



SAPIENZA
UNIVERSITÀ DI ROMA

Mindfulness Oriented Meditation for adults and children: effects on stress and anxiety and links with creativity and psychological well-being.

Facoltà di Medicina e Psicologia - Dipartimento di Psicologia

International PhD programme in Psychology and Social Neuroscience

Curriculum in Cognitive Social and Affective Neuroscience - CoSAN

Viviana Capurso

n° matricola 1590911

Supervisore dr. Cristiano Crescentini

29°Ciclo

INTRODUCTION

STUDY 1: Psychological and physiological responses to stressful situations in immersive virtual reality: Differences between users who practice mindfulness meditation and controls

Abstract

Introduction

1. Materials and methods

2. Participants

3. Mindfulness oriented meditation training (MOM)

4. Questionnaires and IVE tasks

- Questionnaires
- Immersive virtual environments
- Low-stress school building
- High-stress school building
- Low-stress train station.
- High-stress train station.

5. Physiological measures

- Heart rate and blood volume pulse amplitude.
- Facial electromyography.
- Respiratory frequency
- Skin conductance level

6. Experimental procedure

7. Data analysis

8. Results

- Low-stress and high-stress IVEs: analyses of STAI-S and stress VAS
- Dispositional mindfulness and STAI (trait and state) data
- Analysis of physiological data
- Heart rate and blood volume pulse amplitude

- Facial electromyography
- Respiration frequency
- Skin conductance level

Discussion

STUDY 2: Mindfulness-oriented meditation for primary school children: Effects on attention and psychological well-being.

1. Abstract
2. Introduction
3. Method
4. Participant and setting
5. Assessment measures
6. Statistical methods
7. Results
 - Teacher's report: Child Behavior Checklist – Teacher Report Form (CBCL-TRF)
 - Teacher's report: Conners teacher parent scale revised (CTRS-R)
 - Children's self-report: Short Mood and Feelings Questionnaire (SMFQ)

Discussion

STUDY 3: Mindful creativity: the influence of mindfulness meditation on creative thinking

1. Introduction
2. A commentary on “Meditate to create: the impact of focused-attention and open-monitoring training on convergent and divergent thinking” (Colzato, L. S., Ozturk A., & Hommel (2012). *Frontiers in Psychology*, 3:116)
3. Limitations and future directions

STUDY 4: Mindfulness meditation and creativity

Abstract

Introduction

1. Sources of creativity
2. Mindfulness meditation and Mindfulness skills
3. Mindfulness meditation: Main clinical applications
4. Mindfulness meditation: main cognitive effects
5. Mindfulness meditation, trait mindfulness and creativity
6. Limitations and directions for future research

DISCUSSION AND FUTURE DIRECTIONS

INTRODUCTION

Mindfulness meditation: a definition

In the last 30 years, mindfulness has become the focus of considerable attention for clinicians and empirical psychology. This attitude can be cultivated through mindfulness meditation (MM), a traditional form of Buddhist meditation where the practitioner tries to be attentive to and fully aware of present moment experience with a gentle and non-judgmental attitude (Kabat-Zinn, 1994). The technique originates from Buddhist spiritual practices and was developed as a path leading to the cessation of personal suffering (Thera, 1962; Silananda, 1990) and to the growth of the personal well-being (Germer, Siegel, & Fulton, 2005). The word mindfulness originally comes from the Pali word “sati”, which means having awareness, attention, and remembering (Bodhi, 2000). Mindfulness in contemporary psychology has been adopted as an approach for increasing awareness and responding skillfully to mental processes that could potentially contribute to emotional distress and maladaptive behavior.

Mindful awareness is a state where thoughts and feelings are observed without identifying with them and without automatically reacting to them (Bishop et al., 2004). Constant MM practice may lead to long-lasting changes in trait mindfulness, which reflects the disposition to persist in mindful states over time beyond meditation practice (Crescentini & Capurso, 2015). Thus, mindfulness has state-like as well as trait-like qualities (Brown & Ryan, 2003), and can be described as a skill or a set of skills, which can be improved by meditative practice (Bishop et al., 2004).

Mindfulness practices create a heightened but detached awareness of sensory and thought experience thus helping avoiding unconscious, habitual and automatic patterns. The action seems to be not on the mind's content, by changing it, but rather on our identification with these contents. The idea, in fact, is to replace our habitual patterns with a “seeing” that is more accepting, intuitive, and immediate (Didonna, 2009).

Understanding the therapeutic value of these processes may represent a particularly important integration of Eastern and Western psychologies (Walsh, 1996). The mechanisms of change that builds the basis of mindfulness meditation can be found in most Western

psychotherapeutic perspectives as, for example, the importance of personal, the capacity of the person to heal itself (Didonna, 2009). Western psychotherapies therapy fit perfectly with its Eastern components. This role can give a complementary perspective with regard to some issues of modern psychology: the possibility to cultivate mental health, the nature of the mind, and, most of all, the tools and methods needed to allow the mind to change itself.

The construct of mindfulness: how to measure mindfulness

The abovementioned construct of mindfulness has been examined through different self-report measures (i.e., questionnaires), which have considered mindfulness as a unidimensional construct (Brown & Ryan, 2003), or, more recently, as a multi-faceted concept (Baer Smith, Hopkins, Krietemeyer, & Toney, 2006).

The first scale measuring mindfulness as a single construct is the Freiburg Mindfulness Inventory (FMI; Buchheld, Grossman, & Walach, 2001), a 30-item instrument assessing mindfulness through non-judgmental, present-moment observation and openness to negative experience. The distinctive characteristic of this scale is that it is designed for use by experienced meditators. A more recent measure has been argued to be suitable for assessing trait mindfulness in both expert meditators and non-meditators. The Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003) is a 15-item scale measuring the general tendency to be attentive to and aware of present moment experience in everyday life. The mindfulness skill is here considered as having a single-factor structure, and individuals have to rate how often they experience acting on automatic pilot and not paying attention to present moment on a 6-point Likert scale. The Kentucky Inventory of Mindfulness Skills (KIMS; Baer, Smith, & Allen, 2004) is a 39-item instrument that examines mindfulness as a complex and multi-faceted construct. It is designed to measure four mindfulness skills: observing, describing, acting with awareness, and accepting without judgment present moment experience. The KIMS measures a general tendency to be mindful in daily life and does not require experience with meditation (Baer, Smith, & Allen, 2004). Shortly thereafter, from the KIMS, the same group of researchers developed a scale that considers mindfulness as a five-facet construct, namely the Five Facet

Mindfulness Questionnaire (FFMQ, Baer, Smith, Hopkins, Krietemeyer & Toney, 2006). Besides the four facets included in the KIMS, the FFMQ also involves a facet from the FMI scale, namely non-reactiveness.

Mindfulness Meditation: Main Clinical Applications

A large body of research has documented, in these years, the beneficial effects of MM on physical and psychological well-being (Chiesa & Serretti, 2010). Owing to the success of the specific method ideated by John Kabat-Zinn, the Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982), this practice has revealed positive effects in many different contexts. The mindfulness-based treatment program was originally developed for the management of chronic pain (Bishop et al., 2004; Kabat-Zinn, Lipworth, & Burney, 1985). Since then, the MBSR has been widely used to reduce psychological distress associated with chronic illnesses and to treat a wide range of psychological and behavioral disorders (Didonna, 2009). Starting from the MBSR, many different programs based on MM have been developed such as the Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale 2002); the Mindfulness-Based Relapse Prevention (MBRP; Bowen et al., 2009); the Acceptance and Commitment Therapy (ACT; Hayes, Follette & Linehan, 2004) and the Mindfulness-Based Eating Awareness Training (MB-EAT; Kristeller & Wolever, 2011). Recently, another method based on the original MBSR protocol has been proposed and has proved its beneficial effects, namely the mindfulness-oriented meditation (MOM) (Campanella, Crescentini, Urgesi, & Fabbro, 2014; Crescentini, Matiz, & Fabbro, 2015; Crescentini, Urgesi, Campanella, Eleopra, & Fabbro, 2014; Fabbro & Crescentini, 2015; Fabbro & Muratori, 2012).

In general, the method adopted in the above mentioned MM interventions consists of an 8-week group-based treatment that includes didactic mindfulness training, in-session practice, group discussion, and home formal practice. During meditation exercises, participants try to non-judgmentally observe all bodily sensations and thoughts, bringing back attention to the meditation task when it wanders. The practitioner thus aims to merge a focused attention component with an open monitoring attitude when trying to intentionally

pay attention to present-moment experience (Bishop et al., 2004; Brown & Ryan, 2003; Crescentini & Capurso, 2015).

In the first years after the standardization of the MBSR method, the majority of research has focused on clinical samples to evaluate the efficacy of mindfulness-based interventions. This line of research has primarily addressed the question of efficacy on a variety of clinical conditions such as substance-use disorders, obsessive compulsive disorder, eating disorders, generalized anxiety, depression, and attention deficit/hyperactivity disorder (ADHD) (Didonna, 2009; Greenberg; Reiner & Meiran, 2012; Hölzel et al., 2011).

In particular during these years research on psychophysical effects of MM has found that it helps alleviate anxiety and depression symptoms (Shapiro et al., 1998), decreases stress, rumination, and negative affect (Shapiro et al., 2007), decreases total mood disturbance, including stress, anxiety and fatigue (Rosenzweig, Reibel, Greeson, Brainard, & Hojat, 2003) reduces anger, and stress-related cortisol and increases immunoreactivity (Tang et al., 2007). Waelde et al. (2008) assessed changes in symptoms of depression, anxiety, and posttraumatic stress while Chiesa and Serretti, in their review, underline the positive results of studies about psychological symptoms in cancer, heart disease, chronic pain, and fibromyalgia (Chiesa & Serretti, 2010). This suggests that MM is an effective intervention for the treatment of both psychological and physical symptoms connected to clinical conditions.

Mindfulness Meditation: Main Cognitive Effects

A complementary perspective on MM is concerned with neurocognitive and emotional changes resulting from mindfulness practice. In this case meditation is conceptualized in terms of a mental or cognitive training procedure (Moore & Malinowski, 2009). This additional line of research has investigated the possible applications of mindfulness in clinical and non-clinical samples and results in this field are, likewise, positive. Several findings suggest that MM may lead to better executive functioning and attention regulation abilities (Jha, Krompinger, & Baime, 2007; Lutz, Slagter, & Dunne, 2008; Moore & Malinowski, 2009), better emotion regulation (Arch & Craske, 2006; Chambers, Lo &

Allen, 2009), and positive changes in personality and self awareness (Tang, Hölzel & Posner, 2015) and character (Campanella et al., 2014; Crescentini et al., 2015).

Accordingly, in two recent neuroscience reviews, MM has been defined as a form of attentional training involving in particular the parietal and frontal attentional systems of the brain (Cahn & Polich, 2006; Malinowski, 2013). With regard to behavioral studies linking MM and attention/executive function, Jha and colleagues have demonstrated that experienced meditators have better performance on executive attention tasks when compared with nonmeditators (Jha, Krompinger, & Baime, 2007). This was indicated by smaller error scores and lower reaction times in the Attention Network Test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002), a well-known task used to measure attention functions. Moreover, MM-related improvements in behavioral measures of sustained attention and selective attention have been underlined in the review by Lutz and colleagues (Lutz, Slagter, & Dunne, 2008). Furthermore, a lower Stroop interference effect has been found in experienced meditators compared with controls (Moore & Malinowski, 2009), while decreased interference in inhibitory tasks has been documented in meditators undertaking an MBCT training (Heeren, Van Broeck, & Philippot, 2009). Notably, changes in attentional processing are evident not only in experienced meditators but also in novices undergoing short meditation trainings (Ding et al., 2014; Ren et al., 2011; Tang et al., 2007). These studies thus show that the ability to openly experience the here and now leads to improvements in attentional functions, with this having important consequences for effective self-regulation and well-being.

Mechanisms of action

A number of studies have recently tried to identify a key set of mechanisms of action through which MM may exert its beneficial health effects. In particular Hölzel and colleagues (2011) have identified four interrelated critical components of mindfulness, namely attentional control, emotion regulation, body awareness, and change in the perspective on the self. Among these factors, attention regulation is considered a fundamental prerequisite for the development of the other mechanisms of action and mindfulness skills. In fact during focused attention meditation, the practitioner concentrates

on the meditative object trying to maintain the focus of attention on a pursued object, and letting go distractions (e.g. memories or thoughts; Hölzel, 2010). This conflict monitoring, or executive attention, typically improves in meditators with effects measured in executive attention tasks (see above Jha, Krompinger, & Baime, 2007).

Aside from the documented improvements in executive attention, there are changings in body awareness. Typically meditators, during mindfulness practice, pay attention to many sensory experiences about breath, different body parts and pain. The practitioner is required to accept the experience without any form of judgment and can, this way, learn a better perception of these physical sensations (Mehling et al., 2009). This results in an enhanced awareness of bodily states and greater perceptual clarity of subtle interoception (Hölzel, 2010) and is proved through neuroscientific studies that underlie changes in the function and structure of brain regions related (Craig, 2003; Lazar et al., 2005; Hölzel et al., 2008).

MM also acts on emotion regulation, namely the alteration of ongoing emotional responses through the action of regulatory processes (Ochsner & Gross, 2005). This has a great importance since a variety of psychological disorders are associated with reduced emotion regulation capacity. In particular, mindful emotion regulation has been described as “positive reappraisal,” or the adaptive process through which stressful events are reconsidered as beneficial or meaningful (Garland, Gaylord, & Fredrickson, 2011). Practitioners expose themselves to whatever is present in the field of awareness, avoiding from engaging in internal reactivity toward it, and instead bringing acceptance to their responses (Hart, 1987). Thus unpleasant emotions, such as fear, sadness, or anger, become simple sensations to face, by turning towards them, rather than avoiding them (Santorelli, 2000). A better emotion regulation of meditators has been proved in years through self-reported questionnaire but also through many neuroscientific studies showing changes in brain areas involved in fear, fear responses, and anxiety disorders (Holzel, 2010).

Finally MM has proved its effects on self awareness (Crescentini & Capurso, 2014). All experiences are observed as they arise and pass, this allowing the meditator to experience that the contents of consciousness are in constant change and thus are transient. This causes a disidentification from the static sense of self, that is evident, at an explicit level, in self-report measures of personality. But deeper changes happen, in practitioners, at an implicit

level and the latter is considered more difficult to transform since it reflects more stable and older evaluative representations that have their origins in long-term personal experiences (Crescentini & Capurso, 2014). To sum up this practice fulfills important self-regulatory functions, by letting intuitive self-attitudes to be more easily integrated into explicit self-attitudes, and contributing to a more coherent self-image. In general it is possible to say that operating on aspects such as sense of responsibility, authenticity, compassion, and self-acceptance, toward a more coherent and healthy sense of self and identity, MM is able to change the perspective on the self.

The next studies are meant to give a general overview on the effects of MM and its different applications. In particular we will see changings operated by mindfulness skills in two different contexts with adults and children of primary schools involved in MM trainings. The first study (“Psychological and physiological responses to stressful situations in immersive virtual reality: Differences between users who practice mindfulness meditation and controls”) investigates the effects of an 8-week mindfulness-oriented meditation (MOM) program on personnel from an Italian Hospital verifying the psychological and physiological responses evoked by immersive virtual environments (IVEs) that simulated emergency situations. The second study (Mindfulness-oriented meditation for primary school children: Effects on attention and psychological well-being) tests the effects of a mindfulness-meditation training on a group of healthy school children aged 7–8 years and demonstrates positive improvements in executive functions and general well-being.

The following commentaries (“Mindful creativity: the influence of mindfulness meditation on creative thinking” and “Mindfulness meditation and creativity”) aims at giving a new perspective in an emerging field among the various and different applications of MM. Overall the studies and reviews presented represent a small sample in literature but their results point to the feasibility and utility of interventions based on mindfulness meditation in different contexts b) showing positive influences adults and children’s general psychological well-being.

The strong relation between MM and creativity and the positive effects that both exerts on psycho-physical well-being suggest a new research line that could compare the effects of MM with creative activities (creative writing and painting for instance). Further studies could try to create a standardized model of creative activities training to better understand which is the role of personality and mood in MM and creativity, and which is the key component, if there is one, that makes the difference on personal well-being in this comparison.

REFERENCE

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: emotion regulation following a focused breathing induction. *Behavior Research and Therapy*, 44(12), 1849–1858.

Baer, R. A., Smith, G. T., & Allen, K. B. (2004). Assessment of mindfulness by self-report. *Assessment*, 11(3), 191–206.

Baer, R.A., Smith, G.T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment*, 13, 27–45.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., . . . Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology-Science and Practice*, 11, 230-241.

Bodhi, B. (1993). *A comprehensive manual of Abhidhamma*. Kandy, Sri Lanka: Buddhist Publication Society.

Brown, K.W., & Ryan, R.M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, 84, 822–848.

Buchheld, N., Grossman, P., & Walach, H. (2001). Measuring mindfulness in insight meditation (Vipassana) and meditation-based psychotherapy: The development of the Freiburg Mindfulness Inventory (FMI). *Journal for Meditation and Meditation Research*, 1, 11–34.

Cahn, B.R. & Polich, J. Meditation states and traits: EEG, ERP, and neuroimaging studies. *Psychological Bulletin*, 132, 180–211 (2006).

Chambers, R., Gullone, E., & Allen, N. B. (2009). Mindful emotion regulation: An integrative review. *Clinical Psychology Review*, 29, 560-572.

Chiesa, A., & Serretti, A. (2010). A systematic review of neurobiological and clinical features of mindfulness meditations. *Psychological Medicine*, 40(8), 1239–1252.

Campanella, F., Crescentini, C., Urgesi, C., & Fabbro, F. (2014). Mindfulness-oriented meditation improves self-related character scales in healthy individuals. *Comprehensive Psychiatry*, 55, 1269-1278.

Craig, A.D. (2003). Interoception: The sense of the physiological condition of the body. *Current Opinion in Neurobiology*, 13, 500–505.

Crescentini, C., Urgesi, C., Campanella, F., Eleopra, R., & Fabbro, F. (2014b). Effects of an 8-week meditation program on the implicit and explicit self-referential religious/spiritual representations. *Consciousness and Cognition*, 30, 266-280.

Crescentini, C., Matiz, A., & Fabbro, F. (2015). Improving personality/character traits in individuals with alcohol dependence: the influence of mindfulness-oriented meditation. *Journal of Addictive Diseases*, doi:10.1080/10550887.2014.991657

Crescentini, C. & Capurso, V., (2015) Mindfulness meditation and explicit and implicit indicators of personality and self-concept changes, *Frontiers in Psychology*, 6:44. doi:10.3389/fpsyg.2015.00044.

Ding, X., Tang, Y. Y., Tang, R., & Posner, M. I. (2014). Improving creativity performance by short-term meditation. *Behavioral and Brain Functions*, 10:9.

Didonna, F. (Ed.). (2009). *Clinical Book of Mindfulness*. (F. Didonna, Ed.). New York: Springer.

Fabbro, F., & Muratori, F. (2012). La mindfulness: Un nuovo approccio psicoterapeutico in età evolutiva [Mindfulness: A new psychotherapeutic approach for children]. *Giornale di Neuropsichiatria dell'Età Evolutiva*, 32, 248–259.

Fabbro, F., & Crescentini, C. (2015). Coscienza e meditazione mindfulness [Consciousness and mindfulness meditation]. In E., Casiglia (Ed.), *Trattato d'ipnosi e altre*

modificazioni di coscienza (pp. 917–826) [*Essay on hypnosis and other alterations of consciousness*]. Padova, Italy: Cleup.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, 14(3), 340–347.

Garland, E.L., Gaylord, S.A., & Fredrickson, B.L. (2011). Positive reappraisal mediates the stress-reductive effects of mindfulness: An upward spiral process. *Mindfulness*, 2, 59-67

Germer, C. K., Siegel, R. D., & Fulton, P. R. (2005). *Mindfulness and psychotherapy*. New York: Guilford Press.

Greenberg, J., Reiner, K., & Meiran, N. (2012). “Mind the trap”: Mindfulness practice reduces cognitive rigidity. *PLoS ONE*, 7, e36206.

Hayes, S. C. (2004). Acceptance and Commitment Therapy, relational frame theory, and the third wave of behavior therapy. *Behavior Therapy*, 35, 639-665.

Heeren, A., Van Broeck, N., Philippot, P. (2009). The effects of mindfulness on executive processes and autobiographical memory specificity. *Behavioral Research Therapy*, 47(5), 403–409.

Hölzel, B.K., Lazar, S.W., Gard, T., Schuman-Olivier, Z., Vago, D.R., and Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, 6, 537-559.

Hölzel, B.K., Carmody, J., Evans, K.C., Hoge, E.A., Dusek, J.A., Morgan, L., . . . Lazar, S.W. (2010). Stress reduction correlates with structural changes in the amygdala. *Social Cognitive and Affective Neuroscience*, 5, 11–17.

Hölzel, B. K., Ott, U., Gard, T., Hempel, H., Weygandt, M., Morgen, K., & Vaitl, D. (2008). Investigation of mindfulness meditation practitioners with voxel-based morphometry. *Social Cognitive and Affective Neuroscience*, 3(1), 55–61.

Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness meditation modifies subsystems of attention. *Cognitive Affective and Behavioral Neuroscience*, 7(2), 109–119.

Kabat-Zinn, J. (1994). *Wherever you go, there you are: Mindfulness meditation in everyday life*. New York, NY: Hyperion.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, 4(1), 33–47.

Kabat-Zinn, J., Lipworth, L., and Burney, R. (1985). The clinical use of mindfulness meditation for the self-regulation of chronic pain. *Journal of Behavioral Medicine*, 8(2), 163–190.

Kristeller, J. L., & Wolever, R. Q. (2011). Mindfulness-Based Eating Awareness Training for treating binge eating disorder: The conceptual foundation. *Eating Disorders*, 19, 49-61.

Lazar, S.W., Kerr, C.E., Wasserman, R.H., Gray, J.R., Greve, D.N., Treadway, M.T., . . . Fischl, B. (2005). Meditation experience is associated with increased cortical thickness. *NeuroReport*, 16, 1893–1897.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, 12, 163-169.

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience*, 7, doi: 10.3389/fnins.2013.00008.

Mehling, W.E., Gopisetty, V., Daubenmier, J., Price, C.J., Hecht, F.M., & Stewart, A. (2009). Body awareness: Construct and self- report measures. *PLoS ONE*, 4, e5614.

Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition*, 18, 176–186.

Ochsner, K.N., & Gross, J.J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences*, 9, 242–249.

Ren, J., Huang, Z., Luo, J., Wei, G., Ying, X., Ding, Z., ..., Luo, F. (2011). Meditation promotes insightful problem-solving by keeping people in a mindful and alert conscious state. *Science China - Life Sciences*, 54(10), 961–965.

Rosenzweig, S., Reibel, D. K., Greeson, J. M., Brainard, G. C., & Hojat, M. (2003). Mindfulness-based stress reduction lowers psychological distress in medical students. *Teaching and Learning in Medicine*, 15, 88–92. doi:10.1207/S15328015TLM1502_03.

Santorelli, S. (2000). *Heal thy self: Lessons on mindfulness in medicine*. New York, NY: Three Rivers Press.

Segal, Z., Teasdale, J., & Williams, M. (2002). *Mindfulness-Based Cognitive Therapy for Depression*. New York: Guilford Press.

Shapiro, S. L., Schwartz, G. E., & Bonner, G. (1998). Effects of mindfulness-based stress reduction on medical and premedical students. *Journal of Behavioral Medicine*, 21, 581-599.

Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology*, 62, 373-386.

Silananda, U. (1990). *The four foundations of mindfulness*. Boston: Wisdom Publications.

Tang, Y. Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., . . . Posner, M. I. (2007). Short-term meditation training improves attention and self-regulation. *Proceedings of the National Academy of Sciences of the United States of America*, 104, 17152-17156.

Tang YY, Holzel BK & Posner MI. The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, 2015, 16, 213-225.

Thera, N. (1962). *The heart of Buddhist meditation: A handbook of mental training based on the Buddha's way of mindfulness*. London: Rider and Company.

Waelde, L. C., Uddo, M., Marquett, R., Ropelato, M., Freightman, S., Pardo, A., & Salazar, J. (2008). A pilot study of meditation for mental health workers following hurricane Katrina. *Journal of Traumatic Stress*, 21, 497–500. doi:10.1002/jts.20365

Walsh, R. (1996). Toward a synthesis of Eastern and Western psychologies. In A. A. Sheikh & K. S. Sheikh (Eds.), *Healing East and West* (pp. 542–555). New York: Wiley.

Psychological and physiological responses to stressful situations in immersive virtual reality: Differences between users who practice mindfulness meditation and controls

Cristiano Crescentini, Luca Chittaro, Viviana Capurso, Riccardo Sioni, Franco Fabbro

ABSTRACT

Several studies in the literature have shown positive psychophysical effects during or immediately after mindfulness meditation. However, the extent to which such positive effects are maintained in real-life, stressful contexts, remains unclear. This paper investigates the effects of an 8-week mindfulness- oriented meditation (MOM) program on the psychological and physiological responses evoked by immersive virtual environments (IVEs) that simulate emergency situations that may occur in life. Before and after the 8-week period, healthy MOM participants and a group of controls not involved in any meditation course were administered self-report measures of mindfulness and anxiety, and acted in the IVEs while a set of physiological parameters were recorded. Responses of MOM participants to the immersive virtual experiences were different from those of controls. MOM participants showed increased mindfulness and decreased anxiety levels. They also showed decreased heart rate and corrugator muscle activity while facing IVEs. We explain these results in terms of the awareness and acceptance components of mindfulness. More generally, the present experimental methods could also open up new lines of research that combine psychological and physiological indices with ecologically valid stimuli provided by IVEs in an effort to increase understanding of the impact of mindfulness meditation on realistic life situations.

1. Introduction

Rooted in Eastern contemplative traditions, mindfulness meditation (MM) is usually conceptualized as nonjudgmental attention to present moment somatosensory and mental experience (Brown & Ryan, 2003; Crescentini & Capurso, 2015; Kabat-Zinn, 1990, 2003; Lutz, Slagter, Dunne, & Davidson, 2008). Initially formalized for patients with chronic pain (e.g., Kabat-Zinn, 1982; see Baer, 2003, 2010; Didonna, 2009 for discussions of different

forms of MM therapies), MM interventions have been shown to be effective for the treatment of different types of physical and psychological problems observed in individuals of various age ranges and in different clinical and non-clinical contexts (for reviews see Brown, Ryan, & Creswell, 2007; Chiesa & Serretti, 2010; Didonna, 2009; Goyal et al., 2014).

For example, a number of studies based on self-report measures documented positive effects of MM therapies on anxiety, stress reactivity, depressive symptoms, ruminative thoughts, mood, and ability to regulate disturbing emotions in patients with anxiety and depressive disorders as well as in healthy individuals (Chiesa & Serretti, 2010; Desrosiers, Vine, Klemanski, & Nolen-Hoeksema, 2013; Evans et al., 2008; Garland, Gaylord, & Fredrickson, 2011; Hofmann, Sawyer, Witt, & Oh, 2010; Hoge et al., 2013; Jain et al., 2007; Kabat-Zinn et al., 1992). In these classes of patients as well as in non-clinical samples, such MM-related positive outcomes on mental health also seem to impact physiological parameters associated with stress and anxiety. For example, it has recently been shown in non-clinical populations that a brief training in mindfulness meditation (3e10 days of Vipassana meditation) leads to reduced heart rate (Zeidan, Johnson, Gordon, & Goolkasian, 2010) and increased heart rate variability (which is related to well-being and positive affect; Krygier et al., 2013) immediately after or during meditation tasks. Such findings have been considered to reflect feelings of relaxation (which decreases physiological arousal) or states of effortful, positive immersion in an activity promoted by MM.

Similarly, other longitudinal, within-subject studies or cross-sectional designs in which experienced meditators were compared to naïve meditators or meditation conditions to control conditions (e.g., relaxation or wait-list control conditions), have reported physiological changes during MM. Such changes include reduction of heart and respiratory rates and reduction in skin conductance level, in both clinical (e.g., individuals with fibromyalgia, a chronic pain syndrome; Lush et al., 2009) and non-clinical populations (Cahn & Polich, 2006; Delmonte, 1984, 1985; Ditto, Eclache, & Goldman, 2006; Rubia, 2009). Moreover, a recent study on a sample of depressed patients (Rohde, Adolph, Dietrich, & Michalak, 2014) was able to link negative emotional reactions, experienced

when attention drifted during a MM exercise in which subjects had to focus nonjudgmentally on breathing, to electromyographic response of the corrugator supercilii muscle. The activation of this muscle has been shown to be generally associated with negative affect, and the study by Rodhe et al. (2014) observed increased corrugator activity in depressed vs. healthy individuals after drifting from breathing, a finding that can suggest a deficit of depressed patients in the non-judgmental experience component of mindfulness.

Globally, these psychophysiological findings have been interpreted in terms of a wakeful hypometabolic state promoted by MM. This state would be characterized by increased parasympathetic nervous activity (indicative of physiological relaxation and stress relief) and decreased sympathetic activity (e.g., Rubia, 2009). However, one should note that previous studies focused on the health effects of MM therapies have generally monitored physiological parameters immediately after or during MM exercises. This does not shed light about if and how such positive effects of MM translate and generalize to wider, real-world scenarios. Virtual reality (VR) may represent a more holistic and ecological research instrument, providing users with unique, realistic and immersive experiences that are under full experimenter's control and could open up new possibilities to investigate behavioral and physiological responses of meditators to stressful real-world situations.

In the last years, it has been shown that VR exposure can be so effective in terms of experimental realism as to elicit and modulate psychophysiological symptoms of anxiety and fear reactions (e.g., in terms of electrodermal activity), in both patients with anxiety disorders and healthy individuals (Diemer, Mühlberger, Pauli, & Zwanzger, 2014). More specifically, immersive virtual reality systems, as the one we use in this study, exploit realistic 3D graphics, stereoscopic viewing, and head tracking to create interactive, first-person experiences that can be more ecologically valid than traditional, non-interactive experimental stimuli (written text as well as audio-visual materials; e.g., see Parsons, 2011) and produce users' physiological responses that are consistent with real-world experiences (Chittaro, 2014; Chittaro & Buttussi, 2015; Insko, 2003; Meehan, Razzaque, Insko, Whitton, & Brooks, 2005; Parsons et al., 2009; Patil, Cogoni, Zangrando, Chittaro, & Silani, 2014; Slater, Khanna, Mortensen, & Yu, 2009; Slater, Usoh, & Steed, 1994; Zanon,

Novembre, Zangrando, Chittaro, & Silani, 2014). For example, immersive simulations of emergency situations - such as fires, accidents and other life-threatening events - can provide participants with visual and auditory stimuli that are able to induce negative emotions such as anxiety (Chittaro, 2014) and fear (Chittaro & Buttussi, 2015) as a real emergency would do. Moreover, behavioral responses to virtual emergencies are also consistent with real-world ones, even when particular behaviors such as prosocial behavior (Zanon et al., 2014) or ethnic discrimination (Gamberini, Chittaro, Spagnolli, & Carlesso, 2015) are considered.

To date, the potential of VR in MM studies has been scarcely explored. A few studies have recently tried to use VR and immersive systems to foster the adoption of meditative states (Vidhyarthi & Riecke, 2014) or self-compassion (an important construct related to MM, see Crescentini & Capurso, 2015) (Falconer et al., 2014). In line with these recent attempts to combine VR and meditation, earlier research explored the use of VR in combination with mindfulness and relaxation in the treatment of patients with physical and psychological problems such as chronic pain (e.g., fibromyalgia) and posttraumatic stress disorder (Botella et al., 2013; Gromala et al., 2011; Spira et al., 2006; see also Tong, Gromala, Choo, Amin, & Shaw, 2015). However, to the best of our knowledge, no study has employed VR as an instrument to study how meditators respond to stressful situations that simulate, through interactive immersive experiences in controlled conditions, emergencies that occur in real life.

The aim of the current longitudinal research was to investigate the direct impact of a mindfulness-oriented meditation (MOM) intervention on the psychological and physiological responses evoked by four immersive virtual environments (IVEs) that were designed to elicit different levels of stress (low and high, see section on Immersive Virtual Environments) and that simulated real-life scenarios and activities. The study involved two groups of healthy adults, one group participating in an 8-week MOM training and the second serving as matched control group whose members were not involved in any meditation intervention. In addition to self-report measures of dispositional mindfulness and trait and state anxiety, we recorded a set of physiological parameters (cardiac, electrodermal, electromyographic, and respiratory activity) while subjects were immersed and

acted in the IVEs. This was done in both groups in two different sessions (i.e., before and after the 8-week period during which one of the groups was involved in MOM training). We expected to find evidence of reduced perceived stress and anxiety as well as physiological signs of emotional deactivation and reduced arousal in the MOM subjects when they faced demanding IVEs after vs. before the meditation training.

2. Materials and methods

2.1. Participants

A total of 41 Italian participants were recruited for the study. Twenty-one participants took part in the MOM training (mean age $M = 43.33$, $SD = 10.23$; mean years of education: $M = 15.38$, $SD = 3.52$). They were recruited through advertisements and by word of mouth from employees (administrative personnel, nurses and physicians) of the hospital “Santa Maria della Misericordia” in Udine, Italy. To control for possible influence of occupation, age, education level and gender on the measured psychological and physiological variables, control participants were also recruited among the employees of the same hospital: each MOM participant was asked to recruit in the study a colleague who was potentially interested in participating in a future MOM course. The control group consisted of 20 participants who were not involved in any meditation training (mean age $M = 36.75$, $SD = 9.85$; mean years of education: $M = 15.80$, $SD = 3.15$). Overall, five participants (3 MOM and 2 control participants) were excluded from all the analyses reported below because of technical problems with the physiological recording and/or IVEs described below (2 cases) or because they did not complete the psychological and physiological evaluation (3 cases). Thus, the reported results are based on two groups of 18 individuals. Independent sample *t*-tests showed that the two groups were matched for age (MOM: $M = 42.88$, $SD = 10.99$; Controls: $M = 36.94$, $SD = 10.39$; $t(34) = 1.66$, $p = .10$), years of education (MOM: $M = 15.44$, $SD = 3.71$; Controls: $M = 15.55$, $SD = 3.22$; $t(34) = .09$, $p = .92$), and gender (3 males and 15 females in each group). Two testing sessions (before and after the MOM training for the MOM group and two temporally matched sessions for the control group) were organized to administer all study participants the experimental tasks and

questionnaires described below. The two participant groups were also comparable in terms of days spent between the two testing sessions (MOM: $M = 67.72$, $SD = 7.16$; Controls: $M = 68.22$, $SD = 9.01$; $t(34) = .18$, $p = .85$). In the MOM group, the first testing took place on average 7.33 days before the MOM course start date (range: 0-13 days) while the second testing took place on average 12.38 days (range: 5-29 days) after the MOM course end date.

It must be noted that all recruited participants had no previous experience with mindfulness meditation and with the outcome measures used in the study. All participants reported normal or corrected-to normal vision, and no past history of neurological or mental illness. Signed informed consent was obtained before participation in the study from all participants.

2.2. Mindfulness oriented meditation (MOM) training

The MOM course was led by the first and last author of this paper. Both have several years of experience with mindfulness meditation. The training was based on the practice (summarized below) proposed by Campanella, Crescentini, Urgesi, and Fabbro (2014), Crescentini, Matiz, and Fabbro (2015), Crescentini, Urgesi, Campanella, Eleopra, and Fabbro (2014) and Fabbro and Muratori (2012), which are in turn based on the Mindfulness Based Stress Reduction program (Kabat-Zinn, 1982, 1990, 2003). The MOM course consisted of 8 weekly meetings of about 2 h each. Each meeting was organized in 3 phases: (a) up to 30 min of active teaching on topics related to meditative practice, (b) 30 min of MOM practice (which was divided into 3 parts of about 10 min each: (i) mindfulness of breathing, (ii) contemplation of bodily phenomena, and (iii) vipassana meditation in which participants tried to non-judgmentally observe their here-and-now mental experience), and (c) a final debriefing of up to 1 h during which participants could share their experiences and ask questions to the instructors (see Crescentini et al., 2014, 2015 for further details on the MOM training procedures). At the end of the first meeting, MOM participants were given a CD with a recording of the voice of the instructor (FF), guiding a MOM practice session of half an hour. Participants were encouraged to listen to the CD as an aid for

homework assignments, which consisted of 30 min of daily meditation practice, and were required to keep a written daily diary of the times and duration of the practice.

2.3. Questionnaires and IVE tasks

2.3.1. Questionnaires

To measure possible changes in dispositional mindfulness due to participation in the MOM training, participants in both groups were required to complete, in both testing sessions: (i) the Five Facet Mindfulness Questionnaire (FFMQ, Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006), a 39-item measure consisting of five subscales, respectively assessing the ability to observe, describe, act with awareness, non-judge and non-react to inner experience (Cronbach's alpha: a) FFMQ-observe: Session1 MOM 1/4 .85, controls 1/4 .79; Session2 MOM 1/4 .74, controls 1/4 .82; b) FFMQ- describe: Session1 MOM 1/4 .89, controls 1/4 .91; Session2 MOM 1/4 .88, controls 1/4 .78; c) FFMQ-awareness: Session1 MOM 1/4 .94, controls 1/4 .89; Session2 MOM 1/4 .52, controls 1/4 .79; d) FFMQ-non-judge: Session1 MOM 1/4 .87, controls 1/4 .83; Session2 MOM 1/4 .90, controls 1/4 .93; e) FFMQ-non-react: Session1 MOM 1/4 .65, controls 1/4 .78; Session2 MOM 1/4 .88, controls 1/4 .52); (ii) the Mindful Attention Awareness Scale (MAAS, Brown & Ryan, 2003), a 15-item mindfulness scale assessing global levels of attention and awareness in daily life (Cronbach's alpha MAAS: Session1 MOM 1/4 .89, controls 1/4 .80; Session2 MOM 1/4 .89, controls 1/4 .87); (iii) the Freiburg Mindfulness Inventory (FMI, Buchheld, Grossman, & Walach, 2001), a 30-item questionnaire assessing global level of mindfulness skills (Cronbach's alpha FMI: Session1 MOM 1/4 .86, controls 1/4 .87; Session2 MOM 1/4 .89, controls 1/4 .88).

For each participant and testing session, we also measured trait (T) and state (S) anxiety levels by using the State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), a widely used 40-item, multiple-choice questionnaire (Cronbach's alpha STAI-T: Session1 MOM 1/4 .91, controls 1/4 .88; Session2 MOM 1/4 .86, controls 1/4 .93; Cronbach's alpha STAI-S: Session1 MOM 1/4 .88, controls 1/4 .87; Session2 MOM 1/4 .92, controls 1/4 .92).

Moreover, anxiety experienced during the low- stress and high-stress immersive virtual environments (IVEs) (described below in Section 2.3.2), was assessed using the STAI-S immediately after the virtual experiences (Cronbach's alpha low-stress IVEs: Session1 MOM 1/4 .95, controls 1/4 .91; Session2 MOM 1/4 .93, controls 1/4 .81; Cronbach's alpha high-stress IVEs: Session1 MOM 1/4 .95, controls 1/4 .95; Session2 MOM 1/4 .90, controls 1/4 .93). Overall, except for a few exceptions regarding the act with aware- ness and non-react FFMQ facets, Cronbach's alpha coefficients $> .70$ show a good level of internal reliability for the mindfulness and anxiety scales used in the present study.

Finally, a measure of subjective stress perceived during the low- stress and high-stress IVEs was also collected with a Visual Analog Scale (VAS) immediately after the virtual experiences. The stress VAS consisted of an unmarked 100 mm ruler with endpoints labeled 'Not at all stressed' and 'Totally stressed'. The participants had to indicate how stressed they felt on the ruler, which thus yielded a single subjective stress score between 0 and 100.

2.3.2. Immersive virtual environments

Four different IVEs were designed and developed for this study by the Human-Computer Interaction Laboratory (HCI Lab), at the Department of Mathematics and Computer Science of the University of Udine (Italy). Two of them realistically reproduce an entire train station including the main building and seven tracks. The other two IVEs realistically reproduce a multi-floor school building. Participants navigated the IVEs from a first person perspective. To display the IVEs, we employed a Sony HMZ-T1 stereoscopic head- mounted display (HMD) equipped with two 1280 720 screens with a field of view of 45°. The HMD was connected to a PC with a 2.67 GHz Intel Core i7 processor, 6 GB of RAM and an Nvidia GeForce GTX 480 GPU. We used an Intersense InertiaCube3 3DoF sensor attached to the HMD to track user's head movements and update the view in the IVEs accordingly.

The difference between the two IVEs reproducing the train station (and similarly between the two IVEs reproducing the school building) concerns the intended level of elicited stress. The low- stress IVEs portray a normal, daily life situation, while the high-

stress IVEs portray an emergency situation. In the following, we describe the four virtual experiences in detail. Participants were asked to evacuate the school building or the station as quickly as possible in the high-stress IVEs, or were asked to explore the building or the station in the low-stress IVEs. The existence of an exit was also mentioned to participants in the low-stress IVEs; the exit could be reached by participants during the exploration if desired. To move inside the IVE, participants employed a Nintendo Nunchuck controller (Fig. 1). By moving the Nunchuck's joystick forward or backward, participants walked respectively forward and backward in the virtual world; by moving the joystick to the left or to the right, participants rotated respectively counter-clockwise and clockwise.

2.3.2.1. Low-stress school building.

Participants explored the school building for 3 min, starting from a classroom at the top floor (Fig. 2a). Participants' walking speed in the IVE was designed to replicate a natural adult walking speed (1.5 m/s). During the navigation, participants could explore any floor of the building. Participants found any door connecting two corridors open, while other doors in the building were locked, and participants could not open them. Various groups of virtual students could be seen conversing and walking around the building (Fig. 2b). The simulation included sounds that are common in school buildings: students chatting and walking, doors opening and closing, and furniture being moved.

2.3.2.2. High-stress school building.

This IVE uses the same school building of the previous IVE, but portrays a fire emergency situation. As previously instructed by the experimenter, participants were required to evacuate the building by following the signs placed on walls and doors, starting from the same classroom mentioned in the low-stress experience. The IVE reproduced accurately the familiar signs which are legally mandatory for public buildings in the participants' country. All the doors belonging to the evacuation path were already opened, while other doors in the building were locked, and participants could not open them. Dark and thick smoke filled the environment (Fig. 2c and d), and there were occasional corpses of victims (on which participants could not act) lying on the floor along the evacuation path

(Fig. 2d). Sound included screaming people, ambulance sirens, and fire alarm sounds, and participants could also hear a virtual breathing and heartbeat sound following them that could be interpreted as interoceptive cues in the virtual experience. Such cues were also used to reflect the “health” of participants in the virtual experience. More specifically, at the beginning of the experience, users were in normal health conditions, and able to run inside the IVE (the initial speed was set at 3.25 m/s). However, as the experience progressed, the effects of smoke inhalation and fear were simulated: participants could hear themselves breathing with more and more difficulty, the intensity of the breathing sound increased with time and the frequency and the intensity of the heartbeat sound increased as well. Visual cues were also used to convey this aversive state: a red aura flashed in sync with heartbeat, and the participants' field of view was progressively reduced. Furthermore, walking speed slowed down as time passed, and at the end of the virtual experience (3 min after start) participants were almost unable to move. Finally, during the 3 min, participants could hear the sound of three loud explosions respectively after 30, 90 and 150 s from the start.



Fig. 1. The Nintendo Nunchuck controller employed in the study.

2.3.2.3. Low-stress train station.

Participants started the experience inside the last coach of a train located on the last track of the train station (Fig. 3a). They navigated the train station for 3 min by walking around platforms (Fig. 3b) as well as inside the station lounge. To move among platforms, participants had to take underpasses, consistently with a real-world train station.

2.3.2.4. High-stress train station.

This IVE uses the same train station environment, but portrays an emergency situation in which the station is hit by multiple explosions. Participants started from the same location described in the low-stress experience (Fig. 3c) and had to evacuate the train station by finding a safe path through corpses, wounded people, shattered wagons, and debris (Fig. 3d). Potentially stressful stimuli included sudden and loud explosions, fire and smoke, the sight of wounded people asking for help and corpses, shattered station structures, evacuation routes blocked by fire or debris. Explosions were accompanied by a loud, low- frequency sound, and the shaking of the displayed image. Remaining inside a cloud of smoke caused the reduction of the field of view, as well as intense coughing. Touching fire or metal debris produced red flashing on the screen, together with scream sounds. Some events in the IVE were triggered by particular user actions. In particular, proceeding along the track of the train station after getting off the coach caused a sudden explosion that made the track roof collapse in front of the participant. Also, in multiple occasions along the evacuation path, getting too close to a tank wagon on fire caused its explosion, which was accompanied by a brief white flash on the screen and a few seconds long whistle that simulated a tinnitus effect. In addition to these stimuli, we further added the sound of three loud explosions that were played after 30, 90 and 150 s respectively from the beginning of the 3-min experience.

2.3.3. Physiological measures

Physiological data were recorded with a Thought Technology ProComp Infiniti encoder and Biograph Infiniti software (Thought Technology, 2014). The following physiological variables were acquired for each participant during both testing sessions:

2.3.3.1. Heart rate and blood volume pulse amplitude.

Cardiovascular activity was recorded through a photoplethysmograph placed on the distal phalanx of the index finger of the left hand. The blood volume pulse signal was sampled at 256 Hz; heart rate (HR) and blood volume pulse amplitude (BVPA) values were

calculated in real time by the Biograph Infiniti software. Increases in HR are generally related to emotional activation (Andreassi, 2007), and the studies mentioned in Bradley and Lang (2007) indicate that, in the case of visual stimuli, heart rate acceleration varies consistently with stimulus arousal, increasing with both pleasant and unpleasant arousing stimuli. An increase in BVPA is related to a decreased vasoconstriction and a state of relaxation, while a decrease in BVPA is related to states such as pain, hunger, fear and rage (Frijda, 1986).

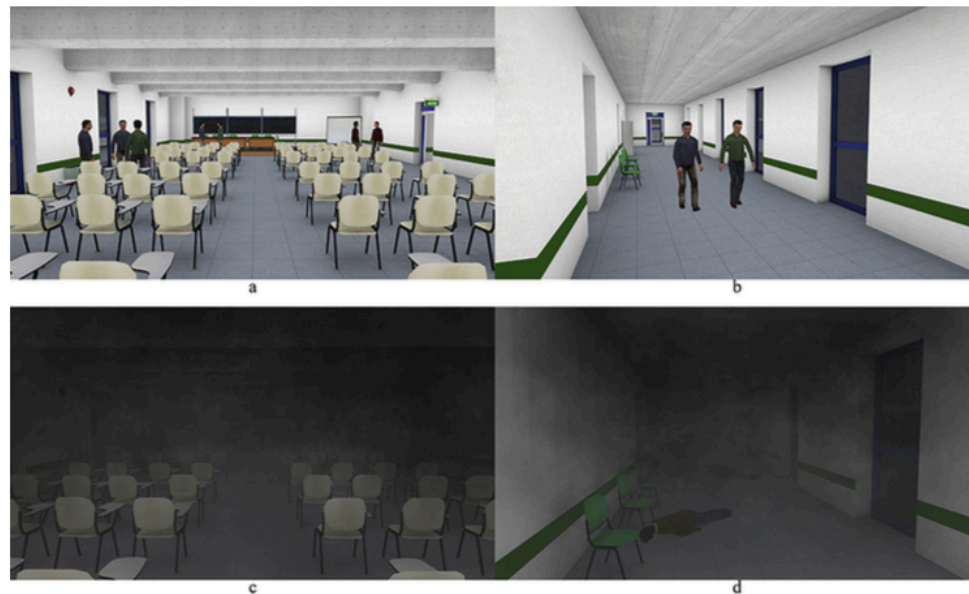


Fig. 2. Screenshots of the low-stress (a and b) and the high-stress (c and d) school building IVEs: the classroom in which participants are located at the beginning of the two IVEs (a and c), and a corridor in the building (b and d).

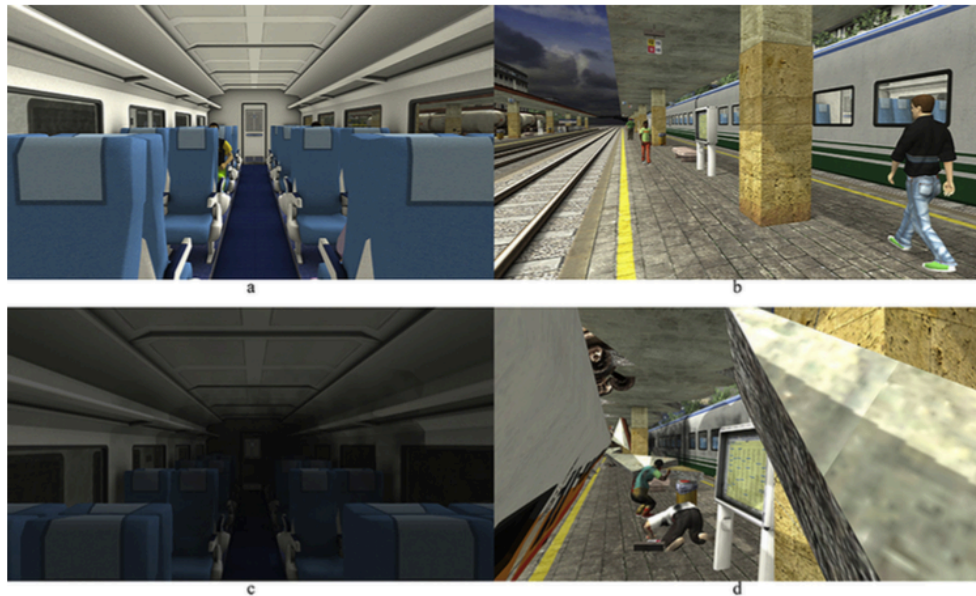


Fig. 3. Screenshots of the low-stress (a and b) and the high-stress (c and d) train station IVEs: the coach in which participants are located at the beginning of the two IVEs (a and c), and a view of a train platform (b and d).

3.3.2. Facial electromyography.

Facial electromyography (EMG) was recorded through two disposable sets of Ag/AgCl electrodes. Each set was composed of a positive, a negative, and a ground electrode. The six electrodes were placed on the skin of participants' face following the guidelines presented in Tassinari, Cacioppo, and Vanman (2000) in order to record the surface activity of the left zygomaticus major and the left corrugator supercilii muscles. Raw EMG signal was filtered in real time using Biograph Infinity: first, a band-pass filter between 10 and 500 Hz was applied to isolate the electrical activity of interest as suggested in Van Boxtel (2001); a band-stop filter around the 50 Hz frequency was also automatically applied by Biograph Infinity to remove any electrical noise coming from the power line. The filtered signal was then rectified through a RMS filter with a non-sliding window of 10 signal samples. Andreassi (2007) discussed various studies in the literature that strongly relate the activity of zygomaticus major and corrugator supercilii muscles to positively- and negatively- valenced emotional stimuli respectively (see also Larsen, Norris, & Cacioppo, 2003; Schwartz, Ahern, & Brown, 1979).

2.3.3.3. Respiratory frequency.

An elastic girth sensor was placed over the participants' chest to measure respiration frequency (respiratory rate), expressed as breaths per minute (BPM). It is known that sympathetic arousal contributes to changes in respiration frequency (Lorig, 2007).

2.3.3.4. Skin conductance level.

Electrodermal activity (EDA) was recorded through a pair of Ag/AgCl electrodes placed on the intermediate phalanges of index and middle fingers of the left hand. The signal was sampled at 256 Hz, and decomposed off-line to get the tonic component of the signal, corresponding to skin conductance level (SCL), using Ledalab (Benedek & Kaernbach, 2010). Changes in skin conductance can be produced by various physical and emotional stimuli that trigger variations in the eccrine sweat gland activity that, unlike many other bodily functions, is controlled exclusively by the sympathetic nervous system (Boucsein, 2006), making EDA an appropriate physiological signal for arousal measurement. Also, the slow-changing nature of the EDA signal makes electrical interferences and artifacts (caused, for example, by participants' movements) easily detectable and removable.

For each physiological variable (HR, BVPA, zygomaticus major EMG, corrugator supercilii EMG, BPM, SCL), we calculated its mean value and standard deviation over the duration (3 min) of each of the four IVE experiences and for the 1 min baseline periods that were recorded before each IVE.

2.4. Experimental procedure

Both groups were administered the IVE tasks and questionnaires in two separate sessions. Participants were tested individually, in a quiet room. The experimenter described to each participant the IVE tasks in terms of environment (school building or train station), duration, goals, and the use of the Nunchuck joystick. Participants were also informed about the HMD and the physiological sensors used during the test. In both testing sessions, each participant first completed the questionnaires in the following order: FFMQ, FMI, MAAS, STAI (state and trait). Then, the skin of participants' left hand, left cheek, and left

part of forehead was cleaned using a cotton pad and denatured alcohol and the physiological sensors were applied. Next, participants wore the HMD and they were asked to hold the joystick with the right hand. They sat in a comfortable position and were asked to relax for about 2 min, while the baseline for the physiological signals was recorded. For the statistical analyses, we considered the central minute of this recording as baseline. During the entire 2-min period, participants could close their eyes, relax and breathe normally.

Participants were then administered one of the two Low-stress IVE 3-min experiences. In each group of participants, half participants used the Low-stress school building IVE, while the second half were administered the Low-stress train station IVE. The reverse order was followed in the second testing session: participants who had experienced the Low-stress school building IVE (resp. train station) in the first session were administered the Low-stress train station IVE (resp. school building) in the second testing session. After the Low-stress IVE experience, the HMD was removed and participants were asked to complete the STAI-S and the stress VAS. Next, the HMD was worn again and another 2-min baseline period was recorded following the same procedure of the first baseline period.

Finally, participants were administered a 3-min High-stress IVE experience: if they had used the Low-stress train station (resp. Low-stress school building) in that session, then the second virtual experience of the session was the High-stress train station (resp. High-stress school building). As a result, the same balancing procedure adopted for the Low-stress IVEs was followed for the High-stress IVEs: participants who were presented with the High-stress train station (resp. High-stress school building) IVE in the first testing session used the High-stress school building (resp. High-stress train station) IVE in the second testing session. The overall procedure ensured that each participant of both groups (MOM and control) interacted with the train station and school building in the Low- and High-stress versions across the two testing sessions to counterbalance possible learning effects and ruling out the possibility that any MOM-related (physiological and behavioral) effect could be due to differences in elicited stress and arousal among the school building and train station IVEs. After the High-stress IVE, each participant completed again the STAI-S and stress VAS, then all physiological sensors were removed. Participants were finally

thanked and offered the opportunity to ask any question about what they had experienced during the whole experiment. The overall procedure (including filling the questionnaires) took altogether around 50e60 min for each of the two sessions.

2.5. Data analysis

The data were analyzed with Statistica 8 (StatSoft, Inc, Tulsa, OK). The main analyses concerned a series of mixed model ANOVAs. For the mindfulness and STAI (State and Trait) questionnaires, the ANOVAs included Session (Session1, Session2) as within-subject factor and Group (MOM, control) as between-subject factor. The dependent variables were the measures obtained for the FMI, the MAAS, the STAI-S and STAI-T, and for the five facets included in the FFMQ.

For the physiological measures, a mixed model ANOVA was carried out for each measure (HR, BVPA, corrugator supercilii EMG, zygomaticus major EMG, BPM, and SCL), with Session (Session1, Session2) and level of stress in the IVE (Low-stress, High-stress) as within-subject factors, and Group (MOM, control) as between-subject factor. For each physiological measure, we considered as dependent variable the data obtained by subtracting the baseline value recorded immediately before using an IVE from the recorded values during that IVE experience. Such subtraction is necessary to account for differences in individual basic arousal levels (Andreassi, 2007).

Before running these analyses, we tested whether the IVEs used in this study actually differed in the level of perceived stress and state anxiety. In particular, we considered the STAI-S and stress VAS (both completed immediately after the Low-stress and High-stress IVEs), and analyzed them with two mixed model ANOVAs involving Session (Session1, Session2) and level of stress in the IVE (Low-stress, High-stress) as within-subject factors, and Group (MOM, control) as between-subject factor. Moreover, in a series of supplementary analyses, we also tested for possible differences between the school building and the train station IVEs.

A .05 significance threshold was used in all statistical tests. In all ANOVAs, significant interactions were followed-up with Duncan's post hoc tests. In the analyses, effect sizes are reported as partial eta squared (η_p^2).

3. Results

3.1. Low-stress and high-stress IVEs: analyses of STAI-S and stress VAS

We assessed state anxiety and stress levels after Low-stress and High-stress IVEs by using the STAI-S and the stress VAS. The 2 (Session: Session1, Session2) 2 (IVE: Low-stress, High-stress) 2 (Group: MOM, control) ANOVA carried out for the STAI-S showed a main effect of IVE ($F(1, 34) = 30.09, p < .01; \eta^2p = .47$; observed power = .99) indicating higher scores (i.e., higher state anxiety) after High-stress rather than Low-stress IVEs (see Fig. 4A). All other main effects and interactions did not reach significance (for all, $F(1, 34) < 3.96, p > .05; \eta^2p < .11$; observed power < .49). The ANOVA performed for the stress VAS also showed a main effect of IVE ($F(1, 34) = 28.14, p < .01; \eta^2p = .45$; observed power = .99), denoting higher perceived stress after High-stress than Low-Stress IVEs (see Fig. 4B). All other main effects and interactions involving the stress VAS data did not reach significance (for all, $F(1, 34) < 2.32, p > .13; \eta^2p < .07$; observed power < .32). These results indicate that the IVEs used in this study actually differed in the level of perceived stress, with High-Stress IVEs subjectively eliciting higher state anxiety and stress than Low-stress IVEs. Nevertheless, there were no differences between groups in these subjective measures, suggesting that MOM training had no significant effect in modulating perceived state anxiety and stress levels immediately after IVE experiences.

In view of these results, we repeated similar analyses this time taking into consideration each of the two different IVEs (i.e., school building and train station). Because of our balancing procedure adopted for the school building and the train station IVEs, these supplementary analyses were carried out separately for the two sessions (note also the non-significant effect of the factor Session in the previous analyses). The 2 (IVE: Low-stress, High-stress) 2 (Group: MOM, control) 2 (IVE-type: school building, train station) ANOVA carried out for the STAI-S data at Session1 showed a main effect of IVE ($F(1, 32) = 21.56, p < .01; \eta^2p = .40$; observed power = .99) indicating higher state anxiety after High-stress than Low-stress IVEs. All other main effects and interactions did not reach significance (for all, $F(1, 32) < 1.49, p > .23; \eta^2p < .05$; observed power < .22). Thus, no main

effect or interaction involving the IVE- type factor was found. The ANOVA performed for the STAI-S data at Session2 also showed a main effect of IVE ($F(1, 32) = 18.17, p < .01; \eta^2 = .36$; observed power $= .98$), but no other main effects or interactions (for all, $F(1, 32) < .55, p > .46; \eta^2 < .02$; observed power $< .12$). Next, we ran two corresponding ANOVAs for the stress VAS data. Similarly to the analyses of the STAI-S data, for both Session1 and Session2, the analyses carried out for the stress VAS only showed a main effect of IVE denoting higher perceived stress after High-stress than Low-Stress IVEs ($F(1, 32) = 17.65, p < .01; \eta^2 = .36$; observed power $= .98$ and $F(1, 32) = 11.01, p < .01; \eta^2 = .26$; observed power $= .89$, respectively for Session1 and Session2), but not other main effects or interactions (for all, $F(1, 32) < 1.38, p > .24; \eta^2 < .05$; observed power $< .21$).

Overall, these results indicate that there were no significant differences between the school building and the train station IVEs in terms of elicited levels of perceived stress and state anxiety, with High-Stress IVEs eliciting higher scores than Low-stress IVEs.

3.2. Dispositional mindfulness and STAI (trait and state) data

The 2 (Session: Session1, Session2) \times 2 (Group: MOM, control) repeated measure ANOVA carried out for the FMI questionnaire did not show significant main effects of Group ($F(1, 34) = .20, p = .65; \eta^2 = .01$; observed power $= .07$) or Session ($F(1, 34) = 1.55, p = .22; \eta^2 = .04$; observed power $= .23$), but pointed out a significant interaction ($F(1, 34) = 17.52, p < .01; \eta^2 = .34$; observed power $= .98$), indicating that dispositional mindfulness changed differently from the first to the second session in the two participant groups. Post-hoc tests carried out to analyze this two-way interaction revealed an increase in FMI scores (i.e., Session2 vs. Session1) in the MOM group ($p < .01$) but not in the control group ($p > .05$) (see Fig. 5A).

A similar 2 \times 2 ANOVA performed for the MAAS questionnaire did not show significant main effects or interaction (for all, $F(1, 34) < 1.39, p > .24; \eta^2 < .04$; observed power $< .21$) (see Fig. 5B). This indicates no significant modulatory effects of the MOM training on the trait mindfulness levels that are measured by the MAAS questionnaire.

For the FFMQ, we performed a 2 (Session) \times 2 (Group) repeated measures ANOVA for each of the 5 facets. A significant interaction between Session and Group was found for the

“observe” facet ($F(1, 34) = 15.53, p < .01; \eta^2 = .31$; observed power $\eta^2 = .97$). Post-hoc tests performed for this interaction showed higher scores in this facet for MOM participants at Session2 vs. Session1 ($p < .01$) and higher scores for MOM vs. control at Session2 ($p < .03$). Interactions and main effects for the remaining four facets (describe, act with awareness, non-judge and non-react) were not statistically significant (for all, $F(1, 34) < 3.33, p > .07; \eta^2 < .09$; observed power $< .43$). For main effects, however, the only significant effect concerned Session ($F(1, 34) = 8.29, p < .01; \eta^2 = .20$; observed power $\eta^2 = .80$) for the “non-judge” facet, indicating higher values, globally for the two groups, at Session2 vs. Session1 (see Fig. 5C).

For STAI-S and STAI-T data, we ran two separate 2 (Session: Session1, Session2) \times 2 (Group: MOM, control) repeated measures ANOVAs. The analysis of STAI-T data highlighted a main effect of Session ($F(1, 34) = 10.08, p < .01; \eta^2 = .23$; observed power $\eta^2 = .87$) and a two-way interaction ($F(1, 34) = 5.51, p < .03; \eta^2 = .14$; observed power $\eta^2 = .62$). The main effect of Group was instead not significant ($F(1, 34) = .28, p = .60; \eta^2 = .01$; observed power $\eta^2 = .08$). Post-hoc analysis of the interaction showed significantly lower STAI-T scores at Session2 vs. Session1 in MOM participants ($p < .01$), but not in controls ($p = .56$) (see Fig. 5D). The analysis of STAI-S data showed no significant main effect of Group ($F(1, 34) = .34, p = .56; \eta^2 = .01$; observed power $\eta^2 = .09$) or Session ($F(1, 34) = .02, p = .90; \eta^2 < .01$; observed power $\eta^2 = .05$) and a significant two-way interaction ($F(1, 34) = 4.15, p < .05; \eta^2 = .11$; observed power $\eta^2 = .51$). Although post-hoc tests performed for the STAI-S did not reach significance, the interaction mediated the tendency of MOM participants to show lower levels of state anxiety at Session2 vs. Session1, together with the opposite tendency in controls (see Fig. 5E).

In sum, the analyses of the mindfulness and STAI questionnaires showed specific effects of the MOM training in increasing both global (i.e., FMI scores) and specific mindfulness skills. In particular, MOM participants self-reported increased abilities to observe inner mental and somatosensory experience after the training (i.e., the “observe” factor in the FFMQ). However, no change was observed in trait mindfulness of MOM and control participants, as measured through the MAAS scale. Finally, MOM participants reported decreased trait and state anxiety levels after the meditation course, while controls

tended to have higher state anxiety at the beginning of the second vs. the first testing session.

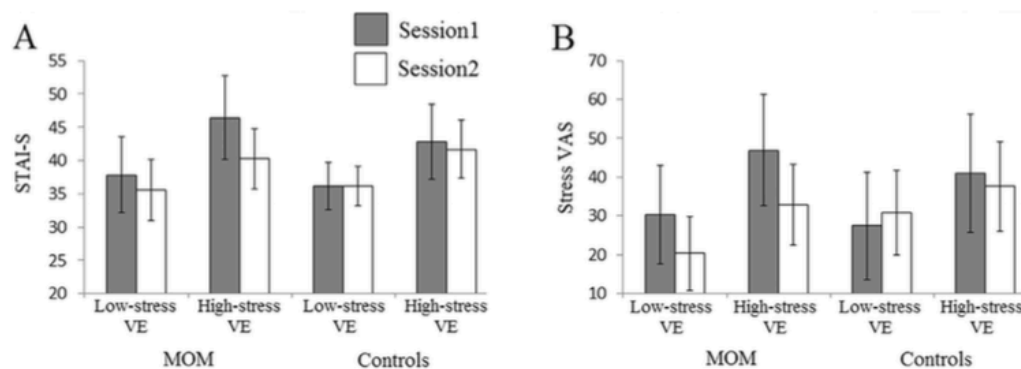


Fig. 4. A) STAI-S raw scores in MOM and control participants for the two testing sessions and for the Low- and High-stress IVEs; B) Stress VAS raw scores in MOM and control participants for the two testing sessions and for the Low- and High-stress IVEs. Vertical bars denote standard deviations.

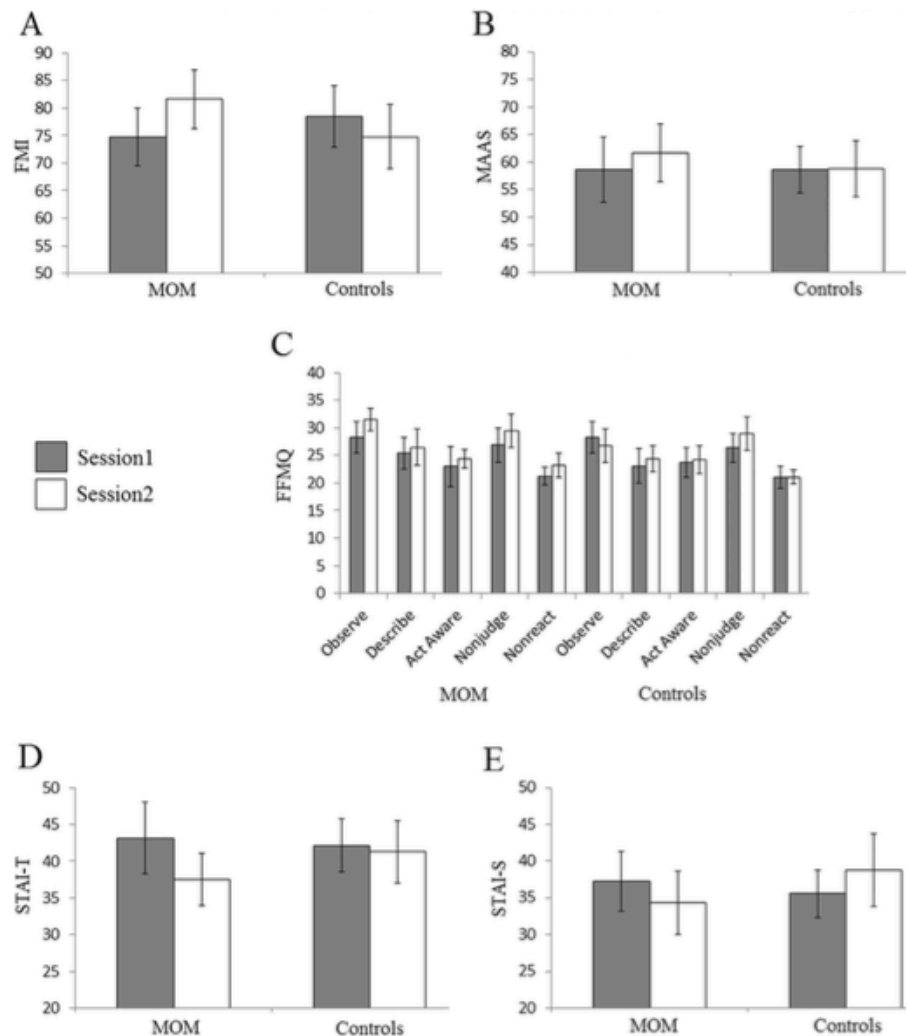


Fig. 5. A) Freiburg Mindfulness Inventory (FMI) raw scores in MOM and control participants for the two testing sessions; B) Mindful Attention Awareness Scale (MAAS) raw scores in MOM and control participants for the two testing sessions; C) Five Facet Mindfulness Questionnaire (FFMQ) raw scores in MOM and control participants for the two testing sessions; D) STAI-T raw scores in MOM and control participants for the two testing sessions; E) STAI-S raw scores in MOM and control participants for the two testing sessions. Vertical bars denote standard deviations.

3.3. Analysis of physiological data

3.3.1. Heart rate and blood volume pulse amplitude

The baseline values recorded before and the physiological values recorded during IVE experiences are reported in Table 1 for the two groups and the two testing sessions, for each physiological measure. As previously explained, the following analyses require subtraction of baseline values from the values recorded during IVE experiences. The 2

(Session: Session1, Session2) 2 (IVE: High- stress, Low-stress) 2 (Group: MOM, control) ANOVA carried out for HR data showed main effects of Session ($F(1, 34) = 12.58$, $p < .01$; $\eta^2 = .27$; observed power $= .93$) and IVE ($F(1, 34) = 31.51$, $p < .01$; $\eta^2 = .48$; observed power $= .99$) as well as their interaction ($F(1, 34) = 6.89$, $p < .02$; $\eta^2 = .17$; observed power $= .72$). Post-hoc analysis of the interaction indicated a significant difference in HR during the two different types of IVEs (HR in High-stress IVEs $>$ HR in Low-Stress IVEs) in Session1 ($p < .01$) but not in Session2 ($p = .20$), and a difference across the two sessions in the High-stress IVE (HR in Session1 $>$ HR in Session2, $p < .01$). More interestingly, there was an interaction between Session and Group ($F(1, 34) = 4.32$, $p < .05$; $\eta^2 = .11$; observed power $= .52$), indicating a decrease in HR in Session2 with respect to Session1 in MOM participants ($p < .01$), but not in controls ($p = .31$) (see Fig. 6A). The fact that there was no three-way interaction involving the IVE factor ($F(1, 34) = .03$, $p = .86$; $\eta^2 < .01$; observed power $= .05$) indicated that the decrease in HR observed in MOM participants after participation in MOM training occurred for both High- and Low-stress IVEs. Globally, these results indicate emotional deactivation and reduced arousal in MOM subjects while facing IVEs for the second time. All other main effects and interactions for HR were not statistically significant (for all, $F(1, 34) < 1.80$, $p > .18$; $\eta^2 < .06$; observed power $< .26$).

The 2 2 2 ANOVA carried out for the BVPA data did not produce instead significant main effects or interactions (for all, $F(1, 34) < 3.37$, $p > .07$; $\eta^2 < .10$; observed power $< .43$).

Table 1

Physiological data recorded during baseline and IVEs periods in testing sessions 1 and 2, for MOM and control participants.

Physiological measure	Session1 baseline1	Session1 baseline2	Session1 low-stress IVE	Session1 high-stress IVE	Session2 baseline1	Session2 baseline2	Session2 low-stress IVE	Session2 high-stress IVE
<i>HR</i>								
MOM	75.23 (13.63)	73.85 (12.78)	77.42 (15.48)	81.29 (14.88)	74.24 (16.06)	75.51 (14.59)	75.22 (16.81)	77.07 (15.53)
Controls	75.69 (12.15)	74.87 (10.51)	76.20 (13.51)	82.14 (14.64)	72.27 (7.27)	73.27 (7.45)	73.88 (9.10)	77.57 (11.29)
<i>BVPA</i>								
MOM	3.77 (3.80)	3.56 (2.71)	3.61 (3.08)	2.98 (2.35)	6.56 (4.02)	6.84 (3.19)	6.88 (3.57)	5.79 (3.23)
Controls	3.71 (2.58)	3.37 (2.35)	2.84 (1.80)	2.70 (1.57)	6.10 (3.39)	5.43 (3.17)	4.59 (2.91)	4.01 (2.67)
<i>Corrugator supercilii</i>								
MOM	4.47 (2.77)	4.16 (1.78)	3.78 (1.21)	5.23 (2.49)	4.52 (1.98)	5.02 (3.46)	3.73 (1.19)	4.87 (2.57)
Controls	4.25 (2.06)	4.36 (2.39)	3.65 (2.10)	4.72 (3.61)	4.67 (2.43)	4.19 (1.85)	4.74 (3.59)	5.39 (3.57)
<i>Zygomaticus major</i>								
MOM	2.78 (1.05)	2.79 (.98)	4.55 (1.85)	4.73 (2.70)	2.69 (1.33)	2.81 (1.31)	6.27 (8.52)	3.68 (1.85)
Controls	2.29 (.92)	2.33 (.85)	3.93 (1.87)	4.47 (1.87)	2.52 (.81)	2.48 (1.06)	4.01 (1.75)	4.26 (2.43)
<i>BPM</i>								
MOM	8.88 (2.47)	9.75 (3.05)	15.55 (1.87)	15.13 (2.48)	10.44 (3.12)	11.69 (3.74)	15.49 (2.41)	16.12 (2.25)
Controls	11.73 (2.40)	11.95 (2.69)	16.54 (1.76)	16.24 (1.73)	12.41 (3.50)	13.19 (3.38)	16.23 (1.33)	15.70 (1.65)
<i>SCL</i>								
MOM	1.91 (1.38)	3.50 (2.26)	3.09 (2.28)	4.24 (2.54)	2.06 (2.23)	3.84 (3.02)	3.17 (2.76)	4.37 (3.10)
Controls ^a	1.34 (1.03)	2.70 (2.39)	2.45 (2.05)	3.24 (2.80)	1.32 (.91)	2.94 (2.79)	2.48 (2.11)	3.75 (3.28)

Notes: IVE = Immersive Virtual Environment; Baseline1 occurred before Low-stress IVE; Baseline2 occurred before High-stress IVE and after Low-stress IVE; MOM = Mindfulness-Oriented Meditation; HR = Heart Rate; BVPA = blood volume pulse amplitude; BPM = breaths per minute; SCL = skin conductance level.

^a Two controls were excluded from SCL analysis (see main text for further details). Standard deviations of the means are reported in parentheses.

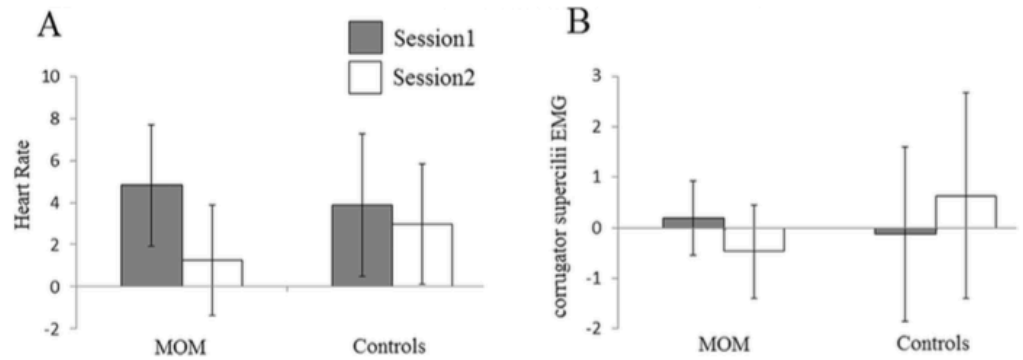


Fig. 6. A) Change of heart rate with respect to baseline values in MOM and control participants for the two testing sessions (Session \times Group interaction: $p < .05$); B) Change of corrugator supercilii muscle activity with respect to baseline values in MOM and control participants for the two testing sessions (Session \times Group interaction: $p < .02$). Vertical bars denote standard deviations.

3.3.2. Facial electromyography

The 2 \times 2 \times 2 ANOVA carried out for the corrugator supercilii muscle showed a main effect of IVE (higher activity of the muscle for High-vs. Low-stress IVEs; $F(1, 34) = 12.21$, $p < .01$; $\eta^2 = .26$; observed power $\eta^2 = .92$) and an interaction between Group and Session ($F(1, 34) = 6.75$, $p < .02$; $\eta^2 = .17$; observed power $\eta^2 = .71$). Although post-hoc tests performed for this interaction did not show statistically significant changes in muscle activity as a function of testing session (all $p > .05$), the interaction was mediated by the tendency of MOM participants to show lower levels of corrugator supercilii muscle activity

at Session2 vs. Session1 while controls displayed an opposite trend. Moreover, MOM and controls tended to differ in this muscle activity particularly at Session2 (see Fig. 6B). Globally, the interaction between Group and Session suggests a role of MOM in determining reduced activity in a muscle generally related to negatively-valenced emotional stimuli. The three-way interaction involving the IVE factor was not statistically significant ($F(1, 34) = 1.00$, $p = .32$; $\eta^2 = .03$; observed power $= .16$), indicating that this effect of MOM involved IVEs with different levels of perceived stress. All other main effects and interactions in the ANOVA of corrugator supercilii muscle data were not statistically significant (for all, $F(1, 34) < .53$, $p > .47$; $\eta^2 < .02$; observed power $< .11$).

The 2 x 2 x 2 ANOVA of zygomaticus major muscle data did not show any significant main effect or interaction (for all, $F(1, 34) < 3.74$, $p > .06$; $\eta^2 < .10$; observed power $< .47$).

3.3.3. Respiration frequency

The 2 x 2 x 2 ANOVA performed for the respiration frequency measure (BPM) showed a main effect of Session (BPM Session1 > BPM Session2; $F(1, 34) = 6.58$, $p < .02$; $\eta^2 = .16$; observed power $= .70$) and IVE (BPM High-stress < BPM Low-stress; $F(1, 34) = 7.04$, $p < .02$; $\eta^2 = .17$; observed power $= .73$), but not a main effect of Group or interactions between factors (for all, $F(1, 34) < 2.60$, $p > .11$; $\eta^2 < .08$; observed power $< .35$).

3.3.4. Skin conductance level

Two control participants were excluded from the analysis, because the sensors placed on the left hand failed to record SCL (i.e., a value of 0 was obtained throughout the entire recording during the two IVEs: this happened at Session1 for one subject and at Session2 for another subject). The 2 x 2 x 2 ANOVA performed for the SCL measure returned a main effect of IVE (SCL High-stress < SCL Low-stress; $F(1, 32) = 10.93$, $p < .01$; $\eta^2 = .25$; observed power $= .89$). All other main effects and interactions were not statistically significant (for all, $F(1, 32) < 2.48$, $p > .12$; $\eta^2 < .08$; observed power $< .34$).

4. Discussion

The goal of the current study was to investigate how meditators respond to stressful situations that simulate in controlled conditions emergencies that may occur in real-world circumstances. To this end, VR was used as an ecological research instrument to study the psychological and physiological responses evoked by a series of IVEs (either reproducing a train station or a school building and differing in the levels of perceived anxiety and stress; i.e., low- stress and high-stress IVEs). Two groups of participants were considered: the MOM group was involved in an 8-week MOM course, while the control group was not involved in any meditation course. Self-report measures of mindfulness and anxiety showed specific increases in mindfulness skills (e.g., the “observe facet” in the FFMQ and the global mindfulness score calculated by the FMI) and decreased trait and state anxiety levels (STAI-S and STAI-T) in MOM vs. control participants at Session2 vs. Session1. Also, we found a decrease in HR in Session2 vs. Session1 in MOM participants but not in controls and a corresponding reduction in the activity of the corrugator supercilii muscle, which is a muscle generally associated to negatively-valenced emotional stimuli, in MOM vs. control participants. It is worth noting that these physiological results were not influenced by the level of subjectively perceived stress elicited by the IVEs. Finally, the other recorded physiological parameters (i.e., BVPA, electromyography of the zygomaticus major muscle, BPM and SCL) did not differ between MOM and controls.

Overall, the results highlighted by the self-report questionnaires are consistent with findings obtained using similar MOM protocols (Carmody & Baer, 2008; Crescentini et al., 2014; Shapiro, Schwartz, & Bonner, 1998; see also Brown & Ryan, 2003), suggesting that the MOM course was effective in positively influencing psychological well-being, by increasing mindfulness skills and decreasing anxiety.

Most previous research on mindfulness-based interventions has focused on self-report measures to characterize the positive effects on psychophysical health. Nevertheless, a series of studies have recently included physiological measures to further study the mechanism underlying the observed health improvement, suggesting that mindfulness may lead to decreased physiological arousal and better autonomic regulation (e.g.,

parasympathetic cardiac control and respiration) (e.g., Solberg et al., 2000; Young & Taylor, 2001; Rubia, 2009; Delgado et al., 2010; Zeidan et al., 2010; see also Introduction). It must be noted that these suggestions have usually been put forward by detecting changes in transient state mindfulness that can arise during and shortly after MM periods or, as in Delgado et al. (2010), by recording physiological parameters in meditators during simple “passive” tasks such as listening intense white noise capable of eliciting cardiac defense (Non-cued defense response paradigm) or while looking at pictures with different valence and arousal scores (Cued startle probe paradigm). The current study was the first to use immersive virtual reality to simulate low- and high-stress situations that can occur in real life while recording a set of physiological parameters in MOM and control participants. Overall, the results obtained for the HR and the corrugator supercilii muscle may be interpreted as indicating a role of MOM in promoting reduced arousal and emotional deactivation while participants faced stressful IVE experiences. As already mentioned, the activation of the corrugator muscle has been shown to increase and decrease respectively with negative and positive affect (Larsen et al., 2003; see also Lang, Greenwald, Bradley, & Hamm, 1993). For example, reduced corrugator activity has been reported in the acceptance and cognitive reappraisal conditions of a study in which healthy subjects were presented with films clips eliciting aversive emotional states (i.e., fear, disgust and sadness; Wolgast, Lundh, & Viborg, 2011); moreover, in other studies, decreased corrugator activity was observed when healthy participants intentionally reduced negative affect elicited by neutral and negative pictures (Lee, Shackman, Jackson, & Davidson, 2009; Ray, McRae, Ochsner, & Gross, 2010).

The present results are unlikely to reflect changes in transient state mindfulness but rather could be due to lasting changes in individuals' trait mindfulness that can persist in MOM participants irrespective of being actively engaged in meditation practice (Brown et al., 2007; Cahn & Polich, 2006). Indeed, participants in the current study were not explicitly asked to be mindful or meditate before or during the IVE experiences. Moreover, in the second testing session they were tested on average after more than 12 days from the MOM course end date to not interfere with state mindfulness levels. More generally, the MOM course allowed participants to face IVE experiences in a state characterized by

increased mindfulness skills (FMI, FFMQ), reduced state and trait anxiety and better physiological, and possibly emotional, regulatory mechanisms. These effects were likely promoted by the two fundamental factors of mindfulness that are believed to lead to improved emotional stability, namely self-regulation of attention (awareness) and non-judgmental/acceptance of internal and external aspects of present-moment experience (Bishop et al., 2004; Chambers, Gullone, & Allen, 2009).

As discussed, the present findings extend in a number of important ways the results of previous studies that tried to combine self-report measures and physiological responses with the aim to better identify the mechanisms underpinning the beneficial health effects of MM. Furthermore, they also highlight the importance of using ecologically valid, real-world applications of immersive VR systems for pinpointing the health effects of MM. This approach could help to further corroborate empirically any possible benefit of MM in developing new and more healthy and adaptive ways to experience and face daily life events (Crescentini & Capurso, 2015; Kabat-Zinn, 1990). In fact, in the context of MM research so far, VR has usually been limited to applications capable to promote the adoption of meditative, or meditation-related, states in healthy subjects (Falconer et al., 2014; Vidyarthi & Riecke, 2014; see also Hudlicka, 2013). Nevertheless, another important area where VR is increasingly being applied concerns the treatment of psychological and mental health disorders. As a few representative examples, VR has been employed effectively for enhancing existing interventions in a variety of medical conditions ranging from exposure therapy for phobia desensitization (North, North, & Coble, 1996), chronic and acute pain (Wiederhold, Soomro, Riva, & Wiederhold, 2014), post-stroke rehabilitation (Imam & Jarus, 2014), post-traumatic stress disorder (Gerardi, Cukor, Difede, Rizzo, & Rothbaum, 2010; McLay et al. 2014), and anxiety disorders (Diemer et al., 2014; McCann et al., 2014; Rothbaum & Hodges, 1999).

In addition to suggesting the usefulness of VR for future studies aimed at maximizing the beneficial effects of MOM interventions, our study indicates that it may be worthwhile to explore the use of VR applications, together with psychophysiological measures, as a tool to evaluate the effects of MM on complex, real-world behaviors, such as those taking

place in stressful, emergency situations or also in social situations that call for prosocial behavior (Zanon et al., 2014).

A number of limitations and suggestions for future research need to be borne in mind when evaluating the theoretical and practical implications of our findings. The first issue concerns the specific IVE experiences we used. Our study could have employed additional validation indices, such as behavioral indices based on navigation behavior expressed in terms of, for example, frequency of collisions with objects in low- and high-stress IVEs or frequency of backward movements while moving toward the exit in the IVEs. Gamberini et al. (2015) provided an example of such behavioral indices of effectiveness of IVEs, used together with self-reports, but however did not consider physiological measures. Beyond contributing to further validate the present IVEs, such behavioral indices might quantify the pattern of response to emergency situations produced by meditators vs. controls. With regard to the physiological indices, some potential confounding could have occurred in association with the fixed sequence of the low-stress and high-stress IVEs. A counterbalanced order might have provided more pronounced physiological differences between the two types of IVEs in the current study, although the low-stress IVE could have been perceived as too little engaging when occurring after the high-stress IVE.

Another issue pertains to sample size and type of experimental design used in our study. First, the relative small sample size raises issue of generalizability of the obtained results and indicates the need to extend the current findings to larger samples of meditators and controls. Although less powerful than longitudinal designs, cross-sectional studies comparing expert meditators with naïve or less expert participants would also be informative with respect to beneficial effects of MM in responding to virtual simulations of real-life emergencies. Second, the inclusion of a non-treatment (non-active), waiting-list control group in our study has allowed controlling for the non-specific effects of the time elapsed between the two testing sessions but, at the same time, makes it more difficult to finally ascribe to meditation practice the changes observed in MOM participants. The latter participants, indeed, received more than MOM practice, having for instance the opportunity to create a fairly intimacy-inducing community. In other words, the difference between MOM and controls in aspects other than MOM practice could have influenced the way in

which MOM participants experienced IVEs in our study. Thus, it is desirable for future research aimed at using IVEs in MM studies to benefit from more rigorous active control conditions (e.g., Delgado et al., 2010; MacCoon et al., 2012), as well as follow-up assessments that, unlike our study, might also allow investigating how long-lasting the changes observed in MOM participants could be.

In conclusion, the present study tested the effects of an 8-week mindfulness meditation program on the psychological and physiological responses evoked by immersive virtual environments, characterized by different levels of elicited stress, which simulated emergency situations that can occur in real life. We showed that continued meditation practice over a period of two months led to increased mindfulness skills and reduced state and trait anxiety, as well as to better physiological and emotional regulation during IVE experiences. These findings were held to be promoted by the two fundamental factors of mindfulness, namely awareness and non-judgmental/acceptance of present-moment experience. Finally, we believe that future studies aimed at further investigating the mechanisms underlying the health effects of MM in both clinical and non-clinical populations should continue to combine psychological and physiological indices of well-being with ecologically valid, real-world applications of immersive VR systems in an effort to increase our understanding of how MM can have a profound impact on day-to-day life.

References

- Andreassi, J. L. (2007). *Psychophysiology of Human behavior & physiological response* (5th ed.). Mahwah, NJ, USA: Lawrence Erlbaum Associates.
- Baer, R. A. (2003). Mindfulness training as a clinical intervention: a conceptual and empirical review. *Clinical Psychology: Science and Practice*, 10, 125-143.
- Baer, R. A. (2010). *Assessing mindfulness and acceptance processes in clients: Illuminating the theory and practice of change*. Oakland, CA: New Harbinger Publications Inc.
- Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment*, 13, 27-45.
- Benedek, M., & Kaernbach, C. (2010). Decomposition of skin conductance data by means of nonnegative deconvolution. *Psychophysiology*, 47, 647-658.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., et al. (2004). Mindfulness: a proposed operational definition. *Clinical Psychology: Science and Practice, 11*, 230-241.

Botella, C., Garcia-Palacios, A., Vizcaíno, Y., Herrero, R., Banos, R. M., & Belmonte, M. A. (2013). Virtual reality in the treatment of fibromyalgia: a pilot study. *Cyberpsychology, Behavior and Social Networking, 16*, 215-223.

Boucsein, W. (2006). *Electrodermal activity* (2nd ed.). New York, NY, USA: Springer.

Bradley, M. M., & Lang, P. J. (2007). Emotion and motivation. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (pp. 581-607). Cambridge, UK: Cambridge University Press.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: the role of mindfulness in psychological well-being. *Journal of Personality and Social Psychology, 84*, 822-848.

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*, 211-237.

Buchheld, N., Grossman, P., & Walach, H. (2001). Measuring mindfulness in insight meditation (Vipassana) and meditation-based psychotherapy: the development of the Freiburg Mindfulness Inventory (FMI). *Journal of Meditation Research, 1*, 11-34.

Cahn, B. R., & Polich, J. (2006). Meditation states and traits: EEG, ERP, and neuro-imaging studies. *Psychological Bulletin, 132*, 180-211.

Campanella, F., Crescentini, C., Urgesi, C., & Fabbro, F. (2014). Mindfulness-oriented meditation improves self-related character scales in healthy individuals. *Comprehensive Psychiatry, 55*, 1269-1278.

Carmody, J., & Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of Behavioral Medicine, 31*, 23-33.

Chambers, R., Gullone, E., & Allen, B. (2009). Mindful emotion regulation: an integrative review. *Clinical Psychology Review, 29*, 560-572.

Chiesa, A., & Serretti, A. (2010). A systematic review of neurobiological and clinical features of mindfulness meditations. *Psychological Medicine, 40*, 1239-1252.

Chittaro, L. (2014). Anxiety induction in virtual environments: an experimental comparison of three general techniques. *Interacting with Computers*, 26, 528-539.

Chittaro, L., & Buttussi, F. (2015). Assessing knowledge retention of an immersive serious game vs. a traditional education method in aviation safety. *IEEE Transactions on Visualization and Computer Graphics*, 21, 529-538.

Crescentini, C., & Capurso, V. (2015). Mindfulness meditation and explicit and implicit indicators of personality and self-concept changes. *Frontiers in Psychology*, 6, 44.

Crescentini, C., Matiz, A., & Fabbro, F. (2015). Improving personality/character traits in individuals with alcohol dependence: the influence of mindfulness-oriented meditation. *Journal of Addictive Diseases*, 34, 75-87.

Crescentini, C., Urgesi, C., Campanella, F., Eleopra, R., & Fabbro, F. (2014). Effects of an 8-week meditation program on the implicit and explicit attitudes toward religious/spiritual self-representations. *Consciousness and Cognition*, 30, 266-280.

Delgado, L. C., Guerra, P., Perakakis, P., Vera, M. N., Reyes del Paso, G., & Vila, J. (2010). Treating chronic worry: psychological and physiological effects of a training programme based on mindfulness. *Behaviour Research and Therapy*, 48, 873-882.

Delmonte, M. M. (1984). Physiological responses during meditation and rest. *Biofeedback and Self-regulation*, 9, 181-200.

Delmonte, M. M. (1985). Effects of expectancy on physiological responsivity in novice meditators. *Biological Psychology*, 21, 107-121.

Desrosiers, A., Vine, V., Klemanski, D. H., & Nolen-Hoeksema, S. (2013). Mindfulness and emotion regulation in depression and anxiety: common and distinct mechanisms of action. *Depression and Anxiety*, 30, 654-661.

Didonna, F. (Ed.). (2009). *Clinical handbook of mindfulness*. New York: Springer.

Diemer, J., Mühlberger, A., Pauli, P., & Zwanzger, P. (2014). Virtual reality exposure in anxiety disorders: impact on psychophysiological reactivity. *The World Journal of Biological Psychiatry*, 15, 427-442.

Ditto, B., Eclache, M., & Goldman, N. (2006). Short-term autonomic and cardiovascular effects of mindfulness body scan meditation. *Annals of Behavioral Medicine*, 32, 227-234.

Evans, S., Ferrando, S., Findler, M., Stowell, C., Smart, C., & Haglin, D. (2008). Mindfulness-based cognitive therapy for generalized anxiety disorder. *Journal of Anxiety Disorders*, 22, 716-721.

Fabbro, F., & Muratori, F. (2012). La mindfulness: un nuovo approccio psicoterapeutico in età evolutiva. *Giornale di Neuropsichiatria dell'Età Evolutiva*, 32, 248-259.

Falconer, C. J., Slater, M., Rovira, A., King, J. A., Gilbert, P., Antley, A., et al. (2014). Embodying compassion: a virtual reality paradigm for overcoming excessive self-criticism. *PLoS One*, 9, e111933.

Frijda, N. H. (1986). *The emotions*. Cambridge, UK: Cambridge University Press.

Gamberini, L., Chittaro, L., Spagnolli, A., & Carlesso, C. (2015). Psychological response to an emergency in virtual reality: effects of victim ethnicity and emergency type on helping behavior and navigation. *Computers in Human Behavior*, 48, 104-113.

Garland, E. L., Gaylord, S. A., & Fredrickson, B. L. (2011). Positive reappraisal mediates the stress-reductive effects of mindfulness: an upward spiral process. *Mindfulness*, 2, 59-67.

Gerardi, M., Cukor, J., Difede, J., Rizzo, A., & Rothbaum, B. (2010). Virtual reality exposure therapy for post-traumatic stress disorder and other anxiety disorders. *Current Psychiatry Reports*, 12, 298-305.

Goyal, M., Singh, S., Sibinga, E. M., Gould, N. F., Rowland-Seymour, A., Sharma, R., et al. (2014). Meditation programs for psychological stress and well-being: a systematic review and meta-analysis. *JAMA Internal Medicine*, 174, 357-368.

Gromala, D., Song, M., Yim, J. D., Fox, T., Barnes, S. J., Nazemi, M., et al. (2011). *Immersive VR: A non-pharmacological analgesic for chronic pain?*. Extended Abstracts CHI 2011 (pp. 1171-1176). ACM Press.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: a meta-analytic review. *Journal of Consulting & Clinical Psychology*, 78, 169-183.

Hoge, E. A., Bui, E., Marques, L., Metcalf, C. A., Morris, L. K., Robinaugh, D. J., et al. (2013). Randomized controlled trial of mindfulness meditation for generalized anxiety

disorder: effects on anxiety and stress reactivity. *Journal of Clinical Psychiatry*, 74, 786-792.

Hudlicka, E. (2013). Virtual training and coaching of health behavior: example from mindfulness meditation training. *Patient Education and Counseling*, 92, 160-166.

Imam, B., & Jarus, T. (2014). Virtual reality rehabilitation from social cognitive and motor learning theoretical perspectives in stroke population. *Rehabilitation Research and Practice*, 2014, 594540.

Insko, B. (2003). Measuring presence: subjective, behavioral and physiological methods. In G. Riva, F. Davide, & W. A. IJsselsteijn (Eds.), *Being There: Concepts, effects and measurement of user presence in synthetic environments* (pp. 110-119). Amsterdam, The Netherlands: IOS Press.

Jain, S., Shapiro, S. L., Swanick, S., Roesch, S. C., Mills, P. J., Bell, I., et al. (2007). A randomized controlled trial of mindfulness meditation versus relaxation training: effects on distress, positive states of mind, rumination, and distraction. *Annals of Behavioral Medicine*, 33, 11-21.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: theoretical considerations and preliminary results. *General Hospital Psychiatry*, 4, 33-47.

Kabat-Zinn, J. (1990). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness*. New York, NY, USA: Delacourt.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: past, present, and future. *Clinical Psychology: Science and Practice*, 10, 144-156.

Kabat-Zinn, J., Massion, A. O., Kristeller, J., Peterson, L. G., Fletcher, K. E., Pbert, L., et al. (1992). Effectiveness of a meditation-based stress reduction program in the treatment of anxiety disorders. *American Journal of Psychiatry*, 149, 936-943.

Krygier, J. R., Heathers, J. A. J., Shahrestani, S., Abbott, M., Gross, J. J., & Kemp, A. H. (2013). Mindfulness meditation, well-being, and heart rate variability: a preliminary investigation into the impact of intensive Vipassana meditation. *International Journal of Psychophysiology*, 89, 305-313.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: affective, facial, visceral, and behavioral reactions. *Psychophysiology*, 30, 261-273.

Larsen, J. T., Norris, C. J., & Cacioppo, J. T. (2003). Effects of positive and negative affect on electromyographic activity over zygomaticus major and corrugator supercilii. *Psychophysiology*, 40, 776-785.

Lee, H., Shackman, A. J., Jackson, D. C., & Davidson, R. J. (2009). Test-retest reliability of voluntary emotion regulation. *Psychophysiology*, 46, 874-879.

Lorig, T. S. (2007). The respiratory system. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (pp. 231-244). Cambridge, UK: Cambridge University Press.

Lush, E., Salmon, P., Floyd, A., Studts, J. L., Weissbecker, I., & Sephton, S. E. (2009). Mindfulness meditation for symptom reduction in fibromyalgia: psychophysiological correlates. *Journal of Clinical Psychology in Medical Settings*, 16, 200-207.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, 12, 163-169.

MacCoon, D. G., Imel, Z. E., Rosenkranz, M. A., Sheftel, J. G., Weng, H. Y., Sullivan, J. C., et al. (2012). The validation of an active control intervention for Mindfulness Based Stress Reduction (MBSR). *Behavior Research and Therapy*, 50, 3-12.

McCann, R. A., Armstrong, C. M., Skopp, N. A., Edwards-Stewart, A., Smolenski, D. J., June, J. D., et al. (2014). Virtual reality exposure therapy for the treatment of anxiety disorders: an evaluation of research quality. *Journal of Anxiety Disorders*, 28, 625-631.

McLay, R., Ram, V., Murphy, J., Spira, J., Wood, D. P., Wiederhold, M. D., et al. (2014). Effect of virtual reality PTSD treatment on mood and neurocognitive outcomes. *Cyberpsychology, Behavior and Social Networking*, 17, 439-446.

Meehan, M., Razzaque, S., Insko, B., Whitton, M., & Brooks, F. P., Jr. (2005). Review of four studies on the use of physiological reaction as a measure of presence in stressful virtual environments. *Applied Psychophysiology and Biofeedback*, 30, 239-258.

North, M. M., North, S. M., & Coble, J. R. (1996). Effectiveness of virtual environment desensitization in the treatment of agoraphobia. *Presence-Teleoperators and Virtual Environments*, 5, 346-352.

Parsons, T. D. (2011). Neuropsychological assessment using virtual environments: enhanced assessment technology for improved ecological validity. In S. Brahnam, & L. C. Jain (Eds.), *Advanced computational intelligence paradigms in healthcare: Virtual reality in psychotherapy, rehabilitation, and assessment* (pp. 271-289). Berlin, Germany: Springer-Verlag.

Parsons, T. D., Courtney, C., Cosand, L., Iyer, A., Rizzo, A. A., & Oie, K. (2009). Assessment of psychophysiological differences of West Point Cadets and civilian controls immersed within a virtual environment. In *Foundations of augmented cognition. Neuroergonomics and operational neuroscience* (pp. 514-523). Berlin Heidelberg: Springer.

Patil, I., Cogoni, C., Zangrando, N., Chittaro, L., & Silani, G. (2014). Affective basis of judgment-behavior discrepancy in virtual experiences of moral dilemmas. *Social Neuroscience*, 9, 94-107.

Ray, R. D., McRae, K., Ochsner, K. N., & Gross, J. J. (2010). Cognitive reappraisal of negative affect: converging evidence from EMG and self-report. *Emotion*, 10, 587-592.

Rohde, K., Adolph, D., Dietrich, D. E., & Michalak, J. (2014). Mindful attention regulation and non-judgmental orientation in depression: a multi-method approach. *Biological Psychology*, 101, 36-43.

Rothbaum, B. O., & Hodges, L. F. (1999). The use of virtual reality exposure in the treatment of anxiety disorders. *Behavior Modification*, 23, 507-525.

Rubia, K. (2009). The neurobiology of meditation and its clinical effectiveness in psychiatric disorders. *Biological Psychology*, 82, 1-11.

Schwartz, G. E., Ahern, G. L., & Brown, S. L. (1979). Lateralized facial muscle response to positive and negative emotional stimuli. *Psychophysiology*, 16, 561-571.

Shapiro, S., Schwartz, G. E., & Bonner, G. (1998). Effects of mindfulness-based stress reduction on medical and premedical students. *Journal of Behavioral Medicine*, 21, 581-599.

Slater, M., Khanna, P., Mortensen, J., & Yu, I. (2009). Visual realism enhances realistic response in an immersive virtual environment. *Computer Graphics and Applications, IEEE*, 29, 76-84.

Slater, M., Usoh, M., & Steed, A. (1994). Depth of presence in virtual environments. *Presence*, 3, 130-144.

Solberg, E., Ingjer, F., Ekberg, O., Holen, A., Standal, P. A., & Vikman, A. (2000). Blood pressure and heart rate during meditation. *Journal of Psychosomatic Research*, 48, 283-283.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state-trait anxiety inventory*. Palo Alto, USA: Consulting Psychologists Press.

Spira, J. L., Pyne, J. M., Wiederhold, B., Wiederhold, M., Graap, K., & Rizzo, A. (2006). Virtual reality and other experiential therapies for combat-related post-traumatic stress disorder. *Primary Psychiatry*, 13, 58-64.

Tassinari, L. G., Cacioppo, J. T., & Vanman, E. J. (2000). The skeletomotor system: surface electromyography. In J. T. Cacioppo, L. G. Tassinari, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed., pp. 267-299). New York, NY, USA: Cambridge University Press (Chapter 12).

Thought Technology. (2014). Biograph infiniti. <http://thoughttechnology.com/index.php/software/biograph-infiniti-software-platform.html>.

Tong, X., Gromala, D., Choo, A., Amin, A., & Shaw, C. (2015). The virtual meditative walk: an immersive virtual environment for pain self-modulation through mindfulness-based stress reduction meditation. In R. Shumaker, & S. Lackey (Eds.), *Virtual, augmented and mixed reality* (pp. 388-397). Springer International Publishing. Vol. 9179 of the series lecture notes in computer science.

Van Boxtel, A. (2001). Optimal signal bandwidth for the recording of surface EMG activity of facial, jaw, oral, and neck muscles. *Psychophysiology*, 38, 22-34.

Vidyarthi, J., & Riecke, B. E. (2014). Interactively mediating experiences of mindfulness meditation. *International Journal of Human-Computer Studies*, 72, 674-688.

Wiederhold, B. K., Soomro, A., Riva, G., & Wiederhold, M. D. (2014). Future directions: advances and implications of virtual environments designed for pain management. *Cyberpsychology, Behavior and Social Networking*, *17*, 414-422.

Wolgast, M., Lundh, L. G., & Viborg, G. (2011). Cognitive reappraisal and acceptance: an experimental comparison of two emotion regulation strategies. *Behavioral Research Therapy*, *49*, 858-866.

Young, J. D., & Taylor, E. (2001). Meditation as a voluntary hypometabolic state of biological estivation. *News in Physiological Sciences*, *13*, 149-153.

Zanon, M., Novembre, G., Zangrando, N., Chittaro, L., & Silani, G. (2014). Brain activity and prosocial behavior in a simulated life-threatening situation. *Neuroimage*, *98*, 134-146.

Zeidan, F., Johnson, S. K., Gordon, N. S., & Goolkasian, P. (2010). Effects of brief and sham mindfulness meditation on mood and cardiovascular variables. *Journal of Alternative and Complementary Medicine*, *16*, 867-873.

Mindfulness-Oriented Meditation for Primary School Children: Effects on Attention and Psychological Well-Being

Cristiano Crescentini, Viviana Capurso, Samantha Furlan, and Franco Fabbro

Mindfulness-based interventions are increasingly being used as methods to promote psychological well-being of clinical and non-clinical adult populations. Much less is known, however, on the feasibility of these forms of mental training on healthy primary school students. Here, we tested the effects of a mindfulness-meditation training on a group of 16 healthy children within 7–8 years of age from an Italian primary school. An active control condition focused on emotion awareness was employed on a group of 15 age-matched healthy children from the same school. Both programs were delivered by the same instructors three times per week, for 8 total weeks. The same main teacher of the two classes did not participate in the trainings but she completed questionnaires aimed at giving comprehensive pre-post training evaluations of behavior, social, emotion, and attention regulation skills in the children. A children's self-report measure of mood and depressive symptoms was also used. From the teacher's reports we found a specific positive effect of the mindfulness-meditation training in reducing attention problems and also positive effects of both trainings in reducing children's internalizing problems. However, subjectively, no child in either group reported less depressive symptoms after the trainings. The findings were interpreted as suggestive of a positive effect of mindfulness-meditation on several children's psychological well-being dimensions and were also discussed in light of the discrepancy between teacher and children's reports. More generally, the results were held to speak in favor of the effectiveness of mindfulness-based interventions for healthy primary school children.

INTRODUCTION

Mindfulness is an attribute of consciousness that can be defined as the ability of paying intentional attention to present moment experience with an open, curious and non-judgmental attitude (Brown and Ryan, 2003; Bishop et al., 2004). A core assumption of mindfulness is that people generally live with an “automatic propensity” that often makes

them unaware of their behavioral patterns and of their continuous past- and future-related thoughts and ruminations. This condition of “mindlessness” may contribute to health and psychological problems (e.g., anxiety, depression, emotion dysregulation, and negative mood) (Kabat-Zinn, 1990; Brown and Ryan, 2003; Didonna, 2009; Hölzel et al., 2011). In contrast, mindful awareness, which can be effectively developed through meditation practice, allows individuals to stay in the here and now and to experience present-moment reality with an open and accepting attitude. This can result in more flexible, adaptive behavior with consequent beneficial health effects at both physical and mental levels (Kabat-Zinn, 1994; Davidson et al., 2003; Didonna, 2009).

Since early eighties onward, mindfulness-meditation techniques have shown to be beneficial in the treatment of different clinical disorders such as chronic pain (Kabat-Zinn, 1982; Brown and Ryan, 2003; Didonna, 2009), eating disorders (Kristeller and Hallett, 1999), anxiety and depression (Miller et al., 1995; Teasdale et al., 2000; Hofmann et al., 2010). In addition to its clinical benefits, a growing body of research focused on testing the cognitive effects that appear to result from this form of cognitive/mental training procedure. Thus, the “observe and accept” approach of mindfulness-meditation has been documented to result in better executive functioning and attention regulation abilities (Jha et al., 2007; Malinowski, 2013).

So far, most of the research on mindfulness-meditation has focused on adults, while only recently the interest on children and adolescents has grown (Zoogman et al., 2014). Preliminary studies in this newborn field suggest that mindfulness-meditation trainings have positive effects on children’s and adolescents’ psychological well-being (Biegel et al., 2009; Burke, 2010; Flook et al., 2010; Semple et al., 2010). However, the status of the overall research is still meager especially in the 1st years of primary school and in healthy children (Zoogman et al., 2014).

To date the restricted body of research examining the effects of mindfulness-meditation trainings on adolescents has reported beneficial effects of this practice for pain management (Thompson and Gauntlett-Gilbert, 2008), depressive relapse prevention (Allen, 2006), reduction of anxiety and depressive symptoms (Beauchemin et al., 2008; Biegel et al., 2009; Broderick and Metz, 2009), and in reducing Attention-Deficit/Hyperactivity Disorder

(ADHD) symptoms (Zylowska et al., 2008). Similarly, mindfulness-meditation trainings delivered to children were shown to be useful for reducing anxiety symptoms (Semple et al., 2005; Lee et al., 2008), increasing self-compassion and mindfulness skills (Saltzman and Goldin, 2008), improving social behavior, social skills and attention (Napoli et al., 2005; Saltzman and Goldin, 2008; Semple et al., 2010), reducing ADHD symptoms (Singh et al., 2010), and for improving behavioral regulation, metacognition, and executive functions (Flook et al., 2010). Of importance, if one considers that problems in executive functions are connected with cognitive deficits and with many behavioral disorders like ADHD, as well as with bullying and delinquency (Hughes et al., 2000; Brocki and Bohlin, 2006), then the latter study by Flook et al. (2010) appears particularly relevant. A positive relation was found in this study between improved executive functions observed in children after meditation practice and children's behavioral regulation, global executive control and metacognition. Thus, mindfulness- meditation can promote enhanced focus and concentration that can then reverberate on children's behavioral regulation, socio-emotional development, and academic skills (Napoli et al., 2005; Beauchemin et al., 2008; Flook et al., 2010).

In addition to studies on mindfulness-meditation interventions in school-age children, it is worth noting the existence of recent proposals that aim at incorporating mindfulness elements with social-emotional learning (SEL) curriculum into school psychology practice (Felver et al., 2013). On this view, it is suggested that integrating mindfulness into existing schoolwide SEL programs could enhance the effectiveness of the whole intervention with respect to critical children's social and emotional skills. Moreover, it could help students to maintain focus and clarity and be particularly effective in preventing behavior problems (Felver et al., 2013).

Although extremely valuable, the above mentioned studies on mindfulness-meditation interventions in children have a series of limitations. The majority of these studies have employed no control group (Lee et al., 2008), waiting-list control group (Saltzman and Goldin, 2008) or silent reading control group (Napoli et al., 2005; Flook et al., 2010), rather than active control groups. Furthermore, in these studies children were generally supposed to meditate together with teachers (Napoli et al., 2005) and/or with parents (Saltzman and

Goldin, 2008; Singh et al., 2010) and the evaluation of mindfulness-meditation effects on children's health and behavior was mainly based on parents' and teachers' reports. The possible risk could be that they exaggerated the observed changes just because they also had participated in the meditation course (i.e., inflated/placebo effect). In this respect, to the best of our knowledge, there are no previous studies in which parents' and teachers' reports (compiled before and after having meditated or not with children) have been compared with children's self-reported measures. Finally, most of previous mindfulness-based interventions with young participants have been conducted with middle and high school students. Indeed, only a few studies involved younger children at the 1st years of primary school (see in Burke, 2010; Zoogman et al., 2014). Moreover, among these few studies, one was conducted on a restricted clinical sample of 5 anxious children (7–8 years) with no control group (Semple et al., 2005), while the other two studies were conducted on non-clinical samples but did not involve active control conditions (Napoli et al., 2005; Flook et al., 2010).

Therefore, the aim of the current research was to address these problems by investigating in healthy primary school Italian children (7–8 years of age) the health effects of a mindfulness-oriented meditation (MOM) program compared with an active control condition focused on emotion awareness but not involving meditation exercises. In particular, we focused on outcome measures (i.e., the Child Behavior Checklist and the Conners Rating Scales) aimed at giving comprehensive evaluations of several children's psychological dimensions such as health, cognitive, emotional, social and behavioral processes. While the first outcome measure (i.e., CBCL) is able to distinguish two higher order factors of behavioral problems, namely internalizing and externalizing, the second measure (i.e., the Conners Rating Scales) is particularly appropriate to provide a thorough assessment of attentional functions and related disorders (i.e., ADHD). Of importance, in the current study teachers and parents were not asked to meditate with children and reports from the main teacher of children were collected pre- post trainings together with a children's self-report measure of mood and depressive symptoms. On the basis of the previous body of research mentioned above, we predicted a specific positive effect of MOM versus the control training on attentional functions. Moreover, we expected to find

better or similar effects of MOM versus control trainings with respect to other children's psychological well-being dimensions, such as those measured by both internalizing and externalizing symptoms and behaviors.

MATERIALS AND METHODS

Participants and Setting

Thirty-one children from 2 s year classes of a primary school in the northeast part of Italy (Brugnera, PN) were enrolled in the study. The MOM group was formed by 16 children (eight boys, eight girls) with an age range of 7–8 years ($M = 7.3$, $SD = 0.5$). The control group was formed by 15 children (seven boys, eight girls) also with an age range of 7–8 years ($M = 7.4$, $SD = 0.5$). MOM and control participants were thus matched for age, gender, and education; moreover, children in the two groups had the same ethnic and linguistic background, with every child being Italian mother-tongue. To be included in the study the children had to attend the meetings of the MOM and control trainings for at least six of the eight total weeks (there were three meetings per week). In the MOM group, one child had 3 days of absence, three children had 2 days of absence and two children had 1 day of absence. In the control group, one child had 3 days of absence, one child had 2 days of absence and three children had 1 day of absence. No child was thus excluded from the study.

The two classes were randomly assigned to MOM or active control. Thus, random assignment occurred at the classroom level in the current study. Children's parents were informed about the activities during a meeting that took place in the school about 1 month before the beginning of the courses. All parents gave consent for their children to participate in the study so that recruitment rate was 100% of eligible students. Children of the two groups received no incentive for participation; moreover, they were blind about the study purpose and did not know they were assigned to a specific group. The children only knew they were expected to work with two trainers on some "exercises" (MOM group) or on reading and commenting a book (control group). Teachers of the two classes were also blind to specific study purpose, specific trainings' activities and to expected results. The current research followed ethical guidelines and was approved by the Institutional School

Board of the “Istituto Comprensivo” di Brugnera, in agreement with the University of Udine. The main teacher of the two classes (having 11 h per week in each class) completed the experimental questionnaires (see next section) approximately 5 days before (baseline session) and 8 days after the completion of the two trainings. For each student, the teacher was required to complete one version of each questionnaire. No teacher was in the classroom during MOM or control trainings. The main teacher just introduced the two instructors (who were the same for the MOM and control trainings) to the classes before the first meeting of the two trainings. The trainings took place in the two classes during school hours. In the same days of the week, children of one class undertook the MOM training and the other class undertook the control training. Both trainings were delivered by the same instructors. The order of MOM and control trainings was randomized.

Assessment Measures

In this study, we employed two reports from the main teacher and one children’s self-report measure. Each measure was collected to compute possible changes in children’s psychological well-being due to participation in MOM or control trainings. Two different teacher’s paper and pencil measures were used: the Italian versions of the Child Behavior Checklist-Teacher Report Form (CBCL-TRF; Achenbach and Dumenci, 2001; Achenbach and Rescorla, 2001; Italian edition: Frigerio, 2001) and the Conners Teachers Rating Scales – Revised (CTRS-R; Conners, 1997; Italian edition: Nobile et al., 2012). As already mentioned in the Introduction, while there is some overlap in outcomes assessed by the two measures, their combined use appears important to get a better picture of the effects on children’s psychological health caused by the MOM and control trainings. On the one hand, the CBCL-TRF is especially focused on emotional, social and behavioral problems, distinguishing between internalizing and externalizing problem scores within the subject. On the other hand, the CTRS-R is more focused on inattention and ADHD symptoms and is broadly used for the clinical assessment of childhood attentional problems. Moreover, in the context of mindfulness-meditation studies in children, the sole use of the CBCL to test the effectiveness of mindfulness interventions on attentional problems was considered not sufficient (Semple et al., 2010).

The CBCL (Achenbach, 1991; Achenbach and Dumenci, 2001; Achenbach and Rescorla, 2001) is a well-standardized inventory with good reliability and validity (Rescorla et al., 2007; see also Berubé and Achenbach, 2010 and Ang et al., 2012 bibliography). The CBCL-TRF consists of 113 problem-behavior items providing subscores for eight specific problem scales: Anxiety/Depression, Withdrawal/Depression, Somatic Complaints, Social Problems, Thought Problems, Attention Problems, Rule-Breaking Behavior, and Aggressive Behavior. The CBCL-TRF also provides scores for the Total Problems Scale, the Internalizing Problems Scale (expressing an overall *T*-score calculated from the sum of the raw scores of the first three specific problem scales mentioned above), and the Externalizing Problems Scale (giving an overall *T*-score calculated from the sum of the raw scores of the last two specific problem scales). Raw scores for each scale were converted into *T*-scores ($M = 50$, $SD = 10$), based on an original standardization sample of 2,368 children between the ages of 6 and 18 years (Achenbach and Dumenci, 2001; Achenbach and Rescorla, 2001). The teacher rated each child's behavior on a 3-point scale: 0-Not true (as far as you know), 1-Somewhat or sometimes true, 2-Very true or often true. Scale scores were converted to *T*-scores using age and gender-based norms.

The CTRS-R scale is a 59-item scale with good reliability and validity (Conners et al., 1998; see also Conners, 1997; Nobile et al., 2012). The teacher form of the scale is appropriate for children from 6 to 18 years of age. The CTRS-R measures six types of problems/behaviors: Oppositional, Cognitive Problems/Inattention, Hyperactivity, Anxious-Shy, Perfectionism, and Social Problems. Moreover, the scale has comprehensive symptom coverage for attention deficit/hyperactivity disorder (ADHD), a restless/impulsive scale, an emotional lability scale as well as a "DSM-IV: Inattention" score and a "DSM-IV: Hyperactivity" score (Diagnostic and Statistical Manual of Mental Disorders 4th Edition; American Psychiatric Association [APA], 2000). As for the CBCL-TRF, raw scores from the items of the CTRS-R were converted for each scale into *T*-scores, using age and gender-based norms. *T*-scores are standardized scores with a mean of 50 and a standard deviation of 10. Responses to statements are Likert-type (0 = not true at all, 3 = very much

true). Original scale standardization was based on data from teachers of 1,973 children aged 3–17 (Conners, 1997).

A short questionnaire was used as children's self-report measure: the Short Mood and Feelings Questionnaire (SMFQ, Angold et al., 1995), child version (age 7–16). In particular, the SMFQ is a 13-item scale whose questions are based on the DSM-III criteria for depression and it measures a unidimensional construct of depressive symptoms (Sharp et al., 2006). Responses are Likert-type (0 = not true at all, 2 = very much true) and total score is obtained by summing each item, with a range from 0 to 26, with higher scores denoting higher depressive symptoms (Angold et al., 1995).

Procedures of the Mindfulness-Oriented Meditation and Active Control Trainings

The MOM training consisted of an 8-week intervention conducted by two mindfulness-meditation instructors with several years of experience with this technique and with education settings (VC and SF). The training was inspired by previous 8-week MOM interventions for clinical and non-clinical adult populations (Fabbro and Muratori, 2012; Campanella et al., 2014; Crescentini et al., 2014, 2015), which were in turn based on the Mindfulness Based Stress Reduction protocol (MBSR; e.g., Kabat-Zinn, 1990, 2003).

The current MOM training was specifically adapted for children and consisted of three meetings per week for a total of 8 weeks. In line with previous mindfulness-meditation programs for healthy children (e.g., Flook et al., 2010), an important characteristic of the MOM training was that meditation periods gradually increased over the 8 weeks (see **Table 1** for an overview of the MOM and control trainings with a brief description of the activities included in each meeting). For the first 2 weeks, the MOM training lasted approximately 30 min per week (i.e., 10 min for each meeting). During week 3 and week 4 it lasted about 45– 55minanditreachedadurationof1handahalfattheendof the course (week 8). The reason for such adaptations of original MOM trainings (which may include meditation sessions of more than 30 min since the first meeting) was the still immature attentional capacity of children aged 7 or 8 years and their difficulty to engage in a single activity for long periods of time (Posner and Petersen, 1990; Siegler, 1991; see also Semple et al., 2010).

Each meeting was divided into a series of three meditation exercises, which focused on three types of activities: (i) mindfulness of breathing, (ii) mindfulness of body parts, (iii) and mindfulness of thoughts. In more details, the three meditation activities were proposed to children as exercises or “games” that were meant to promote awareness of the three aspects of the self, related to breath, body parts and thoughts. In each of the 3 weekly meetings children were first required to concentrate on breath refraining from actively controlling it. In the second meditation exercise they had to kindly focus their attention on different body parts. In the last activity children were encouraged to observe the stream of their thoughts and emotions. Children were supported in carrying out these exercises through the use of tools or mental images. For example a pencil case on the belly was used to better focus and observe the breath, while imaging thoughts as soap bubbles, sea waves or clouds was believed to help children experiencing and understanding the transitory process of thoughts. During the body contemplation exercises, we also used meditation in movement whereby children were asked to mindfully explore their body while they were walking imaging that the floor was made of sand or grass. In each meditation activity, children were encouraged to gently draw attention back to the task without judging themselves when they noticed that their attention was wandering. After each meditation exercise there was a debriefing phase in which trainers explained the next exercise and children could express their feelings and questions about the exercise just completed. Globally, the debriefing phase lasted approximately half the phase dedicated to meditation exercises.

The activities of the control group were designed to be comparable and structurally equivalent to those of the MOM training (see MacCoon et al., 2012 for a discussion and proposal of active control interventions in mindfulness-meditation studies on adults). Thus, similarly to the MOM course, the control training was also organized in a group format of a series of three meetings per week for 8 total weeks. Control participants completed the same amount of class practice as the children in the MOM group.

The activities of the control group consisted in reading and commenting the different chapters of the book: *Six pixies in my heart* (“Sei folletti nel mio cuore”, Corallo, 2011). The book is divided into 21 chapters, so that, based on the number of pages, two or three

chapters were presented to children each week. *Six pixies in my heart* is about a shy and sensitive child deciding to start a path to avoid all his emotions with the aim of not being defined “sensitive” from his friends and school mates. However, at the end of the book, the child learns the importance of feeling positive and negative emotions in his heart and appreciates the fact of being sensitive (see **Table 1** for a brief description of the activities included in the control training).

Similarly to the organization of meetings in the MOM group, each meeting for the control group was divided in a reading part and a discussion part. Duration of reading and commenting parts followed the same progression used in the MOM course: they gradually increased over the 8-week period, starting from 30 min per week during week 1 to reach 1 h and a half per week at the end of the course. The activities of listening and commenting the stories reported in the chapters allowed children to discover all the different emotions and feelings that can be experienced in different situations. This was an indirect training on emotion awareness and acceptance since it implicitly encouraged children to consider their own emotions. In the MOM group instead, children were explicitly asked to focus attention on breath, mind, and body in order to observe and accept any arising feeling, emotion, and thought. In sum, the control training shared several crucial elements with the MOM training, including specific active ingredients (MacCoon et al., 2012) meant to enhance psychological well-being of children but designed to be non-specifically related to the practice of mindfulness. These active ingredients were timing and setting, the group work, the interaction between students and trainers, and the conditions of silence and concentration that were required to children. It should be noted that silent reading/listening (without comment and discussion) has often been used for adults and children as control training condition, or as an activity included in other active control trainings (MacCoon et al., 2012), in mindfulness- meditation studies (Napoli et al., 2005; Flook et al., 2010; Zeidan et al., 2010). Of importance, an effect of silent reading/listening in enhancing participants’ mood but not executive function was found in these previous studies. To conclude, the present control training appeared appropriate as an active control condition for MOM research in children.

TABLE 1 | Overview of the activities included in the MOM and active control training conditions.

Week	Timing per day (min)	Timing per week (min)	Mindfulness-oriented meditation (MOM)	Active control condition
1	9	27	<ul style="list-style-type: none"> Feeling the abdomen moving while breathing. Listening to the sounds of the body after a run. Observing thoughts as they were clouds in the sky. 	Chapter 1–2 Following the protagonist's story, try to listen to the heart and try to feel the emotions laying inside.
2	12	36	<ul style="list-style-type: none"> Feeling the hand on the abdomen while breathing. Slowly walking in the class feeling every single part of the leg moving. Trying to see the main thought – the main cloud - in the mind and writing it down on paper. 	Chapter 3–4–5 Try to associate the feelings with the pixies described in the book.
3	15	45	<ul style="list-style-type: none"> Feeling a mate's breath putting the hands on his/her abdomen. Taking a mate's hand and feeling the contact. Trying to feel the emotions related to the main thought of the moment. 	Chapter 6–7 Try to find the pixies that lay in our heart in the different situations.
4	18	54	<ul style="list-style-type: none"> Trying to feel the breath in the nose, without controlling it. Touching the different parts of the face. Trying to see the path of a thought: where it comes from and how it disappears. 	Chapter 8–9 Express the feelings related to the emotions laying in the heart.
5	21	63	<ul style="list-style-type: none"> Trying to think the word "in" when air enters the nose, "out" when air comes out from the nose. Imaging an object and drawing it. Then observing the chosen object in details and drawing it again. Drawing a mate or a relative and mentally addressing some friendly wishes to the mate (peace, happiness, health). 	Chapter 10–11–12 Try to draw the emotions of the moment.
6	24	72	<ul style="list-style-type: none"> Trying to feel the difference of breath by putting the hands on the throat, on the chest, on the abdomen. Raisin meditation: trying to smell, watch, and touch the raisin before eating it. Silently watching the eyes of the mates. Trying to understand their thoughts. 	Chapter 13–14–15 Try to draw where the emotion found in the heart comes from.
7	27	81	<ul style="list-style-type: none"> Feeling the points that air touches when it comes in and out. Imaging to be an animal and moving like it. Visualizing thoughts as a masquerade parade. Observing them and noticing that they are external to the person. 	Chapter 16–17–18 Try to draw the path of the emotions: where they come from and where they go, if they disappear.
8	30	90	<ul style="list-style-type: none"> Imaging a little man in the nose that moves, following the air coming in and out. Laying down pretending to be a paper and imaging to scan the body, as if you were in a copying machine. Visualizing thoughts as a masquerade parade, drawing them and observing the differences between thoughts and drawing. 	Chapter 19–20–21 Try to find a still and quiet place in the heart to enter when feeling overwhelmed by emotions.

A brief description of the activities is given for each week. Activities remained constant for the three meetings of a given week. Chapter in the active control condition refers to chapters of the Six pixies in my heart book (Corallo, 2011).

Statistical Methods

The data were analyzed with Statistica 8 (StatSoft, Inc, Tulsa, OK). *T*-scores were used for the CBCL-TRF and the CTRS- R scales and subscales while raw scores were used for the children's self-report measure (SMFQ). For the CTRS-R and CBCL-TRF measures, separate multivariate analyses of variance (MANOVAs) were performed to determine whether children from the MOM group differed significantly in their behaviors from children from the control group. More specifically, for the CBCL-TRF measure we focused on the two broadband factors of internalizing and externalizing behavioral problems as well

as on the scores of total behavioral problems (see McFarlane et al., 2003 for a similar approach to CBCL data). The analysis included Group (MOM, controls) as between-subject factor and the pre-post trainings internalizing, externalizing, and total behavior problems scales as dependent variables. For the CTRS-R scale, the MANOVA included Group as between-subject factor and, as dependent variables, it specifically focused on the factors that most directly map onto the ADHD and oppositional spectrum of behaviors in the DSM-IV (see Purpura and Lonigan, 2009 for a similar approach to the CTRS scale). The analysis included the data from the following scales: oppositional behaviors, cognitive problems/inattention, hyperactivity, ADHD index, CGI restless/impulsive behaviors, DSM-IV: Inattention, and DSM-IV: Hyperactivity. In all analyses, significant main-effects and interactions were followed-up with univariate pair-wise comparisons (with Bonferroni correction for multiple comparisons applied). Finally, for the SMFQ data we ran a mixed model analysis of variance (ANOVA) involving the within-subject factor of TIME (pre-training, post-training) and the between-subject factor of Group (MOM, controls). The significance threshold of $p < 0.05$ was used in all statistical tests. In the analyses, effect sizes are reported as η^2p .

RESULTS

Teacher's Report: Child Behavior Checklist-Teacher Report Form *T*-scores for both groups of children are shown in **Table 2** for each problem scale and subscale of the CBCL-TRF (i.e., total problems, internalizing problems and externalizing problems scales considered in the following MANOVA, and the eight specific problem scales). At both testing sessions (i.e., before and after the trainings), children's mean *T*-scores appeared to be in the normal range. In the CBCL-TRF, *T*-scores less than 67 and less than 60 are indeed considered in the normal range, respectively, for the eight syndrome scales and for the total problems, externalizing problems, and internalizing problems scales (Achenbach and Dumenci, 2001; Achenbach and Rescorla, 2001).

A MANOVA was performed on internalizing, externalizing, and total behavior problems scores between children from the MOM and the control groups. The analysis included the scores measured both before and after the trainings (i.e., the factor of TIME at

two levels: pre- and post-training). Results indicated that there were no significant differences between groups [$F(3,27) = 0.91, p = 0.450; \eta^2p = 0.091$] and that the Group factor did not interact with the TIME factor [$F(3,27) = 0.15, p = 0.927; \eta^2p = 0.016$]. However, the main effect of TIME was significant [$F(3,27) = 3.69, p = 0.024; \eta^2p = 0.291$] indicating lower scores globally on the three scales at post- versus pre- training (**Table 2**). After adjusting α to 0.017 (i.e., a Bonferroni correction of three was applied) to control for an inflated type I error, planned pair-wise comparisons showed that this effect was due in particular to total behavior problems [$F(1,29) = 10.77, p = 0.002$] and more marginally to internalizing behaviors [$F(1,29) = 6.13, p = 0.019$] [$F(1,29) = 2.38, p = 0.133$ for externalizing behaviors]. Thus, the data from the CBCL-TRF highlighted the effectiveness of both types of trainings in reducing total behavior problems and, more marginally, internalizing problems.

Teacher’s Report: Conners Teacher Rating Scale-Revised (CTRS-R) As already mentioned, CTRS-R was chosen because of its appropriateness for the study of Children’s attentional functions and related disorders (i.e., ADHD). Accordingly, among the behavior and symptoms covered by the CTRS-R, we focused the analysis specifically on the scales related to attention function/ADHD symptoms. The analysis did not include the scales overlapping to some extent with the types of problems (e.g., internalizing problems) already assessed by the CBCL-TRF (i.e., Anxious-Shy, Perfectionism, Social Problems, CGI-Emotional Lability, and CGI-Total scales). *T*-scores for both groups of children are shown in **Table 3** for each scale and index of the CTRS-R (i.e., the Oppositional, Cognitive Problems/Inattention, Hyperactivity, ADHD index, DSM-IV: Inattention, DSM-IV: Hyperactivity, CGI-Restless/Impulsive scales considered in the following MANOVA and the Anxious-Shy, Perfectionism, Social Problems, CGI-Emotional Lability, and CGI-Total scales). Children’s mean *T*-scores can be classified in the normal range as all of them were less than the threshold value of 60 (Conners, 1997).

The MANOVA was performed between children from the MOM and control groups on scores obtained in the scales measuring oppositional, cognitive problems/inattention, hyperactivity, ADHD index, CGI restless/impulsive, DSM- IV: Inattention, and DSM-IV:

Hyperactivity behaviors. The analysis included the scores measured both before and after the trainings. Results indicated that there were no significant differences between groups [$F(7,23) = 0.93, p = 0.503; \eta^2p = 0.220$]. The main effect of TIME was also non-significant [$F(7,23) = 2.07, p = 0.089; \eta^2p = 0.386$]; however, the two- way TIME \times Group interaction was significant [$F(7,23) = 3.12, p = 0.018; \eta^2p = 0.487$]. After adjusting α to 0.007 (i.e., a Bonferroni correction of seven was applied), planned pair-wise comparisons showed no pre-post training significant differences in any of the seven scale scores for children from the control training [all $F(1,29) < 0.85, p > .350$]. Nevertheless, MOM children showed reduced scores after the training for the following scales: Cognitive Problems/Inattention [$F(1,29) = 8.63, p = 0.006$], ADHD index [$F(1,29) = 16.27, p = 0.001$], and CGI restless/impulsive [$F(1,29) = 23.80, p = 0.001$]. There was also a trend for the DSM-IV: Inattention scale [$F(1,29) = 6.32, p = 0.017$]. For the remaining three scales (Oppositional, Hyperactivity, and DSM-IV: Hyperactivity) there was no reliable change in the scores due to participation in the MOM course [all $F(1,29) < 3.76, p > 0.061$] (**Table 3**).

Overall, the results indicated a specific effect of the MOM training in reducing problems associated with ADHD and in particular those concerning inattention.

TABLE 2 | Mean T-scores and standard deviations (in parentheses) obtained by children in the MOM and control groups in the two testing sessions (i.e., before and after the trainings).

CBCL-TRF	Pre-training MOM group M T-score (SD)	Post-training MOM group M T-score (SD)	Pre-training control group M T-score (SD)	Post-training control group M T-score (SD)
I. Anxious/Depressed	59.88 (8.53)	59.19 (7.73)	54.53 (4.91)	54.53 (4.51)
II. Withdrawn/Depressed	56.31 (6.21)	55.63 (5.43)	57.33 (6.25)	56.20 (6.31)
III. Somatic complaints	53.13 (4.30)	52.69 (4.23)	51.87 (4.24)	51.60 (4.22)
IV. Social Problems	55.56 (5.81)	54.94 (5.37)	55.13 (5.76)	54.93 (5.56)
V. Thought Problems	52.50 (4.85)	52.50 (4.85)	50.93 (2.46)	50.93 (2.46)
VI. Attention Problems	53.94 (5.01)	52.81 (3.63)	52.27 (3.61)	52.27 (3.61)
VII. Rule-breaking behavior	53.69 (5.51)	52.88 (4.16)	54.33 (4.49)	53.60 (4.53)
VIII. Aggressive behavior	54.06 (4.31)	53.88 (4.09)	55.53 (4.58)	55.27 (4.18)
Internalizing problems** (I+II+III)	57.25 (9.56)	56.38 (9.20)	53.93 (7.08)	53.27 (6.77)
Externalizing problems (VII+VIII)	51.88 (7.32)	51.06 (7.22)	53.80 (6.51)	53.47 (6.23)
Total score* (IV+V+VI+Internalizing+ Externalizing +Other problems [§])	53.06 (8.59)	51.75 (7.77)	52.00 (5.58)	51.00 (6.69)

CBCL-TRF stands for Child Behavior Checklist-Teacher Report Form; [§] The Other problems scale refers to 17 items that are not computed as a single scale but are involved in the computation of the Total score; * Indicates the scales for which significant effects were found in the MANOVA analysis after the application of a Bonferroni correction for multiple comparisons; ** Indicates the scales for which marginally significant effects were found in the MANOVA analysis after the application of the Bonferroni correction (see main text for further details). Scales I through VIII were not individually analyzed but the data are still reported in the table.

TABLE 3 | Mean T-scores and standard deviations (in parentheses) obtained by children in the MOM and control groups in the two testing sessions (i.e., before and after the trainings).

CTRS – R	Pre-training MOM group M T-score (SD)	Post-training MOM group M T-score (SD)	Pre-training control group M T-score (SD)	Post-training control group M T-score (SD)
Oppositional	49 (6.76)	48.81 (7.12)	49.46 (5.99)	48.8 (5.11)
Cognitive Problems/Inattention*	49.81 (8.63)	47.75 (5.49)	45.73 (3.01)	45.6 (2.84)
Hyperactivity	48.37 (6.84)	47.87 (6.39)	47.2 (5.33)	47.13 (5.71)
Anxious-Shy	48.56 (9.23)	47.12 (8.13)	44.06 (4.23)	43.26 (3.89)
Perfectionism	45.81 (7.79)	45.12 (7.01)	44.26 (5.67)	43.46 (4.47)
Social Problems	53.12 (9.72)	52 (8.54)	51.06 (5.75)	50 (6.30)
ADHD Index*	48.06 (6.60)	46.37 (4.93)	46.33 (5.15)	46.46 (5.22)
DSM-IV: Inattention**	50.68 (10.16)	48.75 (6.64)	46.73 (5.02)	46.53 (5.04)
DSM-IV: Hyperactivity	47.50 (4.85)	47.31 (4.46)	46.93 (5.25)	47 (5.81)
CGI: Restless-Impulsive*	48.25 (6.90)	46.62 (6.14)	45.86 (5.26)	45.73 (5.11)
CGI: Emotional Lability	49.87 (7.75)	48.06 (6.58)	46.13 (5.19)	46 (5.19)
CGI: Total	48.5 (7.08)	46.81 (6.36)	45.66 (5.17)	45.46 (4.88)

CTRS-R stands for Conners Teacher Rating Scale-Revised; ADHD stands for Attention deficit/hyperactivity disorder; CGI stands for Conners Global Index; DSM-IV stands for Diagnostic and Statistical Manual of Mental Disorders 4th Edition. * Indicates the scales for which significant effects were found in the MANOVA analysis after the application of a Bonferroni correction for multiple comparisons; ** Indicates the scales for which marginally significant effects were found in the MANOVA analysis after the application of the Bonferroni correction (see main text for further details). The anxious-shy, perfectionism, social problems, CGI: Emotional Lability, and CGI: Total scores were not individually analyzed but the data are still reported in the table.

Children’s Self-Report: Short Mood and Feelings Questionnaire Short Mood and Feelings Questionnaire scores for both groups of children are shown in **Table 4**. One child of the MOM group was absent during compilation of the self-report measure at posttest; this left 15 children in both groups for the SMFQ. The 2 (TIME: pre-training, post-training) \times 2 (Group: MOM, controls) ANOVA did not show significant main effects of TIME [$F(1,28) = 0.94, p = 0.338; \eta^2p = 0.032$] and Group [$F(1,28) = 0.55, p = 0.464; \eta^2p = 0.019$] or the interaction between these two factors [$F(1,28) = 0.12, p = 0.722; \eta^2p = 0.004$] (**Table 4**). Thus, no child in either group reported significantly decreased SMFQ scores (i.e., denoting less depressive symptoms) after the trainings.

Globally for the teacher's reports, the data showed specific positive effects of the MOM training in reducing problems associated with ADHD such as inattention and a beneficial effect of both trainings in reducing internalizing and emotional problems. However, subjectively, the children in the MOM or control groups did not report better mood or less depressive symptoms after the trainings.

TABLE 4 | Mean and standard deviations (in parentheses) obtained by children in the MOM and control groups in the two testing sessions (i.e., before and after the trainings).

	Pre- training MOM group <i>M (SD)</i>	Post- training MOM group <i>M (SD)</i>	Pre- training control group <i>M (SD)</i>	Post- training control group <i>M (SD)</i>
SMFQ	5.60 (3.98)	5.20 (3.12)	6.60 (2.97)	5.73 (3.21)

SMFQ stands for Short Mood and Feeling Questionnaire- short version.

DISCUSSION

The aim of the present study was to evaluate the effects of an 8-week MOM training on healthy primary school children. To this end, we used both reports from the children's main teacher (CBCL-TRF and CTRS-R) and a children's self-report measure (SMFQ). Moreover, we compared the MOM training with an active control condition. The control group engaged in a work on emotion awareness and recognition, with modalities similar to those used in the MOM training. Based on reports from the teacher, we found specific positive effects of the MOM training in reducing problems associated with ADHD such as inattention (cf. see Teacher's Report: Conners Teacher Rating Scale-Revised (CTRS-R)). Moreover we also found beneficial effects of both trainings in reducing children's internalizing problems such as anxiety (cf. see Teacher's Report: Child Behavior Checklist-Teacher Report Form). However, subjectively, the children in the MOM or control groups did not report better mood or less depressive symptoms after the trainings (cf. see Children's Self-report: Short Mood and Feelings Questionnaire.).

Overall, the present findings significantly extend prior research on mindfulness-

meditation on children's and adolescents' psychological health (Napoli et al., 2005; Zylowska et al., 2008; Flook et al., 2010; Semple et al., 2010), by showing positive effects of a MOM training on the attentional skills, ADHD symptoms and emotional functions of a group of healthy primary school children. To the best of our knowledge, the present study is the first to compare, in healthy children of this age, mindfulness-meditation training with a structurally equivalent active control condition focused on emotions awareness and recognition. In particular, the specific experimental design used in the current study allowed us to observe similar positive effects of MOM and active control on children's total and internalizing problems (i.e., the significant effect of TIME together with the non-significant TIME \times Group interaction for the CBCL-TRF), together with the superior effect of MOM for children's attentional functions (i.e., the significant TIME \times Group interaction in the CTRS-R scales measuring attentional skills).

Thus, the current study confirms and extends to primary school children the crucial role of attention in MOM interventions (Zylowska et al., 2008; Flook et al., 2010; see also Malinowski, 2013 for a recent review on mindfulness and attention in adults). It has been argued that self-regulation of attention is a fundamental element of MOM and a prerequisite for the development of other related components. One of these components through which mindfulness-meditation exerts its positive health effects is thought to be emotion regulation (Hölzel et al., 2011; Malinowski, 2013). On this view, the current study may thus indirectly lend support to the idea that mindfulness- meditation facilitates emotion awareness and regulation via increased ability to allocate attentional resources and to monitor the content of one's own present-moment emotional experience. Following this hypothesis, the children will gain a better ability to notice and accept any arising emotions, decreasing the tendency to overreacting or avoiding them. Nevertheless, while this possibility may account for the positive effects of the MOM training on children's internalizing and emotional problems, it may not be sufficient to explain the similar effects obtained in the control group. While children in the MOM group had a specific training on attention, the control children made a specific work on emotions awareness and recognition that required them to draw their own conclusions about the importance of emotions in people's lives. Following the conversational approach to theory of mind (Dunn et al., 1991;

Lecce et al., 2014), it is possible that reading and commenting the different chapters of the *Six pixies in my heart* book about the protagonist's emotions and mental states was sufficient for children to relate these experiences to their own feelings and emotions.

An important aspect of the present study concerns the discrepancy between the main teacher's reports of reduced internalizing problems observed after both trainings and the absence of any improvement in mood and depressive symptoms as reported by children. A first possibility for this discrepancy is that children may have experienced difficulties in self-reporting due to their not yet fully developed introspective, metacognitive abilities. During meditation, for example, such abilities could favor a detached, positive view of the emotional content of present-moment experience (i.e., detachment or decentering, a fundamental mechanism of mindfulness-meditation, Shapiro et al., 2006; Hölzel et al., 2011). More in particular, it has been argued that, in the earlier stage of the practice, mindfulness- meditation would act as a top-down emotion regulation strategy involving cognitive reappraisal of negative emotions that could not be fully developed and introspectively accessible by children (e.g., McRae et al., 2012; Chiesa et al., 2013). An alternative explanation is to consider teacher's reports of internalizing symptoms as inherently weaker than children's reports of the same problems. Besides the fact that individuals are typically more accurate self-reporters of internalizing symptoms than parents or teachers, there is evidence that teachers tend to view internalizing symptoms as less problematic possibly because of their "intropunitive", rather than overtly or disruptive, character (Tandon et al., 2009). In other words, the teacher's reports were based on behavioral observations while the children's report was based on subjective experience of emotions. This difference, especially when interpreted in light of the finding of the effects of the MOM training in reducing ADHD-related problems, may suggest that the MOM training could have been particularly effective in changing behavior problems (other than externalizing disorders) rather than the subjective mood of children in the age group studied. A third possibility can be put forward to explain the lack of change observed in the children's self-report measure of mood and depressive symptoms (SMFQ). With a range of SMFQ scores being 0–26 and baseline scores for each group being between 5 and 6, the lack of findings could be due to a floor effect for this measure.

Thus, a number of alternative hypotheses can be proposed to explain the discrepancy between teacher's and children's reports as well as the specific effects and mechanisms of action of the MOM versus the control trainings. Nonetheless, it should be noted that on the basis of the available data, it is not possible to disentangle these possibilities. Careful comparison of these alternatives awaits future research. Moreover, it should be noted that the present study only focused on mood and feelings when trying to compare the effects of the two trainings from the perspective of the main teacher and from that of the children. Future studies collecting self-report measures of attention are needed to clarify whether the discrepancy between the main teacher's reports and the children's reports occurs also for attentional functions.

Overall, the present findings point to the feasibility and utility of interventions based on mindfulness-meditation in educational contexts involving healthy primary school students by showing positive influences of this form of mental training on several dimensions of children's psychological well-being. Nevertheless, a number of limitations and suggestions for future research also need to be considered. The first limitation of the current research is the restricted sample size, which although being similar or larger to that of many other studies on mindfulness-based interventions on children and adolescents (Burke, 2010; Zoogman et al., 2014), suggests replication and extension of current findings to larger samples. Moreover, a randomized design at the individual student level rather than at the classroom level would allow one to control for a possible confound due to differences between the classrooms.

Other issues pertain to the type of experimental material and type of trainings used. First of all, in light of the number of alternative hypotheses that can be proposed to explain the discrepancy between teacher's and children's reports, it is advisable that future studies will try to extend the present findings by comparing teachers' and/or parents' reports with other children's subjective, self-report measures of attention, mindfulness and psychological health changes. For example, available mindfulness scales such as the Child and Adolescent Mindfulness Measure (CAMM, Greco et al., 2011), which is suitable for children aged 6–18 years, could be used and the possible changes in children's mindfulness skills could be related to measures of psychological well-being and academic achievements.

Indeed, it was shown that CAMM scores are positively correlated with quality of life, academic competence, and social skills and negatively correlated with somatic complaints and internalizing and externalizing problems in children (Greco et al., 2011). Physiological measures of stress reduction assessing, for instance, hormones levels, heart rate, or blood pressure could also be used in children both before and after MOM trainings. Moreover, the specific effect of MOM on children's attentional functions suggests that future studies may support teacher's reports with other measures of attention directly collected from children, for instance in the forms of self-report measures or more objective computerized tests such as the Attentional Network Test (ANT, Fan et al., 2002; see Rueda et al., 2004 for the child version of the ANT). This test allows evaluating the function of three distinct attentional networks (alerting, orienting, and executive control), which have been shown to be positively affected by mindfulness meditation in adults and adolescents (e.g., Zylowska et al., 2008; Malinowski, 2013). Future studies may also try to combine the ANT with other behavioral measures of attention and executive functions already explored in past studies of mindfulness meditation in children and adolescents such as the Stroop task and the Trail Making Test (Napoli et al., 2005; Zylowska et al., 2008; Van de Weijer-Bergsma et al., 2012).

The positive effects of MOM on attention and ADHD symptoms, as well as on other behavior problems (e.g., internalizing problems), encourage future applications of mindfulness-based therapies in ADHD, and possibly other disorders, in developmental age. In particular ADHD is a complex and multidimensional disorder on which mindfulness-based interventions have positive effects in terms of better attentional functions and reduced impulsivity, stress, anxiety, and depression symptoms (Zylowska et al., 2008; Van de Weijer-Bergsma et al., 2012). The present MOM training already included some key elements (e.g., walking meditation or exercises of wishing well to self and others) taken from these past mindfulness-based interventions in young ADHD individuals, but it could be further adapted for ADHD samples including, for example, parallel mindful parenting training for parents (e.g., Van der Oord et al., 2012), or asking parents to meditate with their children (Zylowska et al., 2008; Van de Weijer-Bergsma et al., 2012). Moreover, children with ADHD could be helped with shorter meditation sessions, with a stronger

emphasis on impact of mindful awareness in everyday life, and using didactic visual aids to explain mindful awareness concepts (see Zylowska et al., 2008 for a detailed report of mindfulness-meditation in ADHD).

From another perspective, it may be important for future studies to collect parents' reports in addition to the teacher's reports and compare these reports with those from the children. In our research we decided not to include the parents' reports, only focusing on the teacher's reports, because we hypothesized that the parents' reports could be affected if the children shared with them the experience gained during the MOM course. Future studies may overcome this limitation of the present study by collecting reports from both parents and teachers, and directly from the children, and asking different groups of children to meditate (or carrying out the activities of the active control training) only with the instructors or even with their teachers and parents.

With regards to MOM and control trainings, other issues are worth discussing. A general limitation involving both trainings concerns the lack of a follow-up examination. This lack precludes any precise knowledge of the duration of the changes observed in MOM and control children. Another issue pertains to the physical activity and movement component of the MOM intervention that was not included in the active control condition. We believe that this difference did not have any impact on our outcome measures. Movement was indeed a minimal, secondary part of the MOM training and was conceived as a way to enhance awareness of the body rather than as a mere physical exercise. In line with this, recent evidence suggests that the strength of MOM interventions lies more in the acquisition of self-regulatory skills (e.g., attentional control) than in physical movement. For example, when yoga training – integrated with meditation and breath awareness exercises – was compared to physical education programs in school contexts, yoga showed more pronounced positive effects than physical education on several psychosocial well-being measures (e.g., negative affect, anxiety, mood, and mindfulness; Noggle et al., 2012). Despite these findings and the marginal role of the movement component in our MOM training, it is desirable that future studies compare MOM trainings with other active control conditions such as relaxing activities (e.g., muscular relaxation or relaxation with music) or yoga, or with other health enhancement procedures (MacCoon et al., 2012), which can be

suitable for children. Yet another issue that could be addressed more systematically by future research concerns the duration of meditation exercises and number and frequency of meditation sessions in children. In line with other studies on the effects of mindfulness meditation in children (e.g., Flook et al., 2010; Semple et al., 2010; Zoogman et al., 2014; see also Harnett and Dawe, 2012), we showed that gradually increasing length of sessions and duration of structured practices (in addition to having more weekly sessions than in a typical MOM program with adults) led to significant positive effects on children's psychological health. However, the fact that we have systematically assessed the changes only at the end of the course rather than during it, for example once every 2 weeks, does not allow us to easily identify an ideal amount of time for mindfulness practice in our group of children. We believe, however, that the question of the duration of MOM practices and interventions in children is very important; this is an issue that deserves more systematic investigation, in line with what is recently happening with adults (e.g., Carmody and Baer, 2009; see Greenberg and Harris, 2012 and Harnett and Dawe, 2012 for related arguments in children). Finally, the present findings of positive health effects of our active control condition suggest that future studies could integrate mindfulness and other SEL programs into a single, coherent preventive intervention (Felver et al., 2013; see also Introduction).

CONCLUSION

The current longitudinal study showed how the introduction of mindfulness-meditation practices in educational settings can be useful to improve children's cognitive, emotional, and social abilities. This awareness practice could be regularly used during the school year and, combined with other SEL programs, could become a powerful preventive tool and a mean to improve the academic development of students even in the first years of school.

Achenbach, T. M. (1991). *Manual for the Child Behavior Checklist: Ages 4–18, and 1991 Profile*. Burlington, VT: Department of Psychiatry, University of Vermont.

Achenbach, T. M., & Dumenci, L. (2001). Advances in empirically based assessment: revised cross-informant syndromes and new DSM-oriented scales for the CBCL, YSR, and TRF: comment on Lengua, Sadowksi, Friedrich, and Fischer (2001). *Journal of Consulting*

Clinical Psychology, 69, 699–702.

Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA School-Age Forms & Profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.

Allen, N. B. (2006). *Progress Report to the Beyondblue Victorian Centre of Excellence in Depression and Related Disorders*. Parkville: ORYGEN with the University of Melbourne.

American Psychiatric Association [APA] (2000). *Diagnostic and Statistical Manual of Mental Disorders*. 4th Edn, *Text Revision*. Washington, DC: American Psychiatric Association.

Ang, R. P., Rescorla, L. A., Achenbach, T. M., Ooi, Y. P., Fung, D. S., & Woo, B. (2012). Examining the criterion validity of CBCL and TRF problem scales and items in a large Singapore sample. *Child Psychiatry and Human Development*, 43, 70–86.

Angold, A., Costello, E. J., Messer, S. C., Pickles, A., Winder, F., & Silver, D. (1995). The development of a short questionnaire for use in epidemiological studies of depression in children and adolescents. *International Journal of Methods in Psychiatric Research*, 5, 237–249.

Beauchemin, J., Hutchins, T. L., & Patterson, F. (2008). Mindfulness meditation may lessen anxiety, promote social skills, and improve academic performance among adolescents with learning disabilities. *Journal of Evidence-Based Complementary & Alternative Medicine*, 13, 34–45.

Berubé, R. L., & Achenbach, T. M. (2010). *Bibliography of Published Studies Using the Achenbach System of Empirically Based Assessment*, 2006 Edn. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.

Biegel, G. M., Brown, K. W., Shapiro, S. L., & Schubert, C. M. (2009). Mindfulness-based stress reduction for the treatment of adolescent psychiatric outpatients: a randomized clinical trial. *Journal of Consulting Clinical Psychology*, 77, 855–866.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., et al. (2004). Mindfulness: a proposed operational definition. *Clinical Psychology: Science and Practice*, 11, 230–241.

Brocki, K. C., & Bohlin, G. (2006). Developmental change in the relation between executive functions and symptoms of ADHD and co-occurring behaviour problems. *Infant and Child Development*, 15, 19–40.

Broderick, P. C., & Metz, S. (2009). Learning to BREATHE: a pilot trial of a mindfulness curriculum for adolescents. *Advances in School Mental Health Promotion*, 2, 35–46.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, 84, 822–848.

Burke, C. A. (2010). Mindfulness-based approaches with children and adolescents: a preliminary review of current research in an emergent field. *Journal of Child and Family Studies*, 19, 133–144.

Campanella, F., Crescentini, C., Urgesi, C., & Fabbro, F. (2014). Mindfulness-oriented meditation improves self-related character scales in healthy individuals. *Comprehensive Psychiatry*, 55, 1269–1278.

Carmody, J., & Baer, R. A. (2009). How long does a mindfulness-based stress reduction program need to be? A review of class contact hours and effect sizes for psychological distress. *Journal of Clinical Psychology*, 65, 627–638.

Chiesa, A., Serretti, A., & Jakobsen, J. C. (2013). Mindfulness: top–down or bottom–up emotion regulation strategy? *Clinical Psychology Review*, 33, 82–96.

Conners, C. K. (1997). *Conners' Rating Scales: Revised Technical Manual*. North Towanda, NY: Multi-Health Systems.

Conners, C. K., Sitarenios, G., Parker, J. D., & Epstein, J. N. (1998). Revision and restandardization of the conners teacher rating scale (CTRS-R): factor structure, reliability, and criterion validity. *Journal of Abnormal Child Psychology*, 26, 279–291.

Corallo, R. (2011). *Sei folletti nel mio cuore (Six Pixies in My Heart)*. Trento: Centro Studi Erickson.

Crescentini, C., Matiz, A., & Fabbro, F. (2015). Improving personality/character traits in individuals with alcohol dependence: the influence of mindfulness-oriented meditation. *Journal of Addictive Disease*, 34, 75–87.

Crescentini, C., Urgesi, C., Campanella, F., Eleopra, R., & Fabbro, F. (2014). Effects of an 8-week meditation program on the implicit and explicit self-referential religious/spiritual representations. *Consciousness and Cognition*, 30, 266–280.

Davidson, R. J., Kabat-Zinn, J., Schumacher, J., Rosenkranz, M., Muller, D., Santorelli, S. F., et al. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine*, 65, 564–570

Didonna, F. (ed.). (2009). *Clinical Handbook of Mindfulness*. New York, NY: Springer.

Dunn, J., Brown, J., & Beardsall, L. (1991). Family talk about feeling states and children's later understanding of others' emotions. *Developmental Psychology*, 27, 448–455.

Fabbro, F., & Muratori, F. (2012). La mindfulness: un nuovo approccio psicoterapeutico in età evolutiva [Mindfulness: a new psychotherapeutic approach for children]. *Giornale Italiano di Neuropsichichiatria dell'Età Evolutiva [Ital. J. Dev. Neuropsychiatry]* 32, 248–259.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience* 14, 340–347.

Felver, J. C., Doerner, E., Jones, J., Kaye, N. C., & Merrell, K. W. (2013). Mindfulness in school psychology: applications for intervention and professional practice. *Psychology in the Schools* 50, 531–547.

Flook, L., Smalley, S. L., Kitil, M. J., Galla, B. M., Kaiser-Greenland, S., Locke, J., et al. (2010). Effects of mindful awareness practices on executive functions in elementary school children. *Journal of Applied School Psychology*, 26, 70–95.

Frigerio, A. (2001). *CBCL - Child Behavior Checklist*. Bosisio Parini: Medea. Greco, L. A., Baer, R. A., and Smith, G. T. (2011). Assessing mindfulness in children and adolescents: development and validation of the child and adolescent mindfulness measure (CAMP). *Psychological Assessment*, 23, 606–614.

Greenberg, M. T., & Harris, A. R. (2012). Nurturing mindfulness in children and youth: current state of research. *Child Development Perspectives*, 6, 161–166.

Harnett, P. H., & Dawe, S. (2012). The contribution of mindfulness-based therapies for children and families and proposed conceptual integration. *Child and Adolescence Mental*

Health, 17, 195–208.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: a meta-analytic review. *Journal of Consulting Clinical Psychology, 78*, 169–183.

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Sciences, 6*, 537–559.

Hughes, C., White, A., Sharpen, J., & Dunn, J. (2000). Antisocial, angry, and unsympathetic: “Hard-to-manage” preschoolers’ peer problems and possible cognitive influences. *Journal of Child Psychology and Psychiatry Allied Disciplines, 41*, 169–179.

Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive Affective and Behavioral Neuroscience, 7*, 109–119. doi: 10.3758/CABN.7.2.109

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: theoretical considerations and preliminary results. *General Hospital Psychiatry, 4*, 33–47.

Kabat-Zinn, J. (1990). *Full Catastrophe Living: The Program of the Stress Reduction Clinic at the University of Massachusetts Medical Center*. New York, NY: Dell.

Kabat-Zinn, J. (1994). *Wherever You Go, There You Are: Mindfulness Meditation in Everyday Life*. New York, NY: Hyperion.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: past, present, and future. *Clinical Psychology Science and Practice, 10*, 144–156.

Kristeller, J. L., & Hallett, C. B. (1999). An exploratory study of a meditation-based intervention for binge eating disorder. *Journal of Health Psychology, 4*, 357–363.

Lecce, S., Bianco, F., Devine, R. T., Hughes, C., & Banerjee, R. (2014). Promoting theory of mind in middle childhood: a training program. *Journal of Experimental Child Psychology, 126*, 52–67.

Lee, J., Semple, R. J., Rosa, D., & Miller, L. (2008). Mindfulness-based cognitive therapy for children: results of a pilot study. *Journal of Cognitive Psychotherapy, 22*, 15–28.

MacCoon, D. G., Imel, Z. E., Rosenkranz, M. A., Sheftel, J. G., Weng, H. Y., Sullivan, J. C., et al. (2012). The validation of an active control intervention for mindfulness based stress reduction (MBSR). *Behavioral Research and Therapy*, 50, 3–12.

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience*, 7:8. doi: 10.3389/fnins.2013.00008

McFarlane, J. M., Groff, J. Y., O'Brien, J. A., & Watson, K. (2003). Behaviors of children who are exposed and not exposed to intimate partner violence: an analysis of 330 black, white, and Hispanic children. *Pediatrics*, 112, e202–e207. doi: 10.1542/peds.112.3.e202

McRae, K., Gross, J. J., Weber, J., Robertson, E. R., Sokol-Hessner, P., Ray, R. D., et al. (2012). The development of emotion regulation: an fMRI study of cognitive reappraisal in children, adolescents and young adults. *Social Cognitive and Affective Neuroscience*, 7, 11–22.

Miller, J. J., Fletcher, K., & Kabat-Zinn, J. (1995). Three-year follow-up and clinical implications of a mindfulness meditation-based stress reduction intervention in the treatment of anxiety disorders. *General Hospital Psychiatry*, 17, 192–200.

Napoli, M., Krech, P. R., & Holley, L. C. (2005). Mindfulness training for elementary school students: the attention academy. *Journal of Applied School Psychology*, 21, 99–125.

Nobile, M., Alberti, B., & Zuddas, A. (2012). *CRS-R: Conners' Rating Scales- Revised*. Firenze: Giunti O.S.

Noggle, J. J., Steiner, N. J., Minami, T., & Khalsa, S. B. (2012). Benefits of yoga for psychosocial well-being in a US high school curriculum: a preliminary randomized controlled trial. *Journal of Developmental & Behavioral Pediatrics*, 33, 193–201.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, 13, 25–42.

Purpura, D. J., & Lonigan, C. J. (2009). Conners' teacher rating scale for preschool children: a revised, brief, age-specific measure. *Journal of Clinical Child and Adolescence Psychology*, 38, 263–272.

Rescorla, L., Achenbach, T. M., Ginzburg, S., Ivanova, M., Dumenci, L., Almqvist, F., et al. (2007). Consistency of teacher-reported problems for students in 21 countries. *School*

Psychology Review, 36, 91–110.

Rueda, M. R., Fan, J., McCandliss, B. D., Halparin, J. D., Gruber, D. B., Lercari, L. P., et al. (2004). Development of attentional networks in childhood. *Neuropsychologia* 42, 1029–1040.

Saltzman, A., & Goldin, P. (2008). “Mindfulness Based Stress Reduction for School-Age Children,” in *Acceptance and Mindfulness Interventions for Children Adolescents and Families*, eds S. C. Hayes & L. A. Greco (Oakland, CA: Context Press/New Harbinger), 139–161.

Semple, R. J., Lee, J., Rosa, D., & Miller, L. F. (2010). A randomized trial of mindfulness-based cognitive therapy for children: promoting mindful attention to enhance social-emotional resiliency in children. *Journal of Child and Family Studies*, 19, 218–229.

Semple, R. J., Reid, E. F., & Miller, L. (2005). Treating anxiety with mindfulness: an open trial of mindfulness training for anxious children. *Journal of Cognitive Psychotherapy*, 19, 379–392.

Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology*, 62, 373–386.

Sharp, C., Goodyer, I. M., & Croudace, T. J. (2006). The short mood and feelings questionnaire (SMFQ): a unidimensional item response theory and categorical data factor analysis of self-report ratings from a community sample of 7-through 11-year-old children. *Journal of Abnormal Child Psychology*, 34, 379–391.

Siegler, R. S. (1991). *Children’s Thinking* 2nd Edn. Englewood Cliffs, NJ: Prentice Hall.

Singh, N. N., Singh, A. N., Lancioni, G. E., Singh, J., Winton, A. S. W., & Adkins, A. D. (2010). Mindfulness training for parents and their children with ADHD increases the children’s compliance. *Journal of Child Family Studies*, 19, 157–166.

Tandon, M., Cardeli, E., & Luby, J. (2009). Internalizing disorders in early childhood: a review of depressive and anxiety disorders. *Child and Adolescent Psychiatric Clinics of North America*, 18, 593–610.

Teasdale, J. D., Segal, Z. V., Williams, J. M., Ridgeway, V. A., Soulsby, J. M., & Lau, M. A. (2000). Prevention of relapse/recurrence in major depression by mindfulness-based

cognitive therapy. *Journal of Consulting Clinical Psychology*, 68, 615–623.

Thompson, M., & Gauntlett-Gilbert, J. (2008). Mindfulness with children and adolescents: effective clinical application. *Clinical Child Psychology and Psychiatry*, 13, 395–407.

Van de Weijer-Bergsma, E., Formsma, A. R., de Bruin, E. I., & Bogels, S. M. (2012). The effectiveness of mindfulness training on behavioral problems and attentional functioning in adolescents with ADHD. *Journal of Child and Family Studies*, 21, 775–787. doi: 10.1007/s10826-011-9531-7

Van der Oord, S., Bögels, S. M., & Peijnenburg, D. (2012). The effectiveness of mindfulness training for children with ADHD and mindful parenting for their parents, *Journal of Child and Family Studies*, 21, 139–147

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: evidence of brief mental training. *Conscious. And Cognition*, 19, 597–605.

Zoogman, S., Goldberg, S. B., Hoyt, W. T., & Miller, L. (2014). Mindfulness interventions with youth: a meta-analysis. *Mindfulness*, 6, 290–302.

Zylowska, L., Ackerman, D. L., Yang, M. H., Futrell, J. L., Horton, N. L., Hale, T. S., et al. (2008). Mindfulness meditation training in adults and adolescents with ADHD: a feasibility study. *Journal of Attention Disorders*, 11, 737–746.

Mindful creativity: the influence of mindfulness meditation on creative thinking

Viviana Capurso, Franco Fabbro and Cristiano Crescentini

A commentary on:

Meditate to create: the impact of focused- attention and open-monitoring training on convergent and divergent thinking by *Colzato, L. S., Ozturk A., and Hommel B.* (2012). *Front. Psychol.* 3:116. doi: 10.3389/fpsyg.2012.00116

INTRODUCTION

Recently the interest in the neurocognitive and psychological effects of meditation, and in particular mindfulness-meditation (MM), has largely grown. From the eighties, research has focused on health ben-efits of MM and on the cognitive and emotional changes resulting from practice (Kabat-Zinn, 1994; Cahn and Polich, 2006). Several findings suggest that the “observe and accept” approach of MM may lead, among others, to better executive functioning and attention regula- tion abilities (Jha et al., 2007; Heeren et al., 2009; Moore and Malinowski, 2009; Zeidan et al., 2010).

A new research line investigates the effects of MM on creativity (Ren et al., 2011; Greenberg et al., 2012; Ostafin and Kassman, 2012). In the first of these stud- ies, creative thinking was compared with logic thinking, examining insight and non- insight problem solving, in individuals with different levels of dispositional mindfulness or undergoing brief MM trainings and a specific positive influence of MM on insight problem-solving was found. This effect was interpreted in the light of MM helping to reduce the influence of habitual verbal-conceptual processes on the analysis of ongoing experience, an account in line with more general roles for MM in terms of “erosion” of habitual patterns of responding (Chambers et al., 2008). Insight problem-solving is in fact a class of problems where non-habitual responses or intuition are key factors leading to problem solution (Schooler et al., 1993; Shirley and Langan-Fox, 1996).

A commentary on “Meditate to create: the impact of focused-attention and open-monitoring training on convergent and divergent thinking” (Colzato, L. S., Ozturk A., & Hommel (2012). *Frontiers in Psychology*, 3:116)

Colzato et al. (2012) provided an important contribution to the issue of meditation and creativity. These authors investigated in expert healthy meditators the effects of Focused Attention meditation (FA) and Open Monitoring meditation (OM) on divergent and convergent creative thinking. During FA meditation, participants had to focus attention to particular parts of the body while during OM meditation, they had to open the mind to any occurring thought or sensation, accepting the latter with a non-judgmental attitude. Of importance, FA and OM meditation are both implicated in commonly used MM trainings such as the mindfulness-based stress reduction (Kabat-Zinn et al., 1985; Lutz et al., 2008).

Colzato et al. used the Alternate Uses Task (AUT) for divergent thinking and the Remote Associates Task (RAT) for convergent thinking. In the AUT the participants had to list “as many possible uses for six common household items” while in the RAT they had to find a common associate within three unrelated words. Different versions of the two tasks were administered to each participant after each one of three 35-min FA, OM, or baseline sessions (separated by 10 days). In the latter, the subjects had to visualize a series of household activities. Perceived mood was also assessed with a visual analog scale, showing enhancement of positive mood after OM and FA meditation as compared to baseline.

In line with predictions, Colzato et al. found that engaging in OM meditation, that is likely to bias toward a cognitive-control state characterized by weak and “distributed” top-down control over upcoming thoughts, facilitated performance specifically in the AUT that also requires weak top-down guidance during generation of new ideas which may represent appropriate task solutions. Indeed, after OM meditation participants showed more flexibility, fluency, and originality in their responses. Contrary to predictions, however, to be biased through FA meditation toward strong, focused top-down control over selected thoughts, did not facilitate performance in the RAT that would also require a focused control style operating to constrain the search space of the solution.

Colzato et al. suggested that OM meditation promotes a “distributed” cognitive-control state that should reflect in a broader allocation of cognitive resources leading to better distributed- attention. Nonetheless, in line with previously reported findings of negative influence of mood on convergent thinking (Akbari Chermahini and Hommel, 2012), they hypothesized that improved mood observed after FA meditation could have hampered RAT performance.

Limitations and future directions

We believe this to be an intriguing possibility that should be further investigated by also taking into consideration the results of those previous studies that more generally examined the role of attention in creativity. For example, while sustained attention or attention-switching have recently been shown to positively influence insight problem-solving (Murray and Byrne, 2005; Ren et al., 2011), other studies suggested that attention itself may be an obstacle to creative thinking, being this associated to states such as dreaming and reverie (Mendelsohn, 1976; Martindale, 1999; Wierda et al., 2010).

A few other issues deserve discussion. Only experienced practitioners were included in Colzato et al. Hence, it would be interesting to see if the same effects can be observed in naïve meditators for whom the biasing of a distributed cognitive-control state by OM meditation could be less evident. Similarly, relative to expert meditators, naïve individuals could be more hindered by habitual verbal-conceptual processes during AUT-like task solution. Moreover, given other studies on MM and creativity have compared creative thinking with logic thinking (Ren et al., 2011; Ostafin and Kassman, 2012), it would be important to test whether training in FA (or OM) meditation influences insight problem-solving as well as logic thinking. On this view, future studies on MM and creativity considering a larger variety of creativity measures could also try to link creativity performance with different attention tasks (distributed, focused, shifting) (e.g., Jha et al., 2007). Capitalizing on Colzato et al., one could try to verify longitudinally the effects of an 8-week MM training on creativity. Although FA and OM abilities would be interchangeably trained by such an intervention (Lutz et al., 2008), this would allow to investigate longer lasting trait-mindfulness (as compared to state- mindfulness) changes

(Cahn and Polich, 2006). Finally it would be interesting to investigate if the effect on creativity is restricted only to performance directly after meditating. This should foster our knowledge on the possible cognitive mechanisms, such as improved mood, better (focused or distributed) attention, or more efficient overcoming of the interference of past experience, through which MM influences creative thinking.

To conclude, Colzato et al. opened a new and interesting scenario that requires further studies to focus on causes of implemented creativity in experienced and naïve meditators, maybe matching long and brief MM trainings to see differences and effects.

Akbari Chermahini, S., & Hommel, B. (2012). Creative mood swings: divergent and convergent thinking affect mood in opposite ways. *Psychological Research*, 76, 634–640.

Cahn, B. R., & Polich, J. (2006). Meditation states and traits: EEG, ERP, and neuroimaging studies. *Psychological Bulletin*, 132, 180–211.

Chambers, R., Lo, B. C. Y., & Allen, N. B. (2008). The impact of intensive mindfulness training on attentional control, cognitive style, and affect. *Cognitive Therapy and Research*, 32, 303–322.

Colzato, L. S., Ozturk, A., & Hommel, B. (2012). Meditate to create: the impact of focused-attention and open-monitoring training on convergent and divergent thinking. *Frontiers in Psychology*, 3:116. doi: 10.3389/fpsyg.2012.00116

Greenberg, J., Reiner, K., & Meiran, N. (2012). “Mind the trap”: mindfulness practice reduces cognitive rigidity. *PLoS ONE* 7:e36206. doi: 10.1371/journal.pone.0036206

Heeren, A., Van Broeck, N., & Philippot, P. (2009). The effects of mindfulness on executive processes and autobiographical memory specificity. *Behavioral Research Therapy*, 47, 403–409. doi: 10.1016/j.brat.2009.01.017

Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness meditation modifies subsystems of attention. *Cognitive Affective and Behavioral Neuroscience*, 7, 109–119. doi: 10.3758/CABN.7.2.109

Kabat-Zinn, J. (1994). *Wherever you Go, There you are: Mindfulness Meditation in Everyday Life*. New York, NY: Hyperion Books.

Kabat-Zinn, J., Lipworth, L., & Burney, R. (1985). The clinical use of mindfulness meditation for the self-regulation of chronic pain. *Journal of Behavioral Medicine*, 8, 163–190.

Lutz, A., Slagter, H. A., & Dunne, J. D. (2008). Attention regulation and monitoring in meditation. *Trends in Cogn. Sciences*, 12, 163–169.

Martindale, C. (1999). “Biological bases of creativity,” in *Handbook of Creativity*, ed R. J. Sternberg (Cambridge: Cambridge University Press), 137–152.

Mendelsohn, G. A. (1976). Associative and attentional processes in creative performance. *Journal of Personality*, 44, 341–369.

Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Conscious and Cognition*, 18, 176–186.

Murray, M. A., & Byrne, R. M. J. (2005). “Attention and working memory in insight problem solving,” in *Proceedings of the XXVII Annual Conference of the Cognitive Science Society*, eds B. G. Bara, L. Barsalou, and M. Bucciarelli (Mahwah, NJ: Erlbaum), 1571–1575.

Ostafin, B. D., & Kassman, K. T. (2012). Stepping out of history: mindfulness improves insight problem solving. *Consciousness and Cognition*, 21, 1031–1036.

Ren, J., Huang, Z., Luo, J., Wei, G., Ying, X., Ding, Z., et al. (2011). Meditation promotes insightful problem-solving by keeping people in a mindful and alert conscious state. *Science China Life Sciences*, 54, 961–965.

Schooler, J. W., Ohlsson, S., & Brooks, K. (1993). Thoughts beyond words: when language overshadows insight. *Journal of Experimental Psychology: General*, 122, 166–183.

Shirley, D. A., & Langan-Fox, J. (1996). Intuition: a review of the literature. *Psychological Report*, 79, 563–584.

Wierda, S. M., van Rijn, H., Taatgen, N. A., & Martens, S. (2010). Distracting the mind improves performance: an ERP study. *PLoS ONE* 5: e15024. doi: 10.1371/journal.pone.0015024

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: evidence of brief mental training. *Consciousness and Cognition*, 19, 597–605.

Mindfulness Meditation and Creativity

Viviana Capurso, Franco Fabbro and Cristiano Crescentini

Abstract

Creativity can be defined as the phenomenon of creating something novel and useful (Ding, Tang, Tang, & Posner, 2014). In the past, creativity has been frequently associated with personal characteristics and personality traits. Now there is evidence that there are many different conditions and skills that can influence creative performance. One of them appears to be mindfulness meditation (MM). MM is a traditional form of Buddhist meditation that implies being attentive to and fully aware of present-moment experience with an open and non-judgmental attitude (Kabat-Zinn, 1994). So far, the existing body of literature on the relation between MM and creativity, insight problem solving and divergent/convergent thinking, has produced mixed results. For example, there is consistent evidence indicating that open monitoring, required during MM, leads to enhanced divergent thinking (Baas, Nevicka, & Ten Velden, 2014; Colzato, Ozturk, & Hommel, 2012; Ding, Tang, Tang, & Posner, 2014). Nonetheless, focused attention, another skill required during MM, should lead to better performance in convergent thinking tasks, but the findings on the association between focused attention and creativity are mixed (Baas et al., 2014; Colzato et al., 2012). The aim of this chapter is to give an overview of the existing literature on MM and creativity, providing a perspective on future directions of this promising line of research.

Keywords: creativity, mindfulness, meditation, open monitoring, focused attention, mind wandering, insight, problem solving

Introduction

Creativity is a very complex construct that plays an important role in people's daily life. Although many psychological and cognitive studies on creativity have been conducted in recent years, research in this field is still in its infancy and the concept is still unclear. In particular, it has been difficult for researchers to give an unambiguous definition of the concept itself, to give an appropriate operationalization of the construct, and to understand the conditions shown in creative thinking and behavior (Feist, 1998; George, 2007; Hennessey & Amabile, 2010).

Torrance (1962), Guilford (1950), and Campbell (1960) proposed a definition of the construct of creativity. In their opinion, creativity involves some key cognitive factors such as ideational fluency, originality of ideas, and elegance of solutions. More specifically, Torrance defines creativity as "the process of sensing gaps or disturbing, missing elements; forming ideas or hypotheses concerning them; testing these hypotheses; and communicating the results, possibly modifying and retesting the hypotheses" (Torrance, 1962, p. 16). For Guilford, creativity has to be examined in terms of "uncommon, yet acceptable, responses to items" (1950, p. 452), while for Campbell (1960) creative ideation has to be divided into a two-stage mental process involving 'blind' variation and selective retention of ideas. More specifically, in his vision, creativity proceeds through a natural selection process that chooses and adapts those random variations of ideas that are most useful.

A more recent definition of creativity was given by Arieti who argued that this construct corresponds to "the production of an aesthetic entity (the art work)" and "the high value of that entity" (Arieti, 1976, p. 33). Sternberg and Lubart have further elaborated this definition of creativity considering this complex construct as "a phenomenon whereby something novel (e.g., original and unexpected) and appropriate (e.g., valuable and adaptive concerning task constraints) is created, such as an idea, an artistic or literary work, a painting or musical composition, a solution, or an invention" (Sternberg & Lubart, 1999, p. 3).

In addition to these recent conceptualizations of creativity, many other psychological studies have taken into account aspects and components such as problem solving, divergent/convergent thinking and cognitive flexibility that underlie creative thinking and behavior. For example, Guilford (1967) related creativity to divergent thinking. He defined the latter as synthetic thinking, or the ability to arrive at many solutions to a problem. In contrast, he defined convergent thinking as the ability to apply rules to arrive at a single correct solution to a problem. With regard to problem solving, Parkhurst stated that creativity is “the ability or quality displayed when solving hitherto unsolved problems, when developing novel solutions to problems others have solved differently” (Parkhurst, 1999, p. 18). An additional concept related to creativity and problem solving is insight problem solving. With “insight-problem” we mean a problem that “has a high probability of leading to an impasse (where the subject does not know what to do next), and that can be solved with an “Aha” experience that suddenly breaks the impasse and leads rapidly to the solution” (Ansburg, 2000; Schooler, Ohlsson, & Brooks, 1993, p. 168; for a definition of how we make insights see also Jung-Beeman & Bowden, 2000; Bowden & Jung-Beeman, 2003). Insight problem solving is often used to investigate creativity while logic problems are often employed to investigate analytic problem solving (e.g., Ansburg, 2000; Ostafin & Kassman, 2012; Zedelius & Schooler, 2015).

Finally, considering cognitive flexibility, this can be defined as the ability to adapt cognitive processing strategies to face new and unexpected conditions (Greenberg, Reiner, & Meiran, 2012). Enhanced cognitive flexibility may lead individuals to elaborate new and unexpected solutions to problems, possibly because they stop persevering in the use of habitual mental or behavioral sets (Chambers, Gullone, & Allen, 2009; Greenberg et al., 2012; Moore & Malinowski, 2009).

Problem solving (Batey & Furnham, 2006), divergent thinking (Batey, Chamorro-Premuzic & Furnham, 2009; Runco, 1991) and cognitive flexibility (De Dreu, Baas, & Nijstad, 2011; Dietrich, 2004) are thus related to the construct of creativity. From another perspective, it is interesting to notice that many recent studies in the field of mindfulness meditation (MM) have tried to investigate the effects of this form of mental training on the very same cognitive aspects (Capurso, Fabbro, & Crescentini, 2014; Colzato, Ozturk, &

Hommel, 2012; Colzato, Szapora, Lippel, & Hommel, 2014; Moore & Malinowski, 2009; Greenberg et al., 2012). After reviewing in more detail the different aspects of creativity, we will explore in the next sections the links between MM and this complex construct.

Sources of Creativity

The quest for the sources of creativity and for what makes people more or less creative has fascinated researchers in the field of psychology for a long time. Psychologist Carl Gustav Jung (1875-1961) posited that “works of creativity” have their deep origins in the individual’s unconscious. Conscious aspects of human experience have an unconscious background that often goes beyond the individual. In his words the creation is “supra-personal” because it goes beyond the limits of the person and its concerns (Jung, 1933). According to Jung, creation can derive from unconscious processes and from more deliberate ones, which bring conscious attention to specific directions. Creativity can then be referred to as a psychological phenomenon since the creative act may be made up of images representing archetypal symbols that originate from the unconscious. Jung’s purpose was to integrate creativity and psychology, with the aim of unlocking symbols of the unconscious, fostering a personal growth of the individual.

A more recent line of psychological research conceptualizes creative behavior as something that originates from “attitudes” (Gough, 1979), suggesting the existence of a “creative personality” with specific and well-defined traits (Batey & Furnham, 2006; Feist, 1998). In particular, the studies examining the Big Five model of personality (Costa & McCrae, 1992) positively link creativity to extraversion (the tendency to be assertive, energetic and sociable) and openness to experience (the tendency to be curious, imaginative and adventurous) while they negatively link creativity to agreeableness (the tendency to be trustworthy and altruistic) and conscientiousness (the inclination to be efficient, organized and to show high self-discipline) (Feist, 1998; Sung & Choi, 2009). Extraversion has also been shown to be positively correlated with divergent thinking (Batey et al., 2009). Other studies have found that creativity is positively affected by extraversion, and possibly

neuroticism trait (propensity toward anxiety, worrying, moodiness, and impulsiveness), and negatively affected by the conscientiousness trait (Batey & Fulham, 2006; Feist, 1998).

A number of researchers have questioned that creativity originates purely from personality traits and investigated the role played by temporary states and contextual cues (George, 2007; Hennessey & Amabile, 2010). In view of the relationship between creativity and transient states of mind, another line of research has considered the possible role played by attention functions, suggesting two opposite ways in which attention can influence creativity (Zedelius & Schooler, 2015). A set of studies have underlined mindful awareness (the tendency to attend to and be aware of present moment experience; Brown & Ryan, 2003), focused attention, and concentration as factors having a facilitatory influence on creativity (Colzato et al., 2012; Greenberg et al., 2012; Ostafin & Kassman, 2012; Ren et al., 2011). In a different set of studies, mind wandering (the tendency of shifting attention away from the present environment often without conscious intention; Smallwood & Schooler, 2006), distraction, and mindlessness have been related to creativity (Baird, Smallwood, Mrazek, Kam, Franklin, & Schooler, 2012; Zedelius & Schooler, 2015).

Focused attention and mindful awareness are characterized as constructs opposite to mind wandering and distraction. Therefore, if there was a direct relationship between sustained or focused attention and creativity, then this evidence could be seen in contrast with the theory that creativity comes from defocused attention and mindlessness. Conversely, creativity could be considered as the “epitome” of cognitive flexibility (Dietrich, 2004), but the mechanisms underlying this construct are still not clear so as the relation with attention and mindful awareness. Within the theoretical framework outlined above, the aim of the remaining sections of this chapter is to clarify the possible links between mindfulness and MM and creativity, first briefly analyzing the constructs of mindfulness and MM and then discussing their influences on different creativity processes (e.g., divergent thinking and convergent thinking).

Mindfulness Meditation and Mindfulness Skills

Mindfulness can be considered as a universal human attitude believed to foster open-heartedness and clear thinking (Ludwig & Kabat-Zinn, 2008). This attitude can be cultivated through MM, a traditional form of Buddhist meditation in which the practitioner tries to be attentive to and fully aware of present moment experience with a gentle and non-judgmental attitude (Kabat-Zinn, 1994). People engaged in a mindfulness-based program are assumed to cultivate mindful awareness, a mindful state where thoughts and feelings are observed without identifying with them and without automatically reacting to them (Bishop et al., 2004). Of importance, constant MM practice may lead to long-lasting changes in trait mindfulness, which reflects the disposition to persist in mindful states over time beyond meditation practice (Crescentini & Capurso, 2015). Thus, mindfulness has state-like as well as trait-like qualities (Brown & Ryan, 2003), and can be described as a skill or a set of skills, which can be improved by meditative practice (Bishop et al., 2004). The construct of mindfulness has been examined through different self-report measures (i.e., questionnaires), which have considered mindfulness as a unidimensional construct (Brown & Ryan, 2003), or, more recently, as a multi-faceted concept (Baer Smith, Hopkins, Krietemeyer, & Toney, 2006).

The first scale measuring mindfulness as a single construct is the Freiburg Mindfulness Inventory (FMI; Buchheld, Grossman, & Walach, 2001), a 30-item instrument assessing mindfulness through non-judgmental, present-moment observation and openness to negative experience. The distinctive characteristic of this scale is that it is designed for use by experienced meditators. A more recent measure has been argued to be suitable for assessing trait mindfulness in both expert meditators and non-meditators. The Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003) is a 15-item scale measuring the general tendency to be attentive to and aware of present moment experience in everyday life. The mindfulness skill is here considered as having a single-factor structure, and individuals have to rate how often they experience acting on automatic pilot and not paying attention to present moment on a 6-point Likert scale. The Kentucky Inventory of Mindfulness Skills (KIMS; Baer, Smith, & Allen, 2004) is a 39-item instrument that

examines mindfulness as a complex and multi-faceted construct. It is designed to measure four mindfulness skills: observing, describing, acting with awareness, and accepting without judgment present moment experience. The KIMS measures a general tendency to be mindful in daily life and does not require experience with meditation (Baer, Smith, & Allen, 2004). Shortly thereafter, from the KIMS, the same group of researchers developed a scale that considers mindfulness as a five-facet construct, namely the Five Facet Mindfulness Questionnaire (FFMQ, Baer, Smith, Hopkins, Krietemeyer & Toney, 2006). Besides the four facets included in the KIMS, the FFMQ also involves a facet from the FMI scale, namely non-reactiveness.

After briefly reviewing the main clinical applications and cognitive effects of MM, in the following sessions, we will analyze mindfulness and MM effects on creativity considering mindfulness both as a specific skill developed in meditation practice (Colzato et al., 2012; Ding, Tang, Tang, & Posner, 2014; Ren et al., 2011) and as a personal skill, independent from meditative practice (Baas, Nevicka, & Ten Velden, 2014; Zedelius & Schooler, 2015).

Mindfulness Meditation: Main Clinical Applications

MM has received a great deal of attention in the last years, because of the large body of research that documents its beneficial effects on physical and psychological well-being (Chiesa & Serretti, 2010). The interest in the clinical applications of mindfulness has been sparked by the standardization of a specific method ideated by John Kabat-Zinn, the Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982). This mindfulness-based treatment program was originally developed for the management of chronic pain (Bishop et al., 2004; Kabat-Zinn, Lipworth, & Burney, 1985). Since then, the MBSR has been widely used to reduce psychological distress associated with chronic illnesses and to treat a wide range of psychological and behavioral disorders (Didonna, 2009). Starting from the MBSR, many different programs based on MM have been developed such as the Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale 2002); the Mindfulness-

Based Relapse Prevention (MBRP; Bowen et al., 2009); the Acceptance and Commitment Therapy (ACT; Hayes, Follette & Linehan, 2004) and the Mindfulness-Based Eating Awareness Training (MB-EAT; Kristeller & Wolever, 2011). Recently, the authors have proposed a method of mindfulness-oriented meditation (MOM) based on the original MBSR protocol (Campanella, Crescentini, Urgesi, & Fabbro, 2014; Crescentini, Matiz, & Fabbro, 2015; Crescentini, Urgesi, Campanella, Eleopra, & Fabbro, 2014; Fabbro & Crescentini, 2015; Fabbro & Muratori, 2012).

In general, the method adopted in the above mentioned MM interventions consists of an 8-week group-based treatment that includes didactic mindfulness training, in-session practice, group discussion, and home formal practice. During meditation exercises, participants try to non-judgmentally observe all bodily sensations and thoughts, bringing back attention to the meditation task when it wanders. The practitioner thus aims to merge a focused attention component with an open monitoring attitude when trying to intentionally pay attention to present-moment experience (Bishop et al., 2004; Brown & Ryan, 2003; Crescentini & Capurso, 2015).

After the standardization of the MBSR method, the majority of research has focused on clinical samples to evaluate the efficacy of mindfulness-based interventions. This line of research has primarily addressed the question of efficacy on a variety of clinical conditions such as substance-use disorders, obsessive compulsive disorder, eating disorders, generalized anxiety, depression, and attention deficit/hyperactivity disorder (ADHD) (Didonna, 2009; Greenberg et al., 2012; Hölzel et al., 2011). The studies conducted have led to promising findings suggesting that MM is an effective intervention for the treatment of both psychological and physical symptoms connected to these clinical conditions.

Mindfulness Meditation: Main Cognitive Effects

A complementary perspective on MM is concerned with neurocognitive and emotional changes resulting from mindfulness practice. In this case meditation is conceptualized in terms of a mental or cognitive training procedure (Moore & Malinowski, 2009). This

additional line of research has investigated the possible applications of mindfulness in clinical and non-clinical samples and results in this field are, likewise, positive. Several findings suggest that MM may lead to better executive functioning and attention regulation abilities (Jha, Krompinger, & Baime, 2007; Lutz, Slagter, & Dunne, 2008; Moore & Malinowski, 2009), better emotion regulation (Arch & Craske, 2006; Chambers, Lo & Allen, 2009), and positive changes in personality and character (Campanella et al., 2014; Crescentini et al., 2015). A number of studies have recently tried to identify a key set of mechanisms of action through which MM may exert its beneficial health effects. For example, Hölzel and colleagues (2011) have identified four interrelated critical components of mindfulness, namely attentional control, emotion regulation, body awareness, and change in the perspective on the self. Among these factors, attention regulation is considered a fundamental prerequisite for the development of the other mechanisms of action and mindfulness skills.

Accordingly, in two recent neuroscience reviews, MM has been defined as a form of attentional training involving in particular the parietal and frontal attentional systems of the brain (Cahn & Polich, 2006; Malinowski, 2013). With regard to behavioral studies linking MM and attention/executive function, Jha and colleagues have demonstrated that experienced meditators have better performance on executive attention tasks when compared with nonmeditators (Jha, Krompinger, & Baime, 2007). This was indicated by smaller error scores and lower reaction times in the Attention Network Test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002), a well-known task used to measure attention functions. Moreover, MM-related improvements in behavioral measures of sustained attention and selective attention have been underlined in the review by Lutz and colleagues (Lutz, Slagter, & Dunne, 2008). Furthermore, a lower Stroop interference effect has been found in experienced meditators compared with controls (Moore & Malinowski, 2009), while decreased interference in inhibitory tasks has been documented in meditators undertaking an MBCT training (Heeren, Van Broeck, & Philippot, 2009). Notably, changes in attentional processing are evident not only in experienced meditators but also in novices undergoing short meditation trainings (Ding et al., 2014; Ren et al., 2011; Tang et al., 2007). These studies thus show that the ability to openly experience the here and now leads

to improvements in attentional functions, with this having important consequences for effective self-regulation and well-being. The next sections show that attention also may play a very important role in a new and recent research line focusing on the relation between mindfulness and MM with creativity.

Mindfulness Meditation, Trait Mindfulness and Creativity

The first study that tried to investigate the relationship between MM and creativity was that of Ren and colleagues (2011). In their study, creativity was operationalized for as the ability of solving problems that require insight solutions. The authors examined creative thinking asking participants to solve 10 insight problems before and after meditating. After 20 minutes of breath meditation, the meditators showed an improved ability of solving insight problems, while controls, who were not meditating, did not show similar changes. This outcome was interpreted as an increased ability of meditators to maintain an alert and mindful state after meditation. This was supported by the percentage of alpha waves recorded during the EEG experiment. The study showed that the higher the percentage of alpha waves (which is generally associated with a more relaxed mental state; Ren et al., 2011), the lower the performance in solving insight problems. This result indicates that attention has a key role in creativity, at least as far as insight problem solving is concerned.

The link between MM, trait mindfulness and insight problem solving has been further investigated by Ostafin and Kassman (2012). In a two-study experiment the authors explored the relationships between MM, trait mindfulness, the ability of problem solving, and positive affect (which reflects the extent to which an individual experiences pleasurable engagement with the environment; Watson, Clark, & Tellegen, 1988). Trait mindfulness was assessed with the MAAS (Brown & Ryan, 2003), while positive affect was assessed with the Positive and Negative Affect Schedule (Watson et al., 1988). Results indicated that high trait mindfulness predicted better insight but not noninsight problem solving and this relation was maintained when controlling for positive affect. Moreover, a 10-minute mindfulness training with a focus on body awareness and non-judgmental attitude was

found to improve insight but not noninsight problem solving. This improvement was partially mediated by state mindfulness levels, measured with a specific MAAS item: “At this moment (right now) I feel like I will rush through activities without being really attentive to them”. Lower values in this item represent greater state mindfulness (Ostafin & Kassman, 2012). In sum, individuals with high trait mindfulness were found to be the most able to solve insight problems and even a brief MM exercise (10 minutes) was effective in enhancing insight problem solving. The authors suggest that high mindfulness fosters creativity because individuals are less influenced by past beliefs when analyzing current information. According to the authors, the aim of mindfulness and MM is to limit the so-called “automatically activated verbal–conceptual contents” that come from one’s past experience in order to promote a reorganization of problems, and the possible manifestation of new and unexpected solutions (Ostafin & Kassman, 2012).

The recent results of Greenberg and colleagues (2012) are consistent with the findings of Ostafin and Kassman and with a previous study conducted by Moore and Malinowski (2009) showing a positive effect of MM on cognitive flexibility. In two different experiments, Greenberg and colleagues compared experienced Vipassana meditators (meditators with minimum 3 years of experience) to novices controls, and individuals who received a 6-week MM training to another group of non-experienced control individuals. Creativity was measured by using the Einstellung Water Jar Task (Luchins, 1942), which taps the ability of changing strategies while solving problems. Compared to controls, Greenberg and colleagues found that experienced meditators and people who received the MM training showed a reduced cognitive rigidity; in other words, they avoided repetitive and perseverative thought patterns and generated more novel solutions to the problems involved in the Einstellung Water Jar Task (insight problem solving task).

In order to pinpoint how MM affects creativity, Colzato and colleagues (2012) recently tested the effects of two different kinds of meditation on creative thinking. The first type of meditation was open monitoring (OM), where individuals aimed to perceive and observe thoughts and sensations without focusing on them, simply letting them go as they arise. In OM meditation, non-reacting to and non-judging present-moment experience are essential attitudes. The second type of meditation was focused attention (FA), where individuals

were asked to concentrate on a particular meditation object, ignoring on purpose all intrusions and interfering stimuli, and shifting attention back when it wandered. Colzato and colleagues referred to creativity in terms of divergent and convergent thinking, choosing the Alternate Uses Task (AUT; Guilford, 1967) to assess divergent thinking and the Remote Associates Task (RAT; Mednick, 1962) to assess convergent thinking. In the AUT, participants saw a series of common objects and had to list as many possible uses for each object. In the RAT, participants were asked to identify a common associate within three unrelated words. Mood was also assessed using a visual analogue scale (VAS). This was because there is evidence that meditation can positively influence mood (e.g., Chang et al., 2004), and improvements in mood can be in turn differentially related to divergent and convergent thinking. In fact, there is a positive relationship between mood and divergent thinking, while a negative relationship has been reported with convergent thinking (Akbari Chermahini, & Hommel, 2012).

In line with the predictions, Colzato and colleagues (2012) found that OM meditation facilitated divergent thinking while, contrary to the hypothesis, FA meditation did not facilitate convergent thinking. The researchers suggested that OM meditation promotes a cognitive-control state that leads to better distributed attention, with this positively affecting divergent thinking. In contrast, to explain RAT performance after FA, Colzato and colleagues (2012) hypothesized that improved mood observed after FA meditation could have hindered convergent thinking performance. The study of Colzato and colleagues suggests that MM is able to favor particular mind states that support some creative cognitive processes while possibly interfering with others. Interestingly, this appeared to be the case both in experienced meditators and in novices (e.g., see Colzato et al., 2014).

Recently, an interesting study has lent support to the original observations of Colzato and colleagues (2012, 2014). After an 8-week MM intervention, Baas and colleagues (2014) demonstrated that a growth in the abilities to observe and describe present-moment feelings and thoughts (two typical mindfulness skills), was consistently linked with enhanced creative behavior, which was measured through the AUT task in terms of creative ideation, fluency and originality. Conversely, the ability of acting with awareness, which is

comparable with the attitude of focusing attention on items, was not associated with creativity.

In another recent study, Ding and colleagues (2014) analyzed levels of creativity in students after a short integrative body-mind training procedure (IBMT), which included meditative practices. Comparing a one-week IBMT training, where participants meditated 30 minutes per day, with a relaxation training control condition, the authors showed enhanced creativity in meditators but not in controls. More specifically, students in the IBMT condition showed improved performance in the Torrance Test of Creativity (Torrance, Ball, & Safer, 1981), which measures divergent thinking in terms of fluency, flexibility, and originality. A distinctive feature of this study was the use of an active control condition based on relaxation. This characteristic has thus highlighted the key role of short-term meditation, beyond relaxation states, in influencing creativity performance. Ding and colleagues discussed the results in the light of mood improvement (assessed with the Positive and Negative Affect Schedule; Watson et al., 1988), which was caused by the meditation practice but not by the relaxation condition. Similar to the study of Colzato and colleagues (2012), this study further underlines the interesting and complex links between MM, creativity, and mood state.

Finally, two more studies deserve attention. In the study of Baird and colleagues (2012) the authors have provided evidence of a possible relation between mind wandering and creativity. This study is considered in this review chapter because, as we already mentioned, mind wandering appears to be in direct opposition to mindful awareness (Schooler, Mrazek, Franklin, Baird, Mooneyham, Zedelius, & Broadway, 2014). Baird and colleagues measured divergent thinking using the Alternate Uses Task (AUT; Guilford, 1967), while the Daydreaming Frequency subscale of the Imaginal Process Inventory (IPI; Singer, & Antrobus, 1972) was used to assess individuals' propensity to mind wander. After completing the AUT, participants were assigned to one of four between-subjects conditions: a demanding task (working memory task), an undemanding task (choice reaction time task), rest (sitting quietly in a room), or no-break (e.g., these participants performed the AUT again without any pause). This phase of the experiment, called "incubation", lasted 12 minutes. Then participants – except for the no-break group –

performed another AUT and filled in the Daydreaming Frequency subscale. Results showed that creativity was enhanced after the undemanding task, in particular in individuals who had a higher tendency of mind wandering. Another very recent study focused on the influence of trait mindfulness, rather than MM, on creativity. Zedelius and Schooler (2015) found that low trait mindfulness (assessed with the MAAS, Brown & Ryan, 2003), which corresponds to a greater tendency towards mind wandering and distraction, was positively associated with an improved ability to solve compound remote associates problems (CRA) through insight. In contrast, higher mindfulness skills predicted an enhanced ability to solve CRA problems through analytic strategy. Overall, these studies suggest that mindfulness skills (and mind wandering) could act differentially on creative thinking and logic thinking (Schooler et al., 2014).

Limitations and Directions for Future Research

As outlined in this chapter, the research linking MM and creativity is still in its infancy, although many important steps have been done in these last years. Crucially, future work in this field should investigate some issues that are here discussed. First of all, it would be helpful to reach a more homogeneous definition of creativity that will allow identifying more consistent measures of this complex construct. Indeed, in the reviewed studies, many different definitions of creativity have been used, and this led to a number of different operationalizations of the construct. As we have seen across the reviewed studies, several instruments exist to measure creativity, from self-reported inventories measuring individual's personality traits, creative behavior and cognitive flexibility, to "practical" activities and tests measuring problem-solving abilities, creative ideation, fluency, originality and elaboration.

An important issue that could be addressed by future studies concerns the effects that different meditation practices, beyond OM and FA meditation, may have on creativity. There is indeed evidence that different forms of meditation originated in Hinduism and Buddhist spiritual traditions may be associated to, at least partially, different brain regions. For example, Hinduism-based meditation practices are primarily associated with different

levels of absorption and activate mainly the posterior temporo-parietal cortex which is connected with spatial orientation and body awareness. In contrast, Buddhist-inspired meditations stress the role of attention and mental presence and preferentially lead to activation of frontal lobe structures (Tomasino, Chiesa, & Fabbro, 2014). Therefore, it would be interesting to compare the effects of Hinduism-based vs. Buddhist-based meditation practices on creativity performance. Based on our previous considerations about mind-wandering, and taking into account some previous results on mindfulness and creativity (Baird et al., 2012; Zedelius & Schooler, 2015), it would be useful to analyze if Hinduism-based meditations could foster insight problem solving where attention and analytical processes may be less crucial.

A further important issue arising from our review is the role of affect as possible mediator between mindfulness and creativity (e.g., Colzato et al., 2012; Ding et al., 2014). Today's evidence suggests that the relationships between mood and cognitive processes, including creativity, are reciprocal and bidirectional (Bar, 2009), but the results are still uncertain and further explorations in this field are necessary. For example, two meta-analyses agree on the link between positive mood and enhanced creativity, analyzing, however, mood under different perspectives (Baas, De Dreu, and Nijstad, 2008; Davis, 2009). Baas and colleagues (2008) analyzed the link between mood and creativity, considering for the former not only the aspect of hedonic tone (i.e., if the mood is positive or negative), but also the level of activation and regulatory focus of mood (i.e., if the mood promotes or prevents action). In their analysis, the authors suggest that there are mood states that are positive in tone and deactivating (calm, relaxed), and others that are positive in tone yet activating (happy, elated). Likewise, there are mood states that are negative in tone and deactivating (sad, depressed), whereas others are negative in tone and activating (anger, fear) (Baas et al., 2008). Besides these characteristics of mood, the review of Baas and colleagues indicates that some positive mood states are linked to successful attainment of personal goals (happy, satisfied) while some negative mood states are linked to unsuccessful attainment (disappointment, discouragement). In all, Baas and colleagues argue that activating positive moods (happy, elated) are associated with higher levels of

creativity compared to mood-neutral controls while deactivating positive moods (relaxed, serene) are not related to higher levels of creativity.

Davis (2009) divided creativity tasks in those related to ideas generation (divergent thinking) and those related to problem solving, positing that the mood-creativity link concerns specifically the ideation phase of the creative process and conforms to an inverted U relationship. Moderately positive mood would be associated with better creative performance than slightly positive mood, while intensely positive mood would have detrimental effects on creativity if compared to moderately positive mood (Davis, 2009; see also Johnson et al., 2012). Moreover, a recent study from Akbari Chermahini and Hommel (2012) aimed at testing if the effects of mood on creativity can be reciprocal. The researchers found that divergent thinking (measured with AUT) was able to increase positive mood states (assessed with the Positive and Negative Affect Schedule), while convergent thinking (measured with RAT) had the opposite effect. Considering also the very recent literature proving that positive affect can be acknowledged as an antecedent and a consequence of creativity in university settings (Rogaten & Moneta, 2015), the complexity of the relation between creativity and mood is evident and requires a deep understanding of the relationship between creativity, motivation and performance, with a focus on the environment. This suggests that further studies testing hypotheses about the mindfulness-creativity link should compare different settings for the experiments, also measuring carefully affect states and considering the latter as a multicomponent concept, thus verifying the effects of every single component on creativity.

Another issue that deserves further exploration concerns the relationship between personality, creativity, and MM. Some recent studies suggest that MM enhances some particular aspects of personality related to self-maturity (Campanella et al., 2014; Crescentini et al., 2015). Notably, the same aspects have been taken into account in a study that related a mature self with a creative personality. Kaasinen, Maguire, Kurki, Bruck, and Rinner (2005) have shown a positive link between self-transcendence (the enduring tendency to identify the self as an integral part of the universe as a whole; Urgesi, Aglioti, Skrap, & Fabbro, 2010), a key aspect of character measured by the Temperament and Character Inventory (TCI, Cloninger, Przybeck, Svrakic, & Wetzal, 1994), and traits

related to creativity (openness to experience and curiosity). Indeed, high scores on self-transcendence are generally related to open, unusual, and divergent thoughts (Bayon, Hill, Svrakic, Przybeck, & Cloninger, 1996; Kaasinen et al., 2005). More specifically, the authors noted that self-transcendence, combined with good development in the other two facets of character in the TCI framework, namely self-directedness (an attitude that maps on concepts such as self-esteem and self-efficacy; Crescentini et al., 2015) and cooperativeness (the tendency of being empathic, tolerant and compassionate; Crescentini et al., 2015), is associated to a mature creativity (Kaasinen et al., 2005). It would thus be interesting to test whether character traits moderate the relationship between MM and creativity with a stronger relation in individuals higher on the abovementioned character traits.

Finally, another interesting aspect to be further addressed by future research relates to the formal practice of MM as a way to influence creativity. As we have shown, previous studies have revealed that high trait, everyday mindfulness, as well as transient changes in state mindfulness levels (obtained for example with brief MM exercises), may be sufficient to affect creative performance. Thus, future research may continue to investigate what a constant, formal MM practice may add to creative thinking and behavior.

Conclusion

Our chapter was an attempt to link the complex construct of creativity to other structured and multifaceted concepts such as those of trait mindfulness and mindfulness meditation. MM differs from other types of passive rest such as relaxation because it requires full and sustained attention, and combines this aspect with open-monitoring and non-judgmental acceptance of all arising stimuli and experiences. As we reviewed, the “observe and accept” attitude of mindfulness and MM is able to affect creative performance and thinking in many different manners, in some cases not yet entirely understood. A more homogeneous definition and measurement of creativity, together with a continuing investigation of the effects of mindfulness meditation practices at the cognitive and

psychological levels, could be another critical step to further our understanding of how anyone of us may promote mindful creativity in one's own everyday life.

References

Akbari Chermahini, S., & Hommel, B. (2012). Creative mood swings: divergent and convergent thinking affect mood in opposite ways. *Psychological Research*, 76(5), 634–640.

Ansburg, P. I. (2000). Individual differences in problem solving via insight. *Current Psychology: Developmental, Learning, Personality, Social*, 19, 143–146.

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: emotion regulation following a focused breathing induction. *Behavior Research and Therapy*, 44(12), 1849–1858.

Arieti, S. (1976). *Creativity: The magic synthesis*. New York, NY: Basic Books.

Baas, M., De Dreu, C. K. W., Nijstad, B. A. (2008). A meta-analysis of 25 years of mood-creativity research: hedonic tone, activation, or regulatory focus? *Psychological Bulletin*, 134(6), 779–806.

Baas, M., Nevicka, B., & Ten Velden, F. S. (2014). Specific mindfulness skills differentially predict creative performance. *Personality and Social Psychology Bulletin*, 40(9), 1092–1106.

Baer, R. A., Smith, G. T., & Allen, K. B. (2004). Assessment of mindfulness by self-report. *Assessment*, 11(3), 191–206.

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment*, 13(1), 27–45.

Baird, B., Smallwood, J., Mrazek, M. D., Kam, J. W. Y., Franklin, M. S., & Schooler, J. W. (2012). Inspired by distraction: mind wandering facilitates creative incubation. *Psychological Science*, 23(10), 1117–1122.

Bar, M. (2009). A cognitive neuroscience hypothesis of mood and depression. *Trends in Cognitive Sciences*, 13(11), 456–463.

Batey, M., & Furnham, A. (2006). Creativity, intelligence, and personality: A critical review of the scattered literature. *Genetic, Social, and General Psychology Monographs*, 132(4), 355–429.

Batey, M., Chamorro-Premuzic, T., & Furnham, A. F. (2009). Intelligence and personality as predictors of divergent thinking: The role of general, fluid and crystallized intelligence. *Thinking Skills and Creativity*, 4(1), 60–69.

Bayon, C., Hill, K., Svrakic, D. M., Przybeck, T. R., & Cloninger, C. R. (1996). Dimensional assessment of personality in an out-patient sample: relations of the systems of Millon and Cloninger. *Journal of Psychiatric Research*, 30(5), 341–352.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., ..., Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, 11(3), 230–241.

Bowden, E. M., & Jung-Beeman, M. (2003). Aha! Insight experience correlates with solution activation in the right hemisphere. *Psychonomic Bulletin & Review*, 10(3), 730–737.

Bowen, S., Chawla, N., Collins, S. E., Witkiewitz, K., Hsu, S., Grow, J., ..., Marlatt, A. (2009). Mindfulness-based relapse prevention for substance use disorders: A pilot efficacy trial. *Substance Abuse*, 30(4), 295–305.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, 84(8), 822–848.

Buchheld, N., Grossman, P., & Walach, H. (2001). Measuring mindfulness in insight meditation (Vipassana) and meditation-based psychotherapy: The development of the Freiburg Mindfulness Inventory (FMI). *Journal for Meditation and Meditation Research*, 1, 11–34.

Campanella, F., Crescentini C., Urgesi, C., & Fabbro, F. (2014). Mindfulness-oriented meditation improves self-related character scales in healthy individuals. *Comprehensive Psychiatry*, 55(5), 1269–78.

Campbell, D. T. (1960) Blind variation and selective retention in creative thought as in other knowledge processes, *Psychological Review*, 67, 380–400.

Capurso, V., Fabbro, F., & Crescentini, C. (2014). Mindful creativity: the influence of mindfulness meditation in creative thinking. *Frontiers in Psychology, 10*, 4:1020.

Carver, C. S. (2006). Approach, avoidance, and the self-regulation of affect and action. *Motivation & Emotion, 30*, 105–110.

Chang, V. Y., Palesh, O., Cladwell, R., Glasgow, N., Abramson, M., Luskin, F., ..., Koopman, C. (2004). The effects of a mindfulness-based stress reduction program on stress, mindfulness and self-efficacy, and positive states of mind. *Stress Health, 20*(3), 141–147.

Chiesa, A., & Serretti, A. (2010). A systematic review of neurobiological and clinical features of mindfulness meditations. *Psychological Medicine, 40*(8), 1239–1252.

Colzato, L. S., Ozturk, A., & Hommel, B. (2012). Meditate to create: the impact of focused-attention and open-monitoring training on convergent and divergent thinking. *Frontiers in Psychology, 18*, 3:116.

Colzato, L. S., Szapora, A., Lippelt, D., & Hommel, B. (2014). Prior meditation practice modulates performance and strategy use in convergent- and divergent- thinking problems. *Mindfulness*.

Costa, P. T., Jr., & McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO PI-R) and NEO Five-Factor Inventory (NEOFFI): Professional manual*. Odessa, FL: Psychological Assessment Resources.

Chambers, R., Lo, B. C. Y., & Allen, N. B. (2008). The impact of intensive mindfulness training on attentional control, cognitive style, and affect. *Cognitive Therapy and Research, 32*(3), 303–322.

Chermahini, S. A., & Hommel, B. (2012). Creative mood swings: Divergent and convergent thinking affect mood in opposite ways. *Psychological Research, 76*(5), 634–640.

Cloninger, C. R., Przybeck, T. R., Svrakic, D. M., & Wetzel, R. D. (1994). *The Temperament and Character Inventory (TCI): a guide to its development and use*. St. Louis, MO: Center for Psychobiology of Personality, Washington University.

Crescentini, C., Urgesi, C., Campanella, F., Eleopra, R., & Fabbro, F. (2014). Effects of an 8-week meditation program on the implicit and explicit self-referential religious/spiritual representations. *Consciousness and Cognition*, 30, 266–80.

Crescentini, C., & Capurso, V. (2015). Mindfulness meditation and explicit and implicit indicators of personality and self-concept changes, *Frontiers in Psychology*, 6(44).

Crescentini, C., Matiz, A., & Fabbro, F. (2015). Improving personality/character traits in individuals with alcohol dependence: the influence of mindfulness-oriented meditation. *Journal of Addictive Diseases*, 34(1), 75–87.

Davis, M. A. (2009). Understanding the relationship between mood and creativity: A meta-analysis. *Organizational Behavior and Human Decision Processes*, 108(1), 25–38.

De Dreu C. K., Nijstad B. A., & Baas M. (2011). Behavioral activation links to creativity because of increased cognitive flexibility. *Social Psychological and Personality Science*, 2, 72–80.

Dietrich, A. (2004). The cognitive neuroscience of creativity. *Psychonomic Bulletin and Review*, 11(6), 1011–1026.

Didonna, F. (Ed.). (2009). *Clinical handbook of mindfulness*. New York, NY: Springer.

Ding, X., Tang, Y. Y., Tang, R., & Posner, M. I. (2014). Improving creativity performance by short-term meditation. *Behavioral and Brain Functions*, 10:9.

Fabbro, F., & Muratori, F. (2012). La mindfulness: Un nuovo approccio psicoterapeutico in età evolutiva [Mindfulness: A new psychotherapeutic approach for children]. *Giornale di Neuropsichiatria dell'Età Evolutiva*, 32, 248–259.

Fabbro, F., & Crescentini, C. (2015). Coscienza e meditazione mindfulness [Consciousness and mindfulness meditation]. In E., Casiglia (Ed.), *Trattato d'ipnosi e altre modificazioni di coscienza* (pp. 917–826) [Essay on hypnosis and other alterations of consciousness]. Padova, Italy: Cleup.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience*, 14(3), 340–347.

Feist, G. J. (1998). A meta-analysis of the impact of personality on scientific and artistic creativity. *Personality and Social Psychological Review*, 2(4), 290–309.

- George, J. M. (2007). Creativity in organizations. *Academy of Management Annals*, 1(1), 439–477.
- Gough, H. G. (1979). A creative personality scale for the adjective check list. *Journal of Personality and Social Psychology*, 37(1), 1398–1405.
- Greenberg, J., Reiner, K., & Meiran, N. (2012). “Mind the trap”: Mindfulness practice reduces cognitive rigidity. *PLoS ONE*, 7(5), e36206.
- Guilford, J. P. (1950). Creativity. *American Psychologist*, 5(9), 444–454.
- Guilford, J. P. (1967). *The Nature of Human Intelligence*. New York, NY: McGraw-Hill.
- Hayes, S. C., Follette, V. M., & Linehan, M. M. (2004). *Mindfulness and acceptance: Expanding the cognitive-behavioral tradition*. New York, NY: Guilford Press.
- Hennessey, B. A., & Amabile, T. M. (2010). Creativity. *Annual Review of Psychology*, 61, 569–598.
- Heeren, A., Van Broeck, N., Philippot, P. (2009). The effects of mindfulness on executive processes and autobiographical memory specificity. *Behavioral Research Therapy*, 47(5), 403–409.
- Higgins, E. T. (2006). Value from hedonic experience and engagement. *Psychological Review*, 113(3), 439–460.
- Hölzel, B. K., Ott, U., Gard, T., Hempel, H., Weygandt, M., Morgen, K., & Vaitl, D. (2008). Investigation of mindfulness meditation practitioners with voxel-based morphometry. *Social Cognitive and Affective Neuroscience*, 3(1), 55–61.
- Hölzel, B.K., Lazar, S.W., Gard, T., Schuman-Olivier, Z., Vago, D.R., and Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspect. Psychol. Sci.* 6, 537-559.
- Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness meditation modifies subsystems of attention. *Cognitive Affective and Behavioral Neuroscience*, 7(2), 109–119.
- Johnson, S. L., Murray, G., Fredrickson, B., Youngstrom, E. A., Hinshaw, S., Bass, J. M., ..., Salloum, I. (2012). Creativity and bipolar disorder: touched by fire or burning with questions? *Clinical Psychological Review*, 32(1), 1–12.

Jung, C. G. (1933). *Modern Man in Search of a Soul*. London, UK: Routledge & Kegan Paul.

Jung-Beeman, M. J., & Bowden, E. M. (2000). The right hemisphere maintains solution-related activation for yet-to- be-solved problems. *Memory & Cognition*, 28(7), 1231–1241.

Kaasinen, V., Maguire, R. P., Kurki, T., Bruck, A., & Rinner, J. O. (2005). Mapping brain structure and personality in late adulthood. *NeuroImage*, 24(2), 315–322.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, 4(1), 33–47.

Kabat-Zinn, J. (1994). *Wherever you go, there you are: Mindfulness meditation in everyday life*. New York, NY: Hyperion.

Kabat-Zinn, J., Lipworth, L., and Burney, R. (1985). The clinical use of mindfulness meditation for the self-regulation of chronic pain. *Journal of Behavioral Medicine*, 8(2), 163–190.

Kristeller, J. L., & Wolever, R. Q. (2011). Mindfulness-Based Eating Awareness Training for treating binge eating disorder: The conceptual foundation. *Eating Disorders*, 19(1), 49–61.

Luchins, A. S. (1942). Mechanization in problem solving – the effect of einstellung. *Psychological Monographs*, 54,(6, Whole No. 248).

Ludwig, D. S., & Kabat-Zinn, J. (2008). Mindfulness in medicine. *Journal of the American Medical Association*, 300(11), 1350–1352.

Lutz, A., Slagter, H. A., & Dunne, J. D. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Science*, 12(4), 163–169.

Mednick, S. (1962). The associative basis of creative problem solving process. *Psychological Review*, 69, 200–232.

Malinowski, P. (2008). Mindfulness as psychological dimension: Concepts and applications. *Irish Journal of Psychology*, 29(1), 155–166.

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience*, 7:8.

Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition*, 18(1), 176–186.

Ostafin, B. D., & Kassman, K. T. (2012). Stepping out of history: mindfulness improves insight problem solving. *Consciousness and Cognition*, 21(2), 1031–1036.

Parkhurst, H. B. (1999). Confusion, lack of consensus, and the definition of creativity as a construct. *Journal of Creative Behavior*, 33(1), 1–21.

Ren, J., Huang, Z., Luo, J., Wei, G., Ying, X., Ding, Z., ..., Luo, F. (2011). Meditation promotes insightful problem-solving by keeping people in a mindful and alert conscious state. *Science China - Life Sciences*, 54(10), 961–965.

Rogaten, J. , & Moneta, G. B. (2015). Use of creative cognition and positive affect in studying: Evidence of a reciprocal relationship. *Creativity Research Journal*, 27(2), 225–231.

Runco, M. A. (Ed.) (1991). *Divergent thinking*. Norwood, NJ: Ablex.

Schooler, J. W., Mrazek, M. D., Franklin, M. S., Baird, B., Mooneyham, B. W., Zedelius, C., & Broadway, J. M. (2014). The Middle Way: Finding the balance between mindfulness and mind-wandering. In B. H. Ross (Ed.), *The Psychology of Learning and Motivation* (Vol. 60, pp. 1–33). Burlington, MA: Academic Press.

Schooler, J. W., Ohlsson, S., & Brooks, K. (1993). Thoughts beyond words: When language overshadows insight. *Journal of Experimental Psychology: General*, 122(2), 166–183.

Segal, Z. V., Williams, J. M. G., & Teasdale, J. D. (2002) *Mindfulness-based cognitive therapy for depression: A new approach to preventing relapse*. New York, NY: Guilford Press.

Singer, J. L., & Antrobus, J. S. (1972). Daydreaming, imaginal processes, and personality: A normative study. In P. W. Sheehan (Ed.), *The function and nature of imagery* (pp. 175–202). New York, NY: Academic Press.

Smallwood, J., & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin*, 132(6), 946–958.

Sternberg, R. J., & Lubart, T. I. (1999). The concept of creativity: prospects and paradigms. In R. J. Sternberg (Ed.) *Handbook of Creativity* (pp. 3–15). New York, NY: Cambridge University Press.

Sung, Y. S., & Choi, J. N. (2009). Do Big Five Personality factors affect individual creativity? The moderating role of extrinsic motivation. *Social behavior and personality*, 37(7), 941–956.

Tang, Y. Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., ..., Posner, M. I. (2007) Short-term meditation training improves attention and self-regulation. *Proceedings of the National Academy of Sciences USA*, 104(43), 17152–17156.

Tomasino, B., Chiesa, A., & Fabbro, F. (2014). Disentangling the neural mechanisms involved in Hinduism- and Buddhism-related meditations. *Brain and Cognition*, 90, 32–40.

Torrance, E. P. (1962). *Guiding creative talent*. Englewood Cliffs, NJ: Prentice Hall.

Torrance, E. P., Ball, O. E., Safter, H. T. (1981). *Torrance Tests of Creative Thinking*. Bensenville, IL: Scholastic Testing Service.

Urgesi, C., Aglioti, S. M., Skrap, M., & Fabbro, F. (2010). The spiritual brain: Selective cortical lesions modulate human self-transcendence. *Neuron*, 65(3), 309–319.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of Personality and Social Psychology*, 54(6), 1063–1070.

Zedelius, C. M., & Schooler, J. M. (2015). Mind wandering “Ahas” versus mindful reasoning: Alternative routes to creative solutions. *Frontiers in Psychology*, 6:834.

Discussion

The first two studies indicate that meditation practices in education can improve children's cognitive, emotional, and social abilities and how in IVE contexts they can reduce state and trait anxiety, improving physiological and emotional regulation in adults. In the following reviews about MM and creativity we've pointed out that there is a link between MM and creative performance that has not been entirely understood yet.

The first two studies stressed the link between MM and reduction of anxiety. Notably some studies have also considered the link between creativity and anxiety and more generally between creativity and health. A first general premise is that research about correlations between stress and creativity has assessed that it is not objective stressful events *per se* that can affect mental and emotional health, but how individuals "perceive, subjectively experience, and successfully cope with the stress in their lives" (Carson & Runco, 1999). One of the major point seems to be the ability of people to cope with stress, where the activity of coping includes intellectual as well as emotional skills. The ability to generate new ideas and to find unexpected solutions to problems seems to be another important factor linked not only to creativity but also to personal and emotional well-being. Suicide ideation, for instance, has been associated with problems in fluency when generating solutions and in flexibility when trying to solve problems (Mraz & Runco, 1994). This seems to be in contrast with previous studies where creativity was strictly associated to depression (Jamison, 1989; Slaby, 1992; Post, 1994). The study of Slaby, for example, suggested that impulsive suicides were caused by changes in the serotonergic system responsible of risk taking, a typical trait in creative and innovative personalities (Slaby, 1992).

Contrary to this idea, in the last years, literature suggested that creative people tend to have well-integrated personalities (Carson & Runco, 1999). A possible explanation of these apparently contrasting theories comes from a different perspective linking creativity and personality. Cloninger and Cloninger (2013), for example, suggest a connection between creative process and a healthy character configuration, showing practical mental and

physical benefits of the latter. In their study creativity was measured as the product of the three character scores in the TCI (Self-Transcendence, Self-Directedness, Cooperativeness) and was significantly correlated with a greater balance between positive and negative affect and with greater parasympathetic balance (Cloninger & Cloninger, 2013). Following this research line, the study of Leung and colleagues argues that negative emotions may benefit creativity only in individuals with certain personality dispositions (Leung et al., 2014). They introduced the construct of trait-consistent emotion regulation, a state where the motivational inclination elicited by a mood state (e.g., positive mood) is compatible with the nature of task (e.g., fun; Leung et al., 2014). In this light, the authors investigated if trait-consistent emotion regulation could help individuals attain higher creative performance than non-trait consistent emotion regulation. Results confirm this hypothesis and stress the fundamental role of personality in creative tasks. Individuals with higher neuroticism, assessed with the Neuroticism scale of the Goldberg's Big Five factor structure (Goldberg, 1992), preferred experiencing worrisome emotions before facing a demanding creativity task and they produced creative designs that were rated as being more creative (Leung et al., 2014). Preference was assessed with a list of 12 events (Tamir, 2005), evoking happiness, worry, calmness or boredom. It's worthwhile noticing how this study goes beyond the precedent literature, offering new insights in a research line that links personality traits, creativity and emotion regulation (Leung et al., 2014).

A recent literature review (Baas, Nijstad. Boot & De Dreu, 2016) lends support to this theory, speaking in favor of the positive effects of creativity on psychological well-being, and tries to clarify the link between creativity – in its different forms – and mental health. The authors propose that inclinations toward psychopathology and creativity depends on the bio-behavioral system involved and the psychopathology identified. More in details they affirm that “psychopathologies that are grounded in the approach system (positive schizotypy, (hypo)mania) positively relate to creativity; propensities for psychopathologies that are grounded in the avoidance system (e.g., depressive mood, anxiety, and negative schizotypy) tend to be negatively associated with creativity” (Baas et al., 2016, p. 685).

An additional point on this topic has been raised by the neuroscientific perspective about creativity. The article of Fink and colleagues examined the generation of cognitive

reappraisal, which implies the operation of creativity-related processes in an affective context (Fink et al., 2016). Cognitive reappraisal means a deliberate switch of perspective and a re-interpretation of an emotionally evocative event thus changing its emotional impact (Lazarus & Alfert, 1964; Lazarus & Folkman, 1984; Fink et al., 2016). It requires an individual to shift attention from the habitual pattern to a new perspective with the aim of adopting new strategies, and relies on basic executive functions such as the inhibition of highly activated representations, memory updating, and cognitive switching (Fink et al., 2016). The latter are involved, and play a major role, in creativity (Gilhooly et al., 2007; Runco, 2010; Benedek et al., 2012; Fink et al. 2016). The generation of reappraisal is proved to be strictly linked with divergent thinking (Weber et al., 2014), but it seems to include a wider range of demands. Cognitive reappraisal has positive implications for psychological health and well-being (Garnefski et al., 2002; Gross & John 2003) and is commonly used in modern psychotherapeutic approaches. Notably, as we've pointed out in the precedent chapters, it is a typical mechanism involved in MM (Garland, Gaylord, & Fredrickson, 2011; Hölzel et al., 2011). The study suggests cognitive reappraisal, measured with the Reappraisal Inventiveness Test (RIT, Weber et al., 2014), was generally associated with a pattern of alpha oscillations, measured with a Brainvision BrainAmp Research Amplifier, that were similar to those generated during verbal creative ideation. This study is the first one investigating a pattern strictly linked to mental health – reappraisal - in a neuroscientific perspective, thus giving an important contribution to objective measures of brain mechanisms underlying creativity, emotion regulation and psychological well-being.

Following the studies we have examined in this essay we want here to underline here an interesting pattern of correlations between cardiac variability and the various measures of creativity (Bowers & Keeling, 1971). In the experiment of Bowers and Keeling, 20 subjects were hypnotized, then were presented a series of slides of selected Holtzman inkblots and realistic scenes and had to give a creative answer to the scene. Heart rate was monitored during the experiment. The day after the experiment the subjects did the Revised Art Preference Scale (Welsh & Barron, 1963) and the Remote Associates Test (RAT; Mednick & Mednick, 1967). Better performance in RAT was related to a better heart rate variability and the authors argued that since heart-rate variability is less under conditions of high

anxiety than it is under low anxiety, heart rate variability can be correlated with creativity. On this topic recent literature (Gillie & Thyler, 2014) has proved that for instance in Post Traumatic Stress Disorder there is cognitive control deficits and low resting HRV associated with poorer performance on tasks that require cognitive control processes, especially those that tap inhibition. For these reasons future studies should aim to evaluate the relationship between individual differences in HRV and cognitive control ability both before and after trauma exposure. Another study (Hildebrandt, L.K., McCall, C., Engen, H.G., and Singer, T., 2016) demonstrated that people with greater cognitive flexibility in an affective task-switching task showed better regulation of physiological arousal (, during less-threatening phases of an experience in IVE. Individuals with higher trait resilience and individuals with higher resting heart rate variability showed more regulation in terms of their subjective arousal experience. The results indicate that emotional, cognitive, and physiological flexibility support nuanced adaptive regulation of objective and experienced arousal in the ongoing presence of threats.

The abovementioned studies open an interesting line of research that could involve, based on the first study presented in this essay, the relation between mindfulness meditation, creativity (here intended as a form of cognitive flexibility) and heart rate variability, possibly considering mindfulness as a mediator.

Finally a recent study deserves attention, since it creates a tight connection between creativity, psychological well-being and MM. Gouda and colleagues (2016) have taken into consideration the effects of MM on creativity and anxiety, comparing two different groups, one of teachers and one of students (Gouda, Luong, Schmidt and Bauer, 2016). After the eight-week training, on the basis of the results of the Freiburg Mindfulness Inventory (FMI; Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006), the Perceived Stress Questionnaire (PSQ; Fliege, Rose, Arck Levenstein & Klapp, 2001) the Hospital Anxiety and Depression Scale (HADS; Hermann-Lingen, Buss & Snaith 2005) and the Emotion Regulation Skills Questionnaire (ERSQ; Berking and Znoj, 2008), students showed a decrease in internalizing problems, namely interpersonal problems, anxiety and stress and an improved creativity, assessed with the Test for Creative Thinking- Drawing Production (TSD-DP; Urban and Jellen, 1995). Teachers showed higher mindfulness levels, fewer

interpersonal problems, and promising effect sizes on emotion regulation and anxiety. This study opens a new and interesting research line that points out the effects of MM on creativity in different developmental stages (adulthood vs adolescence; Gouda et al. 2016) and a possible influence of age on creativity.

Future directions

After examining the positive effects of MM on anxiety, emotion regulation and internalizing problems, and the possible links between creativity and mindfulness, we have taken into consideration here the positive effects of creativity on the same areas where MM acts. There is an interesting overlapping of MM and creativity in the abovementioned fields.

Many authors in these years have considered the positive effects of enhancing creativity and divergent thinking in both children and adults (Carson and Runco, 1999). For example openness in considering reality, suspending judgment, learning to integrate thoughts and emotions are considered useful skills in helping people taking decisions and solving problems with positive effects on mental and physical health. (Torrance, 1983; Benjamin, 1984; Baer, 1993; Barron, 1988; Stein, 1988). This allows us to make a comparison between these attitudes and those typical attitudes people develop with MM as non-judgmental attitude, openness to experience, and beginner's mind. There is an increasing recognition that creativity plays an important role in improving the health and well-being of individuals but literature of creative arts as therapeutic measure is still meager, possibly for a lack of a clear definition of "creative arts/activities" (Leckey, 2011). The impact of creative arts in care delivery is very difficult to measure because of the diverse interpretations of this construct. Moreover the range of creative arts is quite wide. The review of Hacking and colleagues (Hacking, Secker, Kent, Shenton, & Spandler, 2006), gives a general overview of creative arts in therapy and states that the most common arts, used as a tool for improving personal well-being, are drawing and painting (77%), crafts (60%) and writing (59%).

It seems important, for the future, to find out the different components of creative activities in order to identify the areas of action of each component.

To date, as far as we know, only one study has compared the effects of creative activities with MM (Garland et al., 2007), and one has compared Art therapy with Mindful art therapy (Ando & Ito, 2014). Garland and colleagues, in a non-randomized study, compared a Mindfulness-Based Stress Reduction (MBSR) program and a Healing through the creative Arts (HA) program. They verified the effects on spirituality, stress, and mood disturbance in cancer patients. The HA program consisted in an explicit work on self-knowledge (answering to question like “Who am I?; How am I?”) through movement, journaling, creative writing, and drawing (Garland et al. 2007). Results showed that MBSR participants improved more than those of HA in spirituality, anxiety, anger, total stress, and mood disturbance. The authors suggest that spirituality, the typical ingredient of MM programs, could be the component to explain the stronger effects of MM in the comparison with creative arts. Furthermore it is important to consider here the limitation of the non-randomization as a key point to analyze in the future, to possibly link creative personality and trait mindfulness.

A second study compared Creative Art Therapy with Mindfulness Art Therapy on mood of healthy people (Ando & Ito, 2014). The difference between the two groups laid in the fact that the Mindfulness Art Therapy group received a mindfulness training that included breathing, yoga, and body scan before performing the creative activities (collage and paintings). The score of Total Mood, measured through the The Japanese Profile of Mood States (POMS) short version (Yokoyama, 2010), significantly decreased only in the Mindfulness Art Therapy Short version. It could be interesting to design a similar experiment, lasting for more the two sessions of this study, to verify the effects of longer treatments. Overall a tentative conclusion could be that the Mindfulness component may be more effective in enhancing mood than the artistic activities alone.

These exploratory studies require to be implemented to test the roles of MM and creativity. Future studies could take into consideration to compare a creative art training (creative writing, painting,) with MM in healthy people, verifying the possible role of mood and personality as mediators. Furthermore, heart rate variability could be considered to verify the link between mindfulness, creativity and HRV and the possible role of mindfulness as a mediator.

The work that researchers have done in recent years seems to assess a link between MM and creativity. It would be then interesting to verify if a creative personality (Cloninger and Cloninger, 2013) can be considered to be intrinsically mindful, if the traits of the creative person can be facilitators for being more mindful. In particular, the research of Garland and colleagues could be used, together with some recent studies about MM and spirituality (Campanella, Crescentini, Urgesi & Fabbro, 2014; Crescentini, Urgesi, Campanella, Eleopra & Fabbro, 2014; Crescentini & Capurso, 2015) as a starting point to verify if the element that enhances positive effects of a MM training versus creativity, could lie in self-transcendence and spirituality or in mindfulness (Mac Coon et al., 2012).

Finally it could be interesting to standardize a creative program, developed on 8 weeks as the standard of MM programs, to facilitate a fine-grained comparison between the two trainings and verify if creative activities have effects on divergent thinking and cognitive flexibility and which are the specific components of creative arts that positively influence personal well-being. A standardized creative program, compared with a classical MM program, could be analyzed also in its follow-up (3-6 months) and a neuroscientific perspective could help assessing the effects of creative activities on the brain.

Creativity and Mindfulness have both demonstrated in many years of research their importance in decision making and problem solving. They proved to be effective on anxiety, mood, stress and, more in general, on the individual's well-being. A more homogeneous definition of creative therapy, the ideation of a specific creative training and a deep analysis of the role of mood and personality, could be useful to better identify the role of mindfulness and creativity in people's psychological and physical well-being. And, more in general, to explain their positive role in our daily lives.

Reference

Ando, M. & Ito, S. (2014). Potentiality of Mindfulness Art Therapy Short Version on Mood of Healthy People, *Health*, 6, 1224-1229.

Baas, M., Nijstad, B. A., Boot, N. C., & De Dreu, C. K. (2016). Mad Genius Revisited: Vulnerability to Psychopathology, Biobehavioral Approach-Avoidance, and Creativity, *Psychological Bulletin*, 6, 668–692.

Baer, J. (1993). *Creativity and divergent thinking: A task-specific approach*. Hillsdale, NJ: Erlbaum.

Barron, F. (1988). Putting creativity to work. In R.J. Sternberg (Ed.), *The nature of creativity: Contemporary psychological perspectives* (pp. 76-98). New York: Cambridge University Press.

Benjamin, L. (1984). Creativity and counseling. *Highlights: An ERIC/ CAPS Fact Sheet* (Ed 260 369). Ann Arbor, MI: School of Education, University of Michigan.

Benedek, M., Franz, F., Heene, M., & Neubauer, A. C. (2012). Differential effects of cognitive inhibition and intelligence on creativity. *Personality and Individual Differences*, 53, 480–485.

Berking, M., & Znoj, H. (2008). Entwicklung und validierung eines fragebogens zur standardisierten selbsteinschätzung emotionaler kompetenzen (SEK-27). *Zeitschrift für klinische Psychologie, Psychiatrie und Psychotherapie*. 56, 141–153.

Bowers, K. S., & Keeling, K. R. (1971). Heart-rate variability in creative functioning. *Psychological Reports*, 29(1), 160-162.

Campanella, F., Crescentini, C., Urgesi, C., & Fabbro, F. (2014). Mindfulness-oriented meditation improves self-related character scales in healthy individuals. *Comprehensive Psychiatry*, 55, 1269-1278.

Carson, D.K., & Runco, M.A. (1999). Creative Problem Solving and Problem Finding in Young Adults: Interconnections with Stress, Hassles, and Coping Abilities, *The Journal of creative behavior*, 33, 167-188.

Cloninger, C. R., & Cloninger, K.M. (2013). People Create Health: Effective Health Promotion is a Creative Process, *International Journal of Person Centered Medicine*, 3, 114-122.

Crescentini, C., Urgesi, C., Campanella, F., Eleopra, R., & Fabbro, F. (2014). Effects of an 8-week meditation program on the implicit and explicit self-referential religious/spiritual representations. *Consciousness and Cognition*, 30, 266-280.

Crescentini, C. & Capurso, V., (2015) Mindfulness meditation and explicit and implicit indicators of personality and self-concept changes, *Frontiers in Psychology*, 6:44. doi:10.3389/fpsyg.2015.00044.

Fink A., Weiss, E.M., Schwarzl, U., Weber, H., de Assunção V. L., Rominger, C., Schuler, G., Lackner H. K., & Papousek, I. (2016). Creative ways to well-being: Reappraisal inventiveness in the context of anger-evoking situations. *Cognitive Affective and Behavioral Neuroscience*, doi 10.3758/s13415-016-0465-9.

Fliege, H., Rose, M., Arck, P., Levenstein, S., & Klapp, B. F. (2001). Validierung des "Perceived Stress Questionnaire" (PSQ) an einer deutschen Stichprobe. *Diagnostica*, 47, 142–152.

Garland, E.L., Gaylord, S.A., & Fredrickson, B.L. (2011). Positive reappraisal mediates the stress-reductive effects of mindfulness: An upward spiral process. *Mindfulness*, 2, 59-67.

Garland, S.N., Carson, L.E., Cook, S., Lansdell, L. and Speca, M. (2007). A Non-Randomized Comparison of Mindfulness-Based Stress Reduction and Healing Arts Programs for Facilitating Post-Traumatic Growth and Spirituality in Cancer Outpatients. *Supportive Care in Cancer*, 15, 949-961.

Garnefski, N., Van Den Kommer, T., Kraaij, V., Teerds, J., Legerstee, J., & Ornstein, E. (2002). The relationship between cognitive emotion regulation strategies and emotional problems: Comparison between a clinical and a non-clinical sample. *European Journal of Personality*, 16, 403–420.

Gillie, B.L. & Thayer, J. F. (2014). Individual differences in resting heart rate variability and cognitive control in posttraumatic stress disorder. *Frontiers in Psychology*. 5, 758, doi: 10.3389/fpsyg.2014.00758.

Gilhooly, K. J., Fioratou, E., Anthony, S. H., & Wynn, V. (2007). Divergent thinking: strategies and executive involvement in generating novel uses for familiar objects. *British Journal of Psychology*, 98, 611–625.

Goldberg, L. R. (1992). The development of markers for the Big-Five factor structure, *Psychological Assessment*, 4, 26 – 42.

Gouda S, Luong MT, Schmidt S, Bauer J. (2016) Students and Teachers Benefit from Mindfulness-Based Stress Reduction in a School-Embedded Pilot Study. *Frontiers in Psychology*, 7: 590, <http://dx.doi.org/10.3389/fpsyg.2016.00590>

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and wellbeing. *Journal of Personality and Social Psychology*, 85, 348– 362.

Hacking S., Secker J., Kent L., Shenton J., & Spandler, H. (2006) Mental health and arts participation: the state of the art in England. *The Journal of The Royal Society of the Promotion of Health* 126, 121–127.

Hermann-Lingen, C., Buss, U., & Snaith, R. P. (2005). *HADS-D - Hospital Anxiety and Depression Scale*. Bern: Huber.

Hildebrandt, L., McCall, C., Engen, H. G., & Singer, T. (2016). Cognitive flexibility, heart rate variability, and resilience predict fine-grained regulation of arousal during prolonged threat. *Psychophysiology*. doi: 10.1111/psyp.12632.

Hölzel, B.K., Lazar, S.W., Gard, T., Schuman-Olivier, Z., Vago, D.R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, 6, 537-559.

Jamison, K. R. (1989). Mood disorder and patterns of creativity in British writers and artists, *Psychiatry*, 52,125-134.

Lazarus, R. S., & Alfert, E. (1964). Short-circuiting of threat by experimentally altering cognitive appraisal. *Journal of Abnormal and Social Psychology*, 69, 195–205. doi:10.1037/h0044635

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. New York: Springer.

Leckey, J. (2011). The therapeutic effectiveness of creative activities on mental well-being: a systematic review of the literature. *Journal of Psychiatric and Mental Health Nursing*, 18, 501-509.

Leung, A. K.-y., Liou, S., Qiu, L., Kwan, L., Y.-Y.; Chiu, C.-y. & Yong, J. C. (2014). The role of instrumental emotion regulation in the emotions–creativity link: How worries render individuals with high neuroticism more creative, *Emotion*, 14, 846-856.

MacCoon, D. G., Imel, Z. E., Rosenkranz, M. A., Sheftel, J. G., Weng, H. Y., Sullivan, J. C., ...& Lutz, A. (2012). The validation of an active control intervention for mindfulness based stress reduction (MBSR), *Behaviour Research and Therapy*, 50, 3–12.

Mraz, W. & Runco, M.A. (1994) Suicide Ideation and Creative Problem Solving, *Suicide and Life-Threatening Behavior*, 24, 47-67 .

Post, F. (1994). Creativity and psychopathology: A study of 29 world-famous men. *British Journal of Psychiatry*, 165, 545-555.

Runco, M. A. (2010). Divergent thinking, creativity, and ideation. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge handbook on creativity* (pp. 413–446). Cambridge: Cambridge University Press.

Slaby, A. E. (1992). Creativity, depression and suicide. *Suicide and Life Threatening Behavior*, 22, 157-66.

Stein, M.I. (1988). Creativity: The process and its stimulation. In F. Flach (Ed.), *The creative mind* (pp. 51-75). New York: Bearly Limited.

Tamir, M. (2005). Don't worry, be happy? Neuroticism, trait-consistent affect regulation, and performance. *Journal of Personality and Social Psychology*, 89, 449–461.

Torrance, E.P. (1983). The importance of falling in love with “something.” *Creative Child and Adult Quarterly*, 8, 72-78.

Thera, N. (1962). *The heart of Buddhist meditation: A handbook of mental training based on the Buddha's way of mindfulness*. London: Rider and Company.

Urban, K. K., & Jellen, H. G. (1995). *Test zum Schöpferischen Denken- Zeichnerisch (TSD-Z)*. Frankfurt: Swets Test Services.

Walach, H., Buchheld, N., Büttenmüller, V., Kleinknecht, N., and Schmidt, S. (2006). Measuring mindfulness—the Freiburg mindfulness inventory (FMI). *Personality and Individual Differences*, 40, 1543–1555.

Weber, H., Loureiro de Assunção, V., Martin, C., Westmeyer, H., & Geisler, F. C. (2014). Reappraisal inventiveness: The ability to create different reappraisals of critical situations. *Cognition & Emotion*, 28, 345–360.

Welsh G., S., & Barron, F. (1963). *Barron Welsh Art Scale*. Palo Alto Consulting Psychologists Press.

Yokoyama, K. (2010). *POMS Short Version: Tebiki to Jirei Kaisetsu*. Kaneko Syobo, Japan. (in Japanese)