumination. The four stages of creative thinking appear to involve the swing from cognitive control to transcendence and back again (Beaty et al., 2015; Spreng et al., 2013).

Brain Functioning and Creative Thinking

Activity in the default mode network has been associated with higher frontal alpha EEG coherence (F. Travis et al., 2010). Higher frontal alpha EEG coherence (Schwab, Benedek, Papousek, Weiss, & Fink, 2014) and higher brain connectivity are correlated with higher scores on standardized tests of creativity (Hearne, Mattingley, & Cocchi, 2016).

Coherence is a measure of brain connectivity. Specifically, coherence is the degree of association of the brain waves between two brain regions, representing their functional relationship over time (Bowyer, 2016). Researchers in Oxford compared levels of brain connectivity in 461 healthy participants with their scores on 280 different psychological and behavioral measures. Those with higher brain connectivity scored higher on measures typically deemed to be positive, such as vocabulary, memory, and life satisfaction. In contrast, those with lower brain connectivity exhibited high scores for traits typically considered negative, such as anger, rule-breaking, substance use, and poor sleep quality (Smith et al., 2015)

Brain Integration Scale

A Brain Integration Scale has been created, which is a composite of three brain measures calculated from brain waves recorded during complex tasks. The three measures include: frontal EEG coherence, a measure of brain connectivity, background EEG power, indicating inner orientation (alpha EEG) or outer orientation (gamma EEG), and levels of brain preparatory response during tasks, as(??) a measure of neural efficiency (F. T. Travis et al., 2002).

Brain Integration in Highly Successful People

Scores on the Brain Integration Scale in successful athletes, managers, and classical musicians give the practical significance of this style of brain functioning. Working in collaboration with the National Olympic Training Center in Norway, 33 athletes were selected who were placed among the top 10 in major global competitions (Olympic Games, world championships, and World Cup) for at least three different seasons. These were the World-Class athletes. Another thirty-three control athletes who competed were selected but they were in the lower 50% in championships. The two groups were matched for gender, age, and type of sport. The World-Class athletes scored higher on brain integration, faster speed of ignoring distractions and higher ego and moral reasoning (Harung et al., 2011).

Working with Manpower Norway, 20 Norwegian top-level managers were selected who: (1) were CEOs for 18 years on average, (2) acted as a good example for others, and (3) exemplified corporate social responsibility. Control managers were successful businessmen who had limited management responsibilities (e.g., project manager, senior engineer, and product manager) or were skilled knowledge workers (e.g., associate professor, senior consultant, and programmer). Subjects were matched for age, gender, level of education, and type of organization (private or public). The top-level managers scored higher on brain integration, higher moral reasoning and reported more incidences of good luck in business (Harung & Travis, 2012).

Working with the Oslo Philharmonic Orchestra, the Norwegian Opera in Oslo, and the Gothenburg Symphony Orchestra, 25 professional classical musicians were selected. The comparison group of 25 amateur classical musician were selected from amateur orchestras in Oslo and in Gothenburg. All musicians had been playing their instruments since they were children. In these two groups, all subjects had very high levels of brain integration—similar to the top athletes and top managers. However, the professional musicians, compared to the amateur musicians, scored higher on moral reasoning, three categories of peak experiences, a brain test of vigilance, and a measure of speed of mental processing (F. Travis, Harung, & Lagrosen, 2011).

Brain Integration and Creative Thinking

We have investigated the relationship of brain functioning and creative performance in 21 Swedish product-development engineers working in a company that develops and manufactures aircraft engines and stationary gas turbines (F. Travis & Lagrosen, 2014). They were investigated since creative output is a key factor for their job success.

EEG was measured during paired-reaction time tests to calculate brain integration during two event-related potential tasks to measure speed of processing and vigilance (Polich, 2007). Participants also completed the Stroop Color-Word test a standard measure of frontal executive functioning (Stroop, 1935), and Antonovsky's Orientation to Life questionnaire measuring psychological ''sense of coherence'' ((Antonovsky, 1993), p. 725). The Orientation to Life measure yields three factor: *comprehensibility* - the belief that things happen in an orderly and predictable fashion, *manageability* - the belief that you have the skills and the resources necessary to take care of things, and *meaningfulness* - the belief that life is meaningful, interesting, and a source of satisfaction. Subjects were also administered Gibbs Socio-Moral Reflection questionnaire. This instrument presents moral statements and asks subjects to describe why a moral act may be important to them (Gibbs et al., 1990). Performance on this measure is highly correlated with scores on Kohlberg's Moral Judgment Interview (Gibbs, Basinger, & Fuller, 1992).

To measure creativity, the engineers were administered the parallel lines test (figural creativity) and the alternative uses of a tin can test (verbal creativity) from Torrance test of Creativity Thinking. These tests resulted in three subscales—fluency, which is the ability to produce a large number of responses; flexibility, which is the ability to give responses from different categories; and originality, which is the ability to produce uncommon or unique responses. This test has extensive norms from over 55,600 people, and has very strong reliable and test–retest coefficients (Torrance, Treffinger, & Ball, 1987). The tests were scored according to guidelines in the Torrance Test of Creativity thinking manual.

This study used canonical correlation analysis to explore the relation among scores on the creativity tests and the psychological and physiological measures. Canonical correlation groups variables into two variates representing common variance among the variables in each variate. It then calculates the relation among those two variates.

The first canonical variate included figural and verbal flexibility and originality as the dependent measure and the second variate including: (a) higher scores on the brain integration scale, (b) faster speed of processing in an event-related potential task, (c) faster conflict-resolution during the Stroop task, (d) higher moral reasoning, and (e) higher manageability and lower comprehensibility as independent measures (F. Travis & Lagrosen, 2014). Flexibility and originality reflect the ability to see old situations in new ways leading to unique responses. Greater mental adaptability was associated with greater brain integration and speed of processing along with higher moral reasoning and feeling of being in control.

Brain Integration and Creative Thinking: Inferential Support

Our research has investigated the relation of brain integration and psychological constructs that are related to creative thinking such as personality factors (openness to experience, extraversion and emotional stability), inner/outer orientation and anxiety. Brain Integration was calculated in 51 subjects. Personality was measured by the International Personality Item Pool (IPIP) that measures: extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience (Goldberg, 1992). Inner/outer orientation was measured by Baruss's test of Material/Transcendental Worldview (Baruss & Moore, 1992). Anxiety was measured by the Spielberger's State/Trait Anxiety (STAI) that assesses both your immediate feelings of anxiety (state anxiety) and baseline levels of anxiety (trait anxiety).

Higher values on the Brain Integration Scale positively correlated with emotional stability, openness to experience, extraversion, and agreeableness, and an inner orientation to life, and negatively correlated with state and trait anxiety (F. Travis et al., 2004). These psychological characteristics are closely linked to creative thinking. Openness to experience is the mental state that allows new and novel solutions to arise; a more transcendental world view gives you a balanced state to consider different directions; and low anxiety allows you to play with ideas and possibilities and not be closed down due to fear or anxiety.

TRANSCENDING AND BRAIN INTEGRATION

Fifty-one college students were randomly assigned to learn the TM technique, or to wait till the end of the study. EEG was recorded at pretest, before they learned TM, and after practicing for ten weeks. All subjects also completed the Profile of Mood States, a standardized measure of emotional states at pretest and posttest. Compared to the delayed-start control group, the TM subjects significantly increased in brain integration. They also significantly increased on emotional and behavioral coping and vigor, and significantly decreased in total mood disturbance, anxiety, fatigue and stress reactivity (F. Travis et al., 2010; F. Travis et al., 2009). A similar study investigated effects of four month of TM practice in 96 central office administrators and staff, compared to random assignment controls. Again, brain integration significantly increased and Total Mood Disturbance, anxiety, anger, depression, fatigue, and confusion significantly decreased, and the scale of vigor significantly increased (F. Travis et al., 2018).

CONCLUSION

The World Economic Forum names creativity as one of the top-10 skills needed for workplace success. Creativity in the workplace most often involves upgrades in technologies or software, or new organizational lines to optimizing workflow. This is innovation from the outside. Adding the experience of transcending to enhance incubation of creative ideas is innovation from the inside. Training in transcending could be part of forward looking graduate programs to help their graduates thrive in an ever-changing workspace landscape. Brain Integration is a workplace skill that supports better performance in many professions. TM as a meditation designed for transcending could be a useful addition to any workplace culture to assist in the creative output of its employees.

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