Advancing Innovation and Sustainable Outcomes in International Graduate Education

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A volume in the Advances in Higher Education and Professional Development (AHEPD) Book Series

IGI Global
PUBLISHER of TIMELY KNOWLEDGE

Published in the United States of America by
IGI Global
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA, USA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Library of Congress Cataloging-in-Publication Data

Names: Gurubatham, Mohan Raj, editor. | Williams, Geoffrey Alan, editor.
Title: Advancing innovation and sustainable outcomes in international graduate education / Mohan Raj Gurubatham and Geoffrey Alan Williams, editors.
Description: Hershey, PA : Information Science Reference, 2021. | Includes bibliographical references and index. | Summary: “This book raises awareness of the global challenges posed by accelerating global drivers for graduate education in the 21st century. It also evaluates the impacts of the 4th Industrial Revolution and its impacts on skill sets and high value graduate education”-- Provided by publisher.
Identifiers: LCCN 2020009095 (print) | LCCN 2020009096 (ebook) | ISBN 9781799855149 (hardcover) | ISBN 9781799855156 (paperback) | ISBN 9781799855163 (ebook)
Subjects: LCSH: Universities and colleges--Graduate work. | Education, Higher--Aims and objectives. | Education and globalization.
Classification: LCC LB2371 .A35 2021 (print) | LCC LB2371 (ebook) | DDC 378.1/55--dc23
LC record available at https://lccn.loc.gov/2020009095
LC ebook record available at https://lccn.loc.gov/2020009096

This book is published in the IGI Global book series Advances in Higher Education and Professional Development (AHEPD) (ISSN: 2327-6983; eISSN: 2327-6991)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Chapter 11
Negative and Positive Mind-Wandering

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ABSTRACT

Mind-wandering is considered by many as a sign of an "unhappy mind" and associated with ill-health. Since the mind wanders half of the time, it is unlikely that mind-wandering plays no role in cognitive processing. Mind-wandering can be filled with negative thoughts - negative mind-wandering associated with worry and rumination; or it can be filled with positive thoughts - positive mind-wandering associated with imagination and fantasy, essential elements of a healthy, satisfying mental life. Mind-wandering with positive thoughts enables the mind to escape the constraints of the current situation and explore novel solutions.

NEGATIVE AND POSITIVE MIND-WANDERING

Is a wandering mind an unhappy mind, as an article in *Science* is entitled (Killingsworth and Gilbert, 2010)? Using an iphone app, Killingsworth and colleagues sent 2,250 adults a text randomly during the day that asked: "How are you feeling right now?", "What are you doing?" and "Is your mind on task or wandering?" In this study, participants reported that their mind wandered almost half the time (46.9%) regardless of the activity they were engaged in—except making love. And the majority of the time their mind-wandering was filled with positive thoughts.

DOI: 10.4018/978-1-7998-5514-9.ch011

Is Mind-Wandering Dysfunctional?

Two categories of mind-wandering involve negative content: *guilty-dysphoric daydreaming*, characterized by ruminating thoughts and unpleasant emotions that drive depression, and *poor attentional control* as in difficulty in focusing one's attention (Antrobus et al., 1970; Singer, 1975). These two categories of negative mind-wandering represent the failure of the executive-control system to deal with the interference of automatically generated thoughts in response to environmental and mental cues (McVay and Kane, 2010).

High levels of negative mind-wandering have been associated with rumination in clinically depressed individuals (Burkhouse et al., 2016){Burkhouse, 2016 #148;Burkhouse, 2016 #197}, increased frequency of false alarms in memory retrieval tasks (Smallwood et al., 2003), poorer performance in sustained attention tasks (Mrazek et al., 2012), reduced working memory capacity (Kane et al., 2007), slower reading times (Foulsham et al., 2013) and reduced comprehension of difficult texts (Feng et al., 2013). Moreover, negative mind-wandering has been associated with poorer performance on time estimation tasks (Terhune et al., 2017) and on measures of fluid intelligence and working memory (Mrazek et al., 2012).

On the Other Hand

Another category of mind-wandering can be termed positive mind-wandering. This is p*ositive-constructive daydreaming,* which is dominated by curiosity and future planning, essential elements of mental and physical health (Smallwood and Schooler, 2015). Previous studies that reported a relationship between mind-wandering and depression combined positive mind-wandering, rumination, and worry under the single term "repetitive thinking" (Vess et al., 2016; Hobbiss et al., 2019). This composite variable was related to negative mental and physical health.

However, the negative effects of "mind-wandering" vanish when negative mind-wandering (perseverative cognition) is differentiated from positive mind-wandering. Seventy-three healthy subjects were interviewed about a neutral and a personally-relevant negative event. After the interview they were administered a 20-min tracking task with thought-probes to assess mind-wandering (Ottaviani et al., 2013). Electrocardiogram was continuously recorded during the tracking task to calculate heart rate variability. Perseverative cognition was associated with higher levels of cognitive inflexibility (slower reaction times, higher levels of intrusiveness), autonomic rigidity (lower heart rate variability), and worsening mood (more symptoms of depression) compared to positive mind-wandering (Ottaviani et al., 2013). Another study also separated positive and negative mind-wandering and found no relationship between positive mind-wandering and depression symptoms cross-sectionally at

baseline or one-year longitudinally within subjects (Ottaviani & Couyoumdjian, 2013). These findings highlight the need to differentiate positive mind-wandering—future-oriented mind-wandering associated with auto- biographical planning (Baird et al., 2011; Smallwood et al., 2011) from negative mind-wandering—future worrisome thoughts (Brosschot et al., 2007).

Positive Mind-Wandering

Positive mind-wandering allows attentional cycling between personally meaningful values and external goals (Baird et al., 2012). The content of positive mind-wandering is predominantly future-focused, autobiographical planning (Stawarczyk et al., 2011) oriented toward personal goal resolution (Baird et al., 2011; Smallwood et al., 2011). Singer in the 1960's included positive mind-wandering with imagination and fantasy as essential elements of a healthy, satisfying mental life (Singer, 1966; Antrobus et al., 1970). Higher levels of positive mind-wandering were seen in children who were able to wait longer in a delayed gratification task (Singer, 1961) and may aid individuals in optimizing task performance (Allen et al., 2013).

Schooler and colleagues (2011) suggested that positive mind-wandering serves four broad adaptive functions: (1) *Future planning* - enhanced by self-reflection and attenuated by unhappiness and worry; (2) *creativity* - specifically incubation and problem solving; (3) *attentional cycling* - oscillating between personally meaningful and external goals; and (4) *dishabituation* - enhancing learning by providing short breaks from external tasks. Positive mind-wandering supports attention switching between self-generated perspectives and external task-related thought that supports high working memory capacity and metacognitive monitoring capacity. (Baird et al., 2011).

Mind-Wandering and Creativity

The incubation phase of creative problem solving, which is the heart of the creative process, is characterized by task-unrelated or stimulus-independent thinking—allowing the mind to sub-consciously play with ideas (Christoff et al., 2016). Being temporarily lost in a free association stream of thought, having lost track of time, place and the current task, has been termed "*positive constructive day dreaming*" by early researchers (Singer, 1975). This state is characterized by playful, wishful imagery (McMillan et al., 2013). This is positive mind-wandering, which has the capacity to mentally escape from the constraints of the present to manage personal goals that extend beyond the current moment and to explore new angles on old situations (Baird et al., 2011;Smallwood and Schooler, 2015).

High levels of positive mind-wandering are associated with higher creativity and higher general intelligence. Subjects were administered the Mind Wandering Questionnaire which presents sentences like: "I have difficulty concentrating on simple or repetitive tasks" or "I do things without paying full attention." Students responded on a 6-point Likert scale to these questions. Higher scores on this questionnaire were significantly related to higher scores on a test of creativity (Remote Associates Task) and fluid intelligence (Ravens Progressive Matrices) (Godwin et al., 2017). Other research reports that positive mind-wandering supports problem solving when approaching problems with insight, but for problems requiring rational analysis mind-wandering decreased performance (Zedelius and Schooler, 2015).

BRAIN FUNCTIONING ASSOCIATED WITH MIND-WANDERING

The brain networks underlying mind-wandering have been identified from two angles. One angle compares control and experimental conditions in neural imaging studies. The other compares neural imaging patterns when processing external environmental stimuli and internal thoughts.

Mind-Wandering and the Brain: Subtracting fMRI Images During Control and Experimental Conditions

Hemoglobin in the blood acts differently in a magnetic field when it is oxygenated than when it is not oxygenated. Using this physiological fact, functional MRI (fMRI) calculates different oxygen levels to identify brain areas involved in tasks. This difference is very small, around 3-5%.

To identify these local areas of activation, fMRI analysis subtracts blood flow patterns during a control task from those during a task condition. This subtraction process removes background brain activity and so highlights small increases due to task processing (Raichle, 1998). For instance, if you were interested in brain areas involved in generating verbs, you could record blood flow patterns while subjects read a list of nouns and then when they read the same list and generated verbs connected to those nouns. By subtracting blood flow patterns when reading the words, from blood flow patterns when reading the words and generating verbs, you can identify brain areas involved in generating verbs (Fox and Raichle, 1986).

Using this protocol, Raichle and colleagues noticed that patterns of decreased blood flow were seen in the back of the brain (medial and lateral parietal cortices) and front of the brain (medial prefrontal cortex) during different goal-oriented tasks compared to simple eyes closed and at rest. Raichle asked why would similar decreases in blood flow be seen during different tasks? He reasoned that the resting

brain is not inactive. Rather, there may be intrinsic activity when at rest that would decrease during a task—leading to decreases when subtracting the two conditions (Raichle et al., 2001; Raichle, 2015). This brain network was called the *default mode network* since it is active when individuals are resting and not engaged in a task.

The default mode network is more active during passive rest as compared to a wide range of active tasks and may serve to consolidate the past and prepare us for the future (Buckner and Vincent, 2007). *Default mode network* activation is lower during goal-directed behaviors requiring executive control (Gusnard et al., 2001; Raichle and Snyder, 2007) and higher during self-referential mental activity, when envisioning the future and when envisioning the actions of others (Buckner and Carroll, 2007).

Mind-Wandering and the Brain: Intrinsic and Extrinsic Networks

Another angle of research identified two distinct networks that are active when we process ongoing experiences—one involved processing of external input (task-positive network), the other involved processing of internal states (task-negative network). These networks were anti-correlated—when one was high the other was low. These networks were identified from fMRI neural images of subjects watching a 16-min segment from the western "The Good, the Bad, and the Ugly." All subjects watched the same segment two times (Golland et al., 2007).

In this study, blood flow patterns were seen correlated with each other and also correlated across the two movie clips. This was called an *extrinsic network*, which is involved in stimulus-driven activity and includes areas in the front and back of the brain (dorsal lateral frontal and later parietal cortices) that are active during goal-directed behavior.

The second system was highly correlated within itself but not correlated between the two videos. This network supports internally oriented mental processes and was called an *intrinsic network*. The intrinsic network included the cortical areas in the front and back of the brain that Raichle later identified in the default mode network (Raichle, 2015). The intrinsic and extrinsic networks include major areas in the front and back of the brain that do not overlap (Golland et al., 2007).

Mind-Wandering: Functional Integration of Default Mode (DMN), Frontoparietal (FPN) and the Doral Attention (DAN) Networks

A meta-analysis of 24 functional neuroimaging studies identified the interaction of three brain circuits important for generating conscious experience. The default

mode network (DMN) (internally-directed or task-negative network), the dorsal attention network (DAN) (externally-directed or task-positive network system processing objects in the environment) and a third network, the frontoparietal network (FPN) that switches between the inner directed DMN and the outer directed DAN (Christoff et al., 2016;Godwin et al., 2017). The DMN and DAN networks share a reciprocal relationship—when one is high the other is low (Huang et al., 2020). In contrast, the FPN has high levels of interconnectivity with both the DMN and the DAN, reciprocally turning one on and the other off many times a minute (Spreng et al., 2013).

Higher connectivity between the DMN and FPN are associated with mind-wandering and higher fluid intelligence (Ravens) and creativity (Remote Associates task). The FPN may balance activity between intrinsic and extrinsic networks to support adaptive cognition (Mrazek et al., 2012) as well as guide positive mind wandering such as prospective thought and autobiographical planning (Smallwood et al., 2012;Christoff et al., 2016), In general, the positive correlations between trait mind-wandering, fluid intelligence, and creativity suggest that positive mind-wander may facilitate attention moving from the details of the task at hand to broader associations that could bridge previously unrelated concepts (Baird et al., 2012;Godwin et al., 2017).

MIND-WANDERING AND MEDITATION PRACTICES

The brain naturally oscillates on average of 20 sec between predominance of activity in the intrinsic network and predominance of activity in the extrinsic network (Vanhaudenhuyse et al., 2011). In this light, it is interesting that meditation practices have been developed that either restrict mind-wandering or work with mind-wandering.

Meditation Practices That Restrict Mind-Wandering

Meditations in the Buddhist tradition have been developed to restrict mind-wandering. These meditations have been divided into two categories: *Focused Attention* and *Open Monitoring* (Lutz et al., 2008). Meditations in the *Focused Attention* category keep the mind from wandering by focusing on one object of experience and bringing the attention back to that object whenever the mind wanders. For instance, focusing on the rising and falling of the abdomen due to natural breathing during Vipassana meditation results in this physiological process completely filling awareness. One is not aware of the rest of the body, the environment, the discursive intellect or even the individual ego experiencing the process (Delorme and Brandmeyer, 2019). When the rising and falling of the abdomen fills awareness, the mind is still, but

it is an object-referral experience (Travis et al., 2004). In terms of an analogy, the sun reflects on all objects around us. Object-referral awareness ignores the sun and holds onto one reflection and tries to not let it go.

Meditations in the *Open Monitoring* category, such as mindfulness practices, aim to foster greater attention to and awareness of present moment experience, maintaining a non-judgmental attitude (Kabat-Zinn, 2003). By analogy, in mindful practices you keep the sun focused on one channel of experience—the body, thoughts, emotions, the breath—and note the objects that move in and out of awareness without judging or trying "fix" them. In terms of the sun analogy, again you miss the sun. Your awareness is filled with each changing reflection.

Meditations in the Buddhist tradition are successful in restricting negative and positive mind-wandering. Mindfulness practices significantly reduce self-reported mind wandering in experienced practitioners (Brandmeyer and Delorme, 2018) and lead to decreased activity in the default mode network, a brain marker of decreased mind-wandering (Brewer et al., 2011; Garrison et al., 2015).

Restricting mind-wandering—especially negative mind-wandering—has a practical value: it reduces perseverative thought such as rumination and worry. In a random assignment study of 35 college students, higher trait mindfulness was associated with higher alpha asymmetry, a brain measure of positive mood, lower rumination and behavioral adaption (Keune et al., 2012). In recurrently depressed patients, mindfulness practices led to higher frontal asymmetry during the practice and reduced reactivity in a "rumination challenge" (Bostanov et al., 2012; Keune et al., 2013).

However, mindfulness practices may be maladaptive when the practice restricts positive mind-wandering. Mindfulness practices reduce creative problem solving when the best approach to solve the problems is with insight (Zedelius and Schooler, 2015). (It is interesting that mindfulness practices improved performance when the task needed analysis.) Mindfulness practices also reduce implicit learning, i.e. gaining knowledge from experiences that were not relevant for the intended goal (Stillman et al., 2014). For instance, in this research subjects responded to a series of green and red dots. A green dot always followed two successive red dots. The mindfulness subjects did not notice this pattern and so their reaction time was slower.

Mindfulness practice led to increased false memories in an association word-list paradigm. In this paradigm, subjects studied a list of words at baseline. Some of the words on the list were strongly associated to words not on the list, such as *Trees* and *Green* were on the list and *Forest* was not. After five weeks of mindfulness training compared to no-treatment controls, subjects in both groups recalled equal number of words that were actually presented. However, the mindfulness group reported significantly more induced false memories—items that had high association to words on the list but were not actually on the list (Wilson et al., 2015; Rosenstreich, 2016).

Mindfulness practices also led to reduced moral intention, perhaps from maintaining a non-judgmental attitude during their practice. Subjects assessed a scenario in which one person harmed another. Subjects randomly assigned to mindfulness practice showed significantly lower intention to repair a situation in which their friend was harmed, and significantly lower intention to change harmful eating habits (Schindler et al., 2019).

MEDITATION PRACTICES THAT USE POSITIVE MIND WANDERING

Rather than restricting the inherent nature of the mind to wander, meditations in the *Automatic Self-Transcending* category use this natural tendency to take the mind to a state of no thought (Travis and Shear, 2010). This state of no thought is called pure consciousness, inner wakefulness without mental activity (Maharishi Mahesh Yogi, 1969; Travis and Pearson, 2000). In terms of the sun and reflection analogy, these meditations turn the attention within to experience the sun that is the basis of all reflections. Meditations from the Yoga tradition such as Transcendental Meditation are in this category.

The movement of the mind during Transcendental Meditation is not under cognitive control. Rather, the attention is pulled by the inherent pleasure of the experience of silent, expanded levels of inner self-awareness, pure consciousness (Maharishi Mahesh Yogi, 1969; Travis and Parim, 2017; Mahone et al., 2018). The lack of control during Transcendental Meditation is supported by higher default mode network activity during the practice (Travis and Parim, 2017), and by the finding that individuals quickly master Transcendental Meditation practice (Travis et al., 2002; Travis and Arenander, 2006).

Can Positive Mind-Wandering be Cultivated?

Using the natural tendency of the mind to wander during TM practice, positive mind-wandering could be made more available after the practice, particularly fostering access to the incubation stage of creativity problem solving. Torrance describes the incubation stage as transcending the boundaries of sequential, controlled rational thinking and experiencing a silent awake state of inner awareness (Torrance and Hall, 1979). Pure consciousness is similarly described as a state of wakefulness free from the processes and contents of knowing (Maharishi Mahesh Yogi, 1969; Travis and Pearson, 2000). The "content" of pure consciousness is self-awareness. It is the source of thought and the source of creative impulses. Functioning from

pure consciousness would enable the individual to transcend the limits of rational linear analysis and explore ideas that are not yet fully formed.

Controlled research supports this inference. Three-months of Transcendental Meditation practice led to higher levels of figural and verbal originality in Torrance tests of creativity (Travis, 1979), and higher scores on the Unusual Uses test (Orme-Johnson and Haynes, 1981; Jedrczak et al., 1985). Also, one year of TM practice led to significant increases in fluid intelligence in a matched design (Cranson et al., 1991), and improvements on six measures associated with intelligence in a random assignment study (So and Orme-Johnson, 2001).

CONCLUSION

The mind wanders half the time. Thus, it seems likely that mind-wandering plays a significant role in cognitive processing. Mind-wandering is a complex concept: the mind can wander with negative thoughts (negative mind-wandering) or with positive thoughts (positive mind-wandering).

Meditation procedures that restrict negative mind-wandering can be useful and can lead to enhanced mental and physical health. However, these procedures also restrict positive mind-wandering, which could deprive a student of the opportunity for personal reflection and making meaning of their experiences (McMillan et al., 2013).

Meditation procedures that use the mind's inherent tendency to wander can take the mind to a state of mental quietness, alertness and playfulness, or pure consciousness, allowing the student to explore ideas that are not yet fully formed enhancing creative behavior and problem solving.

The key to optimal problem solving is a flexible mind that can explore ideas (intrinsic network) and when necessary focus on the immediate sensory boundaries (extrinsic network). Educational researchers advocate practices that promote effective balance between external attention and internal reflection (positive mind-wandering). This dynamic balance helps growth of socio-emotional skills such as compassion, understanding the perspective and emotional state of other people, and deriving meaning from their experiences (Immordino-Yang et al., 2012). Meditations that support positive mind-wandering such as Transcendental Meditation may be useful tools for education.

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