Chapter 8

Attention, consciousness and mindfulness in meditation

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Abstract

The training of attention is a central feature of different meditation methods. This aspect has been emphasized with priority by several authors in recent influential work. However, apart from attentional processes, other neurocognitive processes underlying different aspects of consciousness and self-awareness are crucially involved in meditation. It is therefore important to provide broader theoretical frameworks and hypotheses to incorporate neurocognitive processes implicated in consciousness and self-awareness in meditation, with attentional functions. Based on recent experimental findings, we first characterize focused attention and open monitoring, as well as their relationships, in meditation, with reference to mindfulness. We then consider key aspects of conscious processing and its neural substrates, with special reference to global workspace approaches, and crucial relationships between self-reference, consciousness and mindfulness. We then present a novel hypothesis on the implications of mindfulness-related processes for cognitive and affective flexibility. In the last part of the chapter we focus on the relationships between different facets of consciousness and mindfulness, and provide a neurocognitive characterization of meta-consciousness as related to meditation. Finally, we highlight important research directions related to the theoretical framework presented in the chapter.

Introduction

Meditation can be conceptualized as a family of practices regulating awareness and emotions in which mental and related somatic events are affected by engaging a specific attentional set. The training of attention is a central feature of different meditation methods (Davidson & Goleman, 1977). Indeed, several studies have reported the development of more efficient attentional processes with meditation practice, including increased attentional control and sustained attention (e.g., Slagter et al., 2007; van den Hurk et al., 2010; for a review see Lutz, Slagter, Dunne & Davidson, 2008).

More generally, a number of recent behavioral, electroencephalographic (EEG) and neuroimaging studies have revealed the importance of investigating states and traits related to meditation to achieve an increased understanding of cognitive and affective neuroplasticity, attention and awareness (Cahn & Polich, 2006; Lutz et al., 2008; Raffone & Srinivasan, 2010). Also, clinical applications are increasingly recognized (Cahn & Polich, 2006, Hofmann, Sawyer, Witt & Oh, 2010; van Aalderen et al., 2012).

Meditation practices can be usefully classified into two main styles—*focused attention* (FA) and *open monitoring* (OM)—depending on how the attentional processes are directed (Cahn & Polich, 2006; Lutz et al., 2008; but see Travis & Shear, 2010, for a different perspective). In the focused attention ("concentrative") style, attention is focused on a given object in a sustained manner. The second style, open monitoring meditation, involves the non-reactive monitoring of the contents of ongoing experience, primarily as a means to become reflectively aware of the nature of emotional and cognitive patterns.

In this section we will first characterize focused attention meditation, then open monitoring meditation, and then discuss how focused attention and open monitoring can also be practiced in the same meditation context and understood in a unitary manner.

Focused Attention Meditation

In focused attention meditation practice, high attentional stability and vividness (acuity) are achieved in a mental state of concentrated calm or serene attention, denoted by the word *Samatha* (with the literary meaning of *quiescence*) in the Buddhist contemplative tradition (Wallace, 1999). By using a telescope analogy, Wallace (1999) observed that in focused attention or *Samatha* meditation the development of attentional stability may be likened to mounting a telescope on a firm platform, while the development of attentional vividness is like highly polishing the lenses and bringing the telescope into clear focus.

Apart from sustaining the attentional focus on an intended object, focused attention meditation also implies the regulative skills of monitoring the focus of attention, detecting distraction, disengaging attention from the source of distraction and refocusing on the object (Lutz et al., 2008). Focused attention meditation techniques involve observing the experiential field by allowing thoughts and sensations to arise and pass without clinging to them, maintaining attention on an object or bringing it back to the specific object of focused attention, in order to develop an internal "witnessing observer" (Cahn & Polich, 2006). The attentional and monitoring functions of focused attention meditation have been related to dissociable systems in the brain involved in conflict monitoring and in selective and sustained attention (Lutz et al., 2008; see also Corbetta & Shulman, 2002, and Weissman et al., 2006). The neural correlates of such different focused attention meditation functions have recently been characterized by a functional Magnetic Resonance Imaging (fMRI) study conducted by Hasenkamp et al. (2012).

Srinivasan and Baijal (2007) reported changes in automatic pre-attentive processing due to concentration (i.e., focused attention) meditation. Frequent and infrequent auditory tones were presented to the meditators (before meditation and while exiting meditation) and

control group (during relaxation). The results showed increase in mismatch negativity amplitudes immediately after and before meditation indicating enhanced sensitivity of the perceptual system of the meditators even before attention could be allocated for a cognitive task. Changes in perceptual processes have been shown with a study of Buddhist meditators in which expert meditators (Tibetan Buddhist monks) could sustain motion-induced blindness for a long period (Carter et al., 2005), as a focused attention meditation state effect. The study also reported longer durations with a binocular rivalry task indicating possible changes in the brain mechanisms responsible for perceptual awareness, as a state effect of focused attention meditation based on (trait) meditation expertise (Carter et al., 2005).

In addition to enhancement of perceptual processing, practice of meditation results in changes in different attentional processes depending on the nature of meditation practice (Baijal, Jha, Kiyonaga, Singh, & Srinivasan, 2011). A study on children who practiced Transcendental Meditation showed that not all attentional processes are benefited with increased practice and expertise (Baijal et al., 2011). More specifically, they investigated alerting, orienting, and conflict monitoring using the Attention Network Test (ANT). While conflict monitoring and alerting performance was different between meditators and controls, there was no difference in orienting. In addition, the results showed that Transcendental Meditation training also results in helping meditators handle conflict trials that are followed by non-conflict trials indicating a benefit in reactive control mechanisms.

An fMRI study with the practitioners of focused attention meditation showed lower activations to regions related to distraction and task unrelated thoughts compared to the controls during a task that required the observers to ignore auditory stimuli (Brefczynski-Lewis et al., 2007). Practice of focused attention meditation resulted in enhanced ability to focus attention thereby reducing the effects of irrelevant stimuli. During focused attention meditation compared to rest, there was activation in multiple regions associated with

monitoring and engagement of attention such as dorsolateral prefrontal cortex, visual cortex, superior frontal and intraparietal sulci. Interestingly, the strength of activity in these regions showed an inverted *u*-shaped curve with meditators with moderate experience showing stronger activation but very experienced meditators showing less activation. The *u*-shaped pattern of brain activity indicates that with very extensive mental training due to the practice of focused attention meditation, minimal effort might be necessary to sustain the focus of attention.

Open Monitoring Meditation

As suggested by Lutz et al. (2008), open monitoring meditation can lead to a development of regulatory influences on emotional processes, through prefrontal regulation of limbic responses. Indeed, neuroimaging studies have shown that simple verbal labeling of affective stimuli leads to the activation of the (right) ventrolateral prefrontal cortex, and to reduced responses of the amygdala through ventromedial prefrontal cortex activity (Hariri, Bookheimer & Mazziotta, 2000; Lieberman et al., 2007). This strategy of labeling aspects of experience (e.g., "this is unpleasant") is, for example, used in Vipassana (or insight meditation) meditation and enables a detached awareness of affective contents in moment-by-moment experience.

In open monitoring meditation, monitoring is reflected in an open-field capacity to notice arising sensory, feeling and thought events within an unrestricted background of awareness. In the transition from a focused attention to an open monitoring meditative state, the object as the primary focus is gradually replaced by a sustaining of an open awareness (Lutz et al., 2008). Behavioral studies have shown a more distributed attentional focus (Valentine & Sweet, 1999), enhanced conflict monitoring (Tang et al., 2007) and reduced

attentional blink or more efficient resource allocation to serially presented targets (Slagter et al., 2007) in open monitoring meditators.

Lutz, Greischar, Rawlings, Ricard, and Davidson (2004) found a high-amplitude pattern of synchrony in the gamma oscillatory band in expert meditators during an emotional version of open monitoring meditation (i.e., non-referential compassion or loving kindness meditation). In that study, compared with a group of novices, the practitioners (with a mental training of 10,000 to 50,000 hours over time periods ranging from 15 to 40 years) self-induced higher-amplitude sustained gamma band oscillations and long-range phase synchrony, especially over lateral fronto-parietal electrodes, during meditation. This pattern of gamma band oscillations and synchrony was also significantly more pronounced in the baseline state of the long-term practitioners compared with the novices, thus suggesting a neuroplasticity-based transformation in the default brain mode of the practitioners.

Focused Attention and Open Monitoring in a Unitary Context and View of Meditation

Attentional stability and vividness (acuity), as developed in focused attention meditation, are regarded as necessary for deep and reliable introspection to take place in meditation, as in the practice of *Vipassana* (insight) meditation. As remarked by Wallace (1999), Tsongkhapa (1357–1419), an eminent Tibetan Buddhist contemplative and philosopher, refers to another analogy to highlight the importance of attentional stability and vividness for the cultivation of contemplative insight. If an oil-lamp that is both radiant and unflickering is used at night to light a hanging tapestry, the depicted forms can be vividly observed. By contrast, if the oil-lamp is either dim or, even if it is bright, flickers due to wind the depicted images cannot be seen.

It has to be noted that the witnessing observer or meta-awareness function plays a key role in *both* focused attention and open monitoring meditation forms. Such function is also

related to the well-known notion of *mindfulness*, generally defined to include focusing one's attention in a nonjudgmental or accepting way on the experience occurring in the present moment (e.g., Brown, Ryan & Creswell, 2007; Kabat-Zinn, 1990). Indeed, it is possible to be mindfully aware of all that is currently salient, and it is also possible to be mindful of something in particular by focusing attention toward a stimulus or phenomenon (Kornfield, 1993). It is also possible to focus attention on a given object (as breath sensations in meditation), and to be reflectively mindful of such focus and any distracting source. Thus, in several meditation practices, focused attention and open monitoring styles can be more plausibly regarded as two sides of the same coin, as in Buddhist insight meditation (e.g., Khantipalo, 1984), with a fundamental role of mindfulness. As remarked by Chiesa (2012, p. 3), "…concentrative and mindfulness meditation practices are no longer described as opposed processes. Instead, several authors recognize that they usually share a common background of focused attention (concentration), which can take different directions depending on the specific meditation form…While the former primarily concerns the stability of the meditative state, the latter concerns the specific phenomenological "angle" from which the receptive field can be observed." However, other meditation practices, such as non-referential open presence meditation, do not involve focused attention on an object (see Lutz, Dunne & Davidson, 2007, for a review on different forms of Buddhist meditation).

Mindful training that emphasizes focused attention has been found to improve attentional orienting (Jha et al., 2007, van der Hurk et al., 2010) as well as conflict monitoring (Tang et al., 2007; van der Hurk et al., 2010). In contrast, mindfulness training that emphasizes open monitoring improves alerting network as measured using the Attention Network Test (see Jha et al., 2007).

A study with Vipassana (insight) meditation entailing focused attention and open monitoring facets have investigated the phenomenon of attentional blink (AB), which is poor

identification of the second of two targets presented amongst a stream of stimuli presented rapidly one after another. Vipassana meditators showed a reduced attentional blink indicating efficient distribution of the limited attentional resources (Slagter et al., 2007). The Vipassana meditators possibly gained better control over the allocation of attention by reducing the resources devoted to the first target (T1) processing (as exhibited by reduced T1-related P3b amplitude) such that the subsequent target was more often detected (or reduced AB).

In a related study (Slagter et al., 2007), EEG spectral analyses showed that intensive mental training in the form of Vipassana meditation was associated with decreased cross-trial variability in the phase of oscillatory theta activity after successfully detected T2s, in particular, for those individuals who showed the greatest reduction in brain resource allocation to T1. This finding implicates theta phase locking in conscious target perception, and suggests that after meditation-based mental training the cognitive system is more rapidly available to process new target information.

In another investigation, Lutz et al. (2009a) found a reduced variability in attentional processing of target tones after intensive focused attention and open monitoring meditation training, as showed by both enhanced theta-band phase consistency of oscillatory neural responses over anterior brain areas and reduced reaction time variability. Moreover, those participants who showed the greatest increase in neural response consistency showed the largest decrease in behavioral response variability.

In the next section we will introduce and characterize conscious processing and its neural substrates that will be subsequently linked to meditation and mindfulness.

Conscious Processing and Its Neural Substrates

The Global Workspace for Conscious Processing in the Brain

It is generally acknowledged that when a stimulus is accessible in consciousness it is possible to readily perform a large variety of operations on it, including evaluation, explicit memorization, action guidance and verbal report. According to Block (1995), access consciousness makes information available to the brain's "consumer" systems, including systems of memory, perceptual categorization, reasoning, planning, evaluation of alternatives, decision making, voluntary direction of attention, and more generally, rational control of action. Thus, consciousness is a key basis for human cognition and action.

A pioneering theory of human consciousness, with important implications for addressing its neural mechanisms, is Baars' global workspace (GW) theory (1988; 1998, 2002; Baars, Ramsoy & Laureys, 2003). In this theory, unconscious processing occurs locally in a modular fashion, whereas conscious perception involves global access to widespread modular processing resources. Block (1995) characterized this type of consciousness as *access consciousness.* Access consciousness makes information distributed widely across brain regions available to cognitive consumer systems, including explicit memory, explicit perceptual categorization, reasoning, planning, evaluation of alternatives, decision making, and voluntary direction of attention as well as, more generally, the rational control of action. The GW mechanisms provide a gateway to extensive informational resources, but are limited in capacity at any given time.

Dehaene and collaborators revisited Baars' GW theory in a neuronal GW framework based on a coherent set of psychophysical, neuroimaging and computational investigations (Dehaene, Karszberg & Changeux, 1998; Dehaene & Naccache, 2001; Dehaene et al., 2006; Gaillard et al., 2009). This approach postulates that the global availability of information at the brain-scale, i.e., in the GW, is what we subjectively experience as a conscious state. The neuronal GW model is characterized by a *winner-take-all* dynamics at higher stages of neural processing (involving prefrontal cortex), a sort of "neural bottleneck" such that only one

large-scale reverberating neural assembly encoding for a selected conscious content is active in the GW at a given moment.

The Temporal Dynamics of Consciousness

The global neuronal workspace model proposed by Dehaene and collaborators posits two main perceptual processing durations: the first one is the duration sufficient for a stimulus to elicit significant changes of activation to be registered at the level of automatic or unconscious sensory processors, and the second one is the duration needed for the represented stimulus to access the GW, at a conscious level (Dehaene & Naccache, 2001). It crucially involves thalamo-cortical networks and re-entrant processes for conscious access, with a closed-loop system between bottom-up signal processors and top-down or recurrent signals. An implication of the closed-loop system is that it imposes a temporal resolution or granularity on the stream of consciousness, suggesting that a perceptual awareness moment may have a specific duration, with at least 100 ms required for this process to take place (Dehaene & Naccache, 2001).

Neural integrative processes for consciousness are also central to Varela's approach (Varela, 1995; Varela, Lachaux, Rodriguez & Martinerie, 2001). In Varela's encompassing view, *for every cognitive act, there is a singular and specific large cell assembly that underlies its emergence and operation*. Such assemblies are integrated in a time frame of 100 to 300 ms, by re-entrant (recurrent) signaling in the thalamo-cortical system (see also Tononi & Edelman, 1998). Large-scale neural assemblies are thus conceived as transient and dynamical, with a duration (a fraction of a second) that spans the time required to accomplish an elementary cognitive act. Their existence is however long enough for neural activity to propagate at a global brain level through the assembly, involving cycles of re-entrant spike exchanges with transmission cycles lasting tens of milliseconds.

The estimated time periods for consciousness in the models above are consistent with the phenomenon of the psychological refractory period, according to which discriminations occur one at the time (Welford, 1952). The time for such decisions is about 150 milliseconds, remarkably close to the lower limit of the period for conscious integration. Efron (1970) suggested that conscious cognition is temporally discrete and parsed into sensory sampling intervals or ''perceptual frames'', estimated to be about 70–100 ms in average duration. More recently, a time range of 70–100 ms has been interpreted as an attentional object-based sampling rate for visual motion (VanRullen et al., 2006). This sampling could potentially be related to the rate at which information from the automatic processing level reaches the GW for perceptual awareness. It may provide an estimate of the rate at which temporal representations at an unconscious or automatic processing level can be accessed.

Besides the 100-300 ms lower bound for the integration of GW assemblies for conscious access, chronometric studies have also demonstrated robust periodicities in reaction times (with an average of 25 ms), which are task-dependent and attention-independent (Dehaene, 1993; VanRullen & Koch, 2003). These data strongly suggest that the automatic temporal processes underlying perception and action are also discrete, but with shorter intervals than the periods for attention-based conscious integration. These fast and slow forms of temporal discreteness in mental activity might co-exist, with shorter intervals for temporally-structured firing exchanges in a currently dominant large-scale thalamo-cortical assembly for conscious access nested within the longer integration period linked to the short-term stability of the assembly itself (see also VanRullen & Koch, 2003).

Interestingly, the temporally discrete view of consciousness processes stemming from psychophysical investigations and neural models of consciousness, can be related to Buddhist texts, in which it is asserted that the continuum of awareness is characterized by successive *moments*, or *pulses* of cognition (von Rospatt, 1995; Wallace, 1999).

To reconcile conscious framing with the apparent continuity of perceptual experience, John (1990) suggested a mechanism with cortical convergence of a cascade of momentary perceptual frames to establish a steady-state perturbation (spatiotemporal signature) from baseline brain activity. This mechanism has received substantial support from EEG studies, showing that the dynamics of the (EEG) field is represented by intervals of quasi-stability or ''microstates,'' with sudden transitions between them (Strik & Lehmann, 1993). Such EEG microstates have been associated with spontaneous thought and visual imagery, as well as abstract thought (Koenig & Lehmann, 1996; Lehmann et al., 1998). And, as argued by Churchland and Sejnowski (1992), sequences of stable activation patterns at the neural level may be consistent with the seamless nature of our ongoing phenomenal experience, as these stabilizations can take place very rapidly (see also Fingelkurts & Fingelkurts, 2006).

The Mental Context of Consciousness

As suggested by Dehaene et al. (2006), a stimulus can be selected for conscious access in the GW only if the *bottom-up* representation of the stimulus is sufficiently strong *and* if there is a concurrent *top-down* (endogenous) attention allocated to it. Also, in a more encompassing neurodynamical framework, Varela et al. (2001) had emphasized the concurrency of bottom-up (incoming) and endogenous (top-down) neural activity for perception and awareness, with endogenous activity being provided by the states of expectation, motivation, emotion and attention (among others), which are necessarily active at the same time as the sensory input, with psychophysical and physiological evidence for their active participation even at early stages of sensory perception (e.g., von Stein et al., 2000).

Interestingly, in the 19th century Francis Galton and William James observed that conscious contents seem to jump from one to the next, but also that they seem to be linked by

associative themes that emerge many times. This view relates to the eloquent notion of "penumbra" suggested more recently by Crick and Koch (2003) in their framework for consciousness with reference to the dynamics of the Neural Correlate of Consciousness (NCC). In their framework, the NCC stands for the transiently dominant neuronal coalition (assembly) for a given conscious representation, as in the GW: "The NCC at any one time will only directly involve a fraction of all pyramidal cells, but this firing will influence many neurons that are not part of the NCC. These we call the 'penumbra'. The penumbra consists of both synaptic effects and also firing rates. The penumbra is not the result of just the sum of the effects of each essential node separately, but the effects of that NCC as a whole. This penumbra includes past associations of NCC neurons, the expected consequences of the NCC, movements (or at least possible plans for movement) associated with NCC neurons, and so on. For example, a hammer represented in the NCC is likely to influence plans for hammering. The penumbra, by definition, is not itself conscious, although part of it may become part of the NCC as the NCC shifts. Some of the penumbra neurons may project back to parts of the NCC, or its support, and thus help to support the NCC. The penumbra neurons may be the site of unconscious priming" (Crick & Koch, 2003, p. 124).

As related to Crick and Koch's penumbra notion, Baars (1998, 2002) suggested that unconscious or contextual brain systems play a role in shaping conscious events in the GW, acting as a *backstage* in a theater. According to Baars, such contexts work together jointly to constrain conscious events, with motives and emotions viewed as *goal contexts*, and executive functions working as hierarchies of goal contexts (see also Baars & Franklin, 2003). More recently, Barendregt and Raffone (2013) have characterized these contextual or endogenous aspects in terms of *mental states*, regarded as co-determined with discrete conscious transitions.

In particular, emotions may exert a deep influence on both unconscious and conscious processing. As remarked by Le Doux (2000), by its projections to cortical areas, the amygdala can influence perceptual and short-term memory processes, as well as processing in higher-order areas including likely GW areas, such as the anterior cingulate cortex. The amygdala also projects to nonspecific systems involved in the regulation of arousal and bodily responses (behavioral, autonomic, endocrine), and can thus influence cortical processing indirectly. Thus, after a fast unconscious response, which is effective at an unconscious level on the mind and body state, an emotional stimulus can access consciousness with a GW (or NCC) representation.

Given the privileged or dominant status of conscious representations in mental processing and related brain processes, with special reference to action selection and thinking, but also their mutual influences with emotions and motives, we consider the relationships between conscious processing, meditation and mindfulness. In the next section we will characterize fundamental relationships between self-related processing, consciousness and mindfulness.

Self-Reference, Consciousness And Mindfulness

The Experience of the Self

Our experiences are generally characterized by the ongoing feeling that there is a unique entity or agent experiencing the world, as a source of continuity, intentionality and identity. We generally refer to this as "self" (Ghin, 2003). The nature and functioning of the self and its facets has been one of the most debated issues in philosophy, and more recently in psychology and cognitive neuroimaging (e.g., Gallagher, 2000; Gallese, 2003; Northoff, Heinzel, de Greck, et al., 2006; Tagini & Raffone, 2010).

As suggested by James (1892), any consideration of the self needs to refer to the fundamental distinction between an "I" and a "Me". The I is "that which at any given moment *is* conscious. The Me is only one of the things which it is conscious *of*" (James, 1892, p.175, italics in the original). The I or "knower" is regarded as the subject of experience. The "Me" is the object of experience, or the "empirical aggregate of things objectively known" (p.191). Remarkably, James did not postulate the existence of a permanent core self or "unchanging metaphysical entity" that generates experience (p.175). Rather, he claimed that it is ''a thought, at each moment different from that of the last moment'' (p.191). Since the "*stream of thought*", is constantly changing, James did not assume that stable core processes of selfhood existed beyond the flow "*of consciousness, or of subjective life*" itself (James, 1890, p.148; italics in original).

Authors from diverse perspectives have concurred with James on the distinction between an implicit "I", corresponding to a subjective sense of the self as a thinker, causal agent and knower, and the "Me", i.e., the objective or explicit sense of the self with the unique and identifiable features constituting one's self-image or self-concept (e.g., Mead, 1934; Piaget, 1954; see Tagini & Raffone, 2010, for a review). More recently, related to James' view, Gallagher (2000) distinguished the *pre-reflective* aspect of the self, corresponding to the personal pronoun "I", from the *reflective self* extended in time and creating a subjective feeling of identity and continuity throughout time.

Self-Reference and Mindfulness

The default mode network (DMN) is a set of human brain areas characterized by self-referential functions, as recently discovered in neuroimaging. Activity in the DMN is generally reduced during non self-referential goal-directed tasks. This might be related to the folk psychological view of "losing one's self in one's work". Several studies indicate that the

DMN is involved in functions that are self-referential in nature: self-projection in remembering the past and planning the future, perspective taking of desires, beliefs, and intentions of others (Buckner, Andrews-Hanna & Schacter, 2008; Raichle et al., 2001). As found in a fMRI study with Zen Buddhist practitioners, DMN activation can be reduced with attention focused on breath-related sensations (Pagnoni, Cekic & Guo, 2008; for other recent studies about the DMN and meditation see Brewer et al., 2011; Hasenkamp & Barsalou, 2012; Jang et al., 2011; Josipovic et al., 2012).

To shed light on the relationships between self-referential processing, awareness and mindfulness, Farb et al.'s (2007) fMRI study characterized the neural bases of two forms of self-awareness: an *extended* self-reference linking experiences across time, and *momentary* self-awareness centered on the present moment. Specifically, they investigated monitoring of enduring traits ("narrative" focus) or momentary experience ("experiential" focus) in both novice participants and those having attended an 8-week course in Mindfulness Based Stress Reduction (MBSR). MBSR is a program that trains participants to develop attention in the present moment, emphasizing first focused attention and then open monitoring (supported by focused attention) meditation styles. In novices, the experiential focus results in focal reductions in medial prefrontal cortex associated with the narrative focus and the underlying DMN activity. In trained participants, the experiential focus yields more pronounced and pervasive reductions in medial prefrontal cortex, and an increased engagement of a right lateralized network including the lateral prefrontal cortex, the insula and the inferior parietal lobule. Following mindfulness training, the experiential focus results in a shift away from areas involved in affective reactions, such as the amygdala, toward more lateral prefrontal regions. This appears to support a more objective and self-detached analysis of interoceptive (insula) and exteroceptive (somatosensory cortex) sensory events, rather than their subjective or affective self-referential evaluation.

Moreover, functional connectivity analyses in Farb et al.'s (2007) study suggest that a default mode of self-referential awareness may depend upon the habitual coupling between regions in medial prefrontal cortex, supporting cognitive–affective representations of the self and more lateral viscerosomatic neural representations of body states. Farb et al. thus suggested a fundamental neural dissociation between the self across time, related to the Me or narrative (extended) self, and experience in the present moment related to the I, momentary or pre-reflective facets of the self. They also remarked that these two forms of self-awareness, which are habitually integrated, could be dissociated through attentional or mindfulness-based training. Finally, they put forth that mindfulness-based mental training might allow for a distinct experiential mode in which bodily sensations, thoughts and feelings are viewed as less integral to the self. These can then be treated more as transient mental events that can be simply observed in the "here and now", with important clinical and well-being implications (see also Williams, Teasdale, Segal & Kabat-Zinn, 2007).

A Novel Hypothesis on the Implications of Mindfulness for Cognitive and Affective Flexibility

In our view, the fMRI findings of Farb et al. (2007) imply that mental programs and conscious productions, with special reference to their neural codes in anterior insula, can be decoupled from self-referential processing areas with mindfulness meditation training. We hypothesize that such decoupling would reduce an automatic and conditioned selection of mental programs for action and thinking in the GW, and enhance cognitive and affective flexibility. It would thus be possible to re-program cognitive and affective responses to given situations or contexts, otherwise linked to habitual patterns or self-related evaluations and mental programs. Our hypothesis is based on the view that GW processing, capable of exerting a deep influence on cognition, behavior as well as evaluation and affective

processes, is *constrained* by self-related goal contexts, as also reflected in expectations, judgments and attentional biases, among others.

Such constraints would be reduced by mindfulness or ongoing meta-awareness. It is remarkable that in mindfulness meditation judgments, interpretations, self-related involvement in future-oriented projects and (self-)projections in the past are strongly de-emphasized, toward an unbiased awareness of moment by moment experience (Kabat-Zinn, 1990). What could thus provide stability of conscious states and transitions, with a weaker influence of self-related goal contexts and pre-established top-down influences? A focused attention meditation anchor might be given by focusing on a meditation object such as breathing or sitting sensations. In open monitoring meditation terms, such stabilization might arise by a meditative access to the ongoing awareness itself, and sustaining such access (see Lutz, Dunne & Davidson, 2007). Thus, in the presence of attentional stability and mindfulness, conscious mental activity might retain its stability but with a potentially increased flexibility, due to looser self-related constraints.

Stability in mental and conscious activity in the absence of a pronounced or rigid self-reference might also arise from large-scale brain patterns developed with meditation. With this respect, based on EEG coherent oscillatory patterns observed in long-term meditators (Lutz et al., 2004), Lutz et al. (2008) suggested that the emergence of large-scale coherent neural assemblies with meditation states can influence local neuronal processes in the brain. Moreover, by considering that in some versions of open monitoring meditation practitioners drop any explicit effort to control the arising of thoughts or emotions to further stabilize their meditation, and practitioners with high-expertise in focused attention meditation can sustain attentional focus on the intended object and regulate attention with a low effort, Lutz et al. (2008, p. 5) hypothesized that "some meditation states might not be best understood as top-down influences in a classical neuroanatomical sense but rather as dynamical global states

that, in virtue of their dynamical equilibrium, can influence the processing of the brain from moment to moment." Furthermore, they argued, "In this view, the brain goes through a succession of large-scale brain states, with each state becoming the source of top-down influences for the subsequent state. We predict that these large-scale integrative mechanisms participate in the regulatory influence of these meditation states" (Lutz et al., 2008, p. 5).

We then argue that with high mindfulness and attentional focus, the GW for conscious thinking and action control can be decoupled from self-referential brain networks with the activation and integration levels necessary for consciousness. We also suggest that when the GW for consciousness is decoupled from self-referential representations, a high flexibility in mental programs is available, based on mindfulness. With this respect, it has been shown that mindfulness meditation training enhances cognitive flexibility (Moore & Malinowsky, 2009), in tasks in which the GW is centrally involved, such as the Stroop task (Dehaene et al., 1998).

It is remarkable that the DMN network has been associated with both mind wandering (Mason et al., 2007) and self-referential activity (e.g., Raichle et al., 2001) and, that conversely, mind wandering is reduced with mindfulness meditation (Mrazek, Smallwood, & Schooler, 2012). Also, as shown by Farb et al. (2007), self-referential processing can be modulated after mindfulness meditation training. Finally, as shown by Pagnoni et al. (2008) and Brewer et al. (2011), DMN activity can be modulated by mindfulness meditation. We thus remark that mindfulness meditation can reduce mind wandering both by enhancing attentional control (e.g., van den Hurk et al., 2010) and by reducing the parasitic co-activation of self-referential brain areas during cognitive and affective processing, with special reference to conscious GW processing.

Consciousness, Meta-Consciousness and Mindfulness

Facets of Awareness and Mindfulness

Apart from attentional sets, other neurocognitive processes underlying different aspects of consciousness are also implicated in meditation (Raffone & Srinivasan, 2010). Mindfulness and open monitoring in meditation are linked to a *momentary (first person) self-awareness* rather than to a *narrative (third person) self-awareness*, as suggested by Farb et al.'s (2007) study discussed above. As suggested by Farb et al.'s (2007) findings, awareness of subjective or phenomenal aspects of experience in the present moment involves neuronal populations with responses marking transient body states, in particular, right lateralized exteroceptive somatic and interoceptive insular cortices (Craig, 2004; Critchley, Wiens, Rotshtein, Ohman & Dolan, 2004; Damasio, 1999). Somatic marker or momentary self-awareness areas have also been implied in open monitoring or mindfulness-based meditation (Lutz et al., 2008).

Siegel (2007) suggested a distinction between three different forms of awareness with reference to mindfulness-based Buddhist meditation (Cahn & Polich, 2006; Lutz et al, 2008). These are a *receptive* or *mindful awareness*, with openness to whatever comes to mind in the moment, which has been shown to create a state of flexibility in self-regulation enabling an individual to profoundly shift out of habitual ways of adapting and reacting (e.g., Kabat-Zinn, 2003); a *self-observational awareness*, accompanied by reflective self-observation, including the metacognitive investigation of one's mental processes; the integration of this self-reflective state with receptivity is characterized by *curiosity*, *openness*, *acceptance*, and *love* (COAL); and a *reflexive awareness*, implying a more immediate capacity of the mind to know itself, without effort and words, leading to an understanding of the nature of *awareness of awareness*.

The Problem of Meta-Consciousness

The problem of a self-like observer in introspection or meta-consciousness has been approached in depth by the Buddhist contemplative approach that regards introspection, as performed in insight meditation, as a form of metacognition or meta-awareness, thus raising the important problem of whether or not it is possible for the mind to observe itself. In Buddhist texts consciousness is described as a momentary collection of mental phenomena or distinct moments (von Rospatt, 1995), in line with more recent psychophysical and electrophysiological evidence. As Buddhists generally assert that at any given moment consciousness and its concomitant mental processes have coherently the same intentional object, and at any given moment only one consciousness can be produced in a single individual (Vasubandhu, 1991), the problem of whether or not it is possible for the mind to observe itself arises (Wallace, 1999). In this respect, a famous discourse attributed to the Buddha states that the mind cannot observe itself, just as a sword cannot cut itself and a fingertip cannot touch itself; nor can the mind be seen in external sense objects or in the sense organs (*Ratnacutasutra*, cited in Shantideva, 1971; see also Wallace, 1999).

To avoid an infinite regress in terms of a noted observer and the one who simultaneously notes that observer, the eighth-century Indian Buddhist contemplative Shantideva suggested that instead of this kind of metacognition occurring with respect to simultaneously existing cognitions, the recollection of past moments of consciousness takes place. In Shantideva's view, when one remembers seeing a certain event, one recalls both the perceived event and oneself perceiving that event. The subject and object are recalled as an integrated and experienced event, in which the subject is retrospectively identified as such, but Shantideva denies that it is possible for a single cognition to take itself as its own object (Dalai Lama, 1994; Shantideva, 1997; Wallace, 1999).

Wallace (1999, p. 179) clarified Shantideva's view on introspective metacognition: "When one's attention is focused on the color blue, one is not observing one's perception of

that color. However, when one's interest shifts to the experience of blue, one is in fact recalling seeing that color just a moment ago. In this process, one conceptually and retrospectively isolates the subjective element from the remembered experienced event, in which the blue and one's experience of it were integrated. Thus, when the attention is shifted back and forth between attending to the color and to remembering seeing the color, it seems as if such a shift is comparable to shifting the attention from the objects at the center of consciousness to those at the periphery. But according to Shantideva, the attention is instead shifted from the perceived object to a short-term recollection of a previous event. And in remembering that event, the subject is isolated and recalled, even though it was not its own object at the time of its own occurrence. When one is recalling a perception of an earlier event, there is still a sense of duality between oneself and the perception that one is recalling. A single cognition does not perceive itself, so the subject/object duality is sustained."

Here we note an interesting similarity with James' (1982) view on consciousness and the self: "The consciousness of Self involves a stream of thought, each part of which as 'I' can remember those which went before, know the things they knew, and care paramountly for certain ones among them as 'Me', and appropriate to these the rest." This view of meta-consciousness appears to converge with the contemporary connectionist approach to meta-representation and the creation of distributed representations that are then available for re-processing by the same network, thus implementing (meta)representational and (recursive) processing cycles that could be regarded as the parallel distributed processing basis of the stream of thought (Maia & Cleeremans, 2005). The same operational principles might underlie the GW dynamics for consciousness characterized by sequential (recursive) ignitions and transitions, which involve multiple brain systems in parallel.

The Adaptive Workspace Hypothesis: Consciousness and Meditation

Related to these problems, based on experimental evidence in neuroscience and psychology, as well as meditation-related insights and theories, Raffone and Srinivasan (2009) proposed a neurocognitive framework for consciousness, in terms of the *adaptive workspace hypothesis*, for consciousness, meta-consciousness and circular interactions with top-down attention, also with reference to meditation states. In such framework, consciousness may refer to an external or internal object per se (*first order consciousness*), or to the subjective or phenomenal experience of such an object (*second order consciousness*). There is then a *non-referential* or pure consciousness, associated to a fundamental going beyond the cognitive subject-object duality, as the awareness of being aware (see also Arenander & Travis, 2004; Zeki, 2003).

Remarkably, in Raffone and Srinivasan's framework, the notion of mindfulness, derived from Buddhist texts and recently more emphasized in cognitive and clinical psychological contexts (e.g., Cahn & Polich, 2006; Kabat-Zinn, 2003; Sumedho, 2004) is regarded as providing a unifying construct for endogenous attention, monitoring and executive control functions, which are necessary to guide perceptual awareness and self-awareness.

Maharishi Mahesh Yogi, who brought Transcendental Meditation to the West from the Vedic tradition of India (Mason, 1994), characterized the experience of pure consciousness as follows, "When consciousness is flowing out into the field of thoughts and activity it identifies itself with many things, and this is how experience takes place. Consciousness coming back onto itself gains an integrated state...This is pure consciousness". Pure consciousness is thus regarded as 'pure' in the sense that it is free from the contents of knowing. It is a state of consciousness in which the individual is fully aware, with the 'content' of pure consciousness being awareness of itself (Arenander & Travis, 2004). According to Raffone and Srinivasan (2009), this transcendent awareness can only be

developed through meditation-based intuition, and can thus also be characterized as an *intuitive awareness* (Sumedho, 2004), or as the *reflexive awareness* facet of mindfulness (Siegel, 2007).

Conclusion

The neural correlates of different facets of consciousness, for example as characterized in the adaptive workspace hypothesis, need to be clarified in meditation settings. In particular, there might be involvement of highly trained meditators ("virtuosos") capable of switching between different attentional and awareness modes, with attention to (awareness of) external sensory fields or internal (thought- and feeling-related) fields of experience, by using the *neurophenomenology approach* (Lutz & Thompson, 2003; Varela, 1996). In the neurophenomenological approach, quantitative measures of neural activity are combined with first person data about the subject's inner experience. Participants' reports can thus be useful in identifying variability in brain activity from moment to moment. This unique information might guide the detection and interpretation of neural processes correlated to different aspects of conscious experience. Novel techniques for EEG analysis might be fruitfully applied in that framework (Fingelkurts & Fingelkurts, 2006; Thompson & Varela, 2001).

In further studies, it would be insightful to compare brain activity patterns in open monitoring meditation conditions with differential awareness of fields of experience, such as body sensory field, external sensory fields and thoughts and feelings. Moreover, it appears useful to design an experiment comparing brain activity patterns in focused attention meditation with focus on breathing-related sensations and on an external visual point. Indeed, somewhat different brain activity patterns have been observed in expert focused attention meditators with focus on an external visual point (Brefczynski-Lewis et al., 2007) and breathing sensations (Manna et al., 2010).

To shed light on the relationships and contrasts between perceptual awareness, a mindfulness-related momentary awareness and a narrative self-reference, a variant of Goldberg et al.'s (2006) fMRI paradigm might be carried out by contrasting brain activations in a demanding visual categorization task, a momentary self-awareness condition and a narrative self-referential awareness task condition (see also Farb et al., 2007). Such novel investigations combining the earlier studies by Goldberg et al. (2006) and Farb et al. (2007) could involve a group of expert insight meditators and a group of control subjects, with different mindfulness skills.

Also, an increased scientific understanding of compassion (loving kindness) meditation and related brain circuitries is important in light of relevant relationships with empathy and theory of mind (Lutz, Brefczynski-Lewis, Johnstone & Davidson, 2008) and clinical implications of compassion-based mental training (Gilbert, 2009). It also appears relevant to integrate such an understanding with knowledge about the mechanisms of focused attention, monitoring and awareness investigated in other forms of meditation.

Finally, large-scale computational models with biological and cognitive constraints can shed further light on the neural mechanisms of attention and consciousness implied in meditation. In particular, neurocomputational models based on the GW processing principles (e.g., Dehaene et al., 2003; Raffone & Pantani, 2010; Simione et al., 2012) might be usefully adapted to simulate plausible neural mechanisms for focused attention and cognitive monitoring in meditation, including meditation expertise-related effects, and possibly lead to novel testable predictions.

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