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Conscious, Pre-Conscious and Unconscious Mechanisms in Emotional Behaviour. Some Applications to the Mindfulness Approach with Wearable Devices

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Abstract: Conscious, pre-conscious, and unconscious mechanisms are implicated in modulating affective processing in daily activities. Specifically, mental practice fostering awareness and control of affective reactions to external stimuli and stressful events (such as mindfulness and neurofeedback protocols) can be used to improve our ability to manage unconscious negative emotions. Indeed, it is possible to empower self-monitoring and regulation skills, as well as our ability to manage stress and negative emotions coming from everyday events and activities. This can be accomplished, on the one hand, by regularly practicing self-observation and by promoting bodily awareness and an awareness of automatic responses (e.g., uncontrolled affective reactions); on the other hand, by undergoing implicit training protocols that take advantage of brain responses. The present paper elucidates the contribution of both conscious and unconscious levels in emotion regulation and stress management, with a focus on their neural correlates and their role in mindfulness practice and on the potential of body-sensing devices for supporting meditation sessions, for fostering motivation to practice, and for making meditation more appealing and sustainable. We will finally present preliminary evidence on the effect of an intensive technology-mediated meditation protocol based on mindfulness practices and supported by a brain-sensing wearable device. The experimental procedure included three levels of outcome indices: psychometric measures related to perceived stress; neuropsychological and behavioural measures related to cognitive performance; and instrumental measures (resting-state and task-related electroencephalographic markers—EEG-ERPs).

Keywords: conscious; unconscious; emotions; wearable devices; neurofeedback; mindfulness; automatic processing; stress management

1. Introduction

Over the last decades, philosophy of mind, cognitive sciences, social and cognitive psychology, and neuroscience have focused on how conscious and unconscious objects and mechanisms interact to define our behaviour and mental life. The complex interaction of aware and unaware processes provides the integrated, internal representation of the outer world, our organism and their connection, based on actual experiences, perception and memory. Taken together, this information allows us to navigate and act in the world around us [1].

After a brief introduction on recent accounts of human consciousness as well as the differentiation between conscious, pre-conscious and unconscious mechanisms, we will focus on the integration of conscious and implicit information-processing in shaping self-awareness and emotion regulation. Indeed, self-monitoring and emotion regulation skills are thought to benefit from increased awareness of automatic affective reactions. Regular practice of self-observation and mindfulness-based activities proved to empower such skill [2]. Evidence in favour of such claims concerning the neural and cognitive correlates of mindfulness practices will be discussed, with a focus on the potential of brain-sensing devices for supporting meditation sessions, fostering effective levels of motivation to practice, and making meditation practice more appealing, quicker and more sustainable.

2. Human Consciousness and Unconscious Mechanisms

As underlined by Balconi [3], consciousness has been defined both as a complex but unique entity presenting different facets and a coordinated set of independent systems. Recent theoretical perspectives on the topic of consciousness benefit from the gradual integration of Western and Eastern schools of thought, which traditionally described and studied consciousness and awareness in peculiar ways (the interested reader might refer to the following critical reviews [4–7]). The complexity of its structure and its manifestations is mirrored by the dual perspective from where it has been traditionally explored, i.e., the perspective contrasting an internal, subjective point of view (a tradition dating back to Wundt's first phenomenological investigations [8] and Brentano's theoretical-methodological remarks [9] which later evolved into phenomenological theorization [10,11]) and an external objective point of view (based on the analysis of observable, physiological correlates [12], as pursued by the quest for neural correlates of consciousness [13,14]).

Again, different authors transferred such complexity to their remarks on the localization of human consciousness. For example, Damasio initially focused on specific neural structures [15], Tononi focused on the integrated activity of distributed neural structures [16], and Varela underlined the necessity to focus on the whole organism and the interaction between brain, body and environment [17]. Subjective, neuro-functional, and anatomical correlates of human consciousness and of unconscious mechanisms have been the subject of many investigations and reviews [3,16,18] in an attempt to get a picture of their primary functions, features, and substrates both when the balance between conscious and unconscious mental life is critically altered due to pathology or brain lesions, such as cases of prosopagnosia or blindsight, and when it only temporally falters, such as tip-of-the-tongue experiences or during uncontrolled emotion reactions.

In the history of neuroscience and psychology research on consciousness correlates, at least two primary interpretative models have fuelled the debate on the topic: phenomenal consciousness models and access consciousness models [19]. While the first model focuses on the qualitative experience of conscious states, the second defines a state as conscious depending on the accessibility that an agent has to its content. Access consciousness perspectives, then, provide a natural background to discuss the relation and interplay between aware overt responses and unaware covert reactions as well as how the availability of such information might be modulated by specific awareness and meditation practices. As such, we will consider this theoretical framework.

A relevant and widely-diffused theoretical distinction is, in particular, the one between properly conscious, pre-conscious, and unconscious processes. Miller [20] and Neisser [21] started to formally distinguish pre-conscious (or pre-attentive) processes among non-conscious ones, which are defined as less complex and structured than their conscious counterpart. Pre-conscious processes and mechanisms lie at the basis of most everyday actions, in line with recent computational and neurophysiological models that stress the intrinsic limitation of resources and capacity of human consciousness [22].

According to such views, while properly unconscious objects and mechanisms are completely inaccessible by the subject generating them, pre-conscious objects and mechanisms are primarily unaware but can enter the spotlight of consciousness due to top-down attentional amplification [23] or higher-level monitoring and meta-cognitive mechanisms [24]. Finally, according to Dehaene and colleagues [23], the most simple way to define conscious mental contents is based on their access to subjective experience, on the possibility to intentionally attend to them, and on their reportability (see [24] for a partly contrasting point of view).

Conscious, pre-conscious, and unconscious mechanisms have also been differently defined in terms of their neuro-functional and computational correlates. These definitions are built on different but inherently connected basic phenomena, such as dynamic causally-effective integration of information [16], reverberating global information exchange [25], and adaptive resonances [22].

According to the neural global workspace hypothesis [23,25], conscious contents are supported by wide brain activation and long-distance connections between perceptual and associative cortical areas, forming a reverberating neuronal assembly. Preconscious neural processes, instead, are supported by medium-range resonant loops that maintain the representation of the stimulus temporarily active in a sensory buffer but still outside awareness, waiting for a potential amplification that would allow them to ignite global reverberating information exchanges. Unconscious contents, finally, are supported by bottom-up activations that are insufficient to trigger a large-scale reverberating state while still being subliminally processed.

3. The Balance between Aware and Implicit Information-Processing in Emotion Regulation

Conscious, pre-conscious, and unconscious mechanisms continuously and concurrently interact to define our experience *of*, *in*, and *with* the world. The integration of conscious and implicit information-processing is peculiarly critical in shaping self-awareness and emotion regulation.

Indeed, the three basic aspects of human self-consciousness—unity (i.e., the fact that our experience is made of integrated percepts), feelings of ownership and agency (i.e., the implicit attribution of our experience to ourselves and the recognition of ourselves as primary authors of our behaviour), and first-person-perspective (i.e., the fact that the default modality of our experience is egocentric) [26]—pervade different levels of our common experience, from sensorimotor processes to higher cognitive elaborations, and all of them ground on a complex set of interdependent aware and unconscious mechanisms.

These unconscious mechanisms, for example, both allow for the integration of proprioceptive, somatosensory and motor information to let us move in the environment, and drive the implicit recall of affectively-connoted past experiences in response to a particular event or situation. In the end, they lead to conscious outcomes, such as an intentional behaviour or an affective reaction. While the results of those processes and mechanisms are often easily accessible to consciousness, their premises, in the vast majority of situations, lie below the surface of consciousness and can be brought to awareness only by an intentional reflective effort.

Another pivotal example of that differentiation has to do with affective experience and emotion regulation. Traditional psychological and neurophysiological theories of emotion have argued over the relative contribution and salience of aware and unaware processes that shape our ability to feel, recognize, and communicate emotions and affective responses [27] by debating on the primacy of arousal and physiological reactions vs. cognitive appraisal mechanisms in the definition of such experience.

As underlined by Balconi [3], however, the regulation of emotions and affects depends on the complex interplay between conscious subjective experience and aware cognitive mechanisms—which modulate appraisal of the eliciting stimulus and continuous monitoring of subjective experience—and unconscious automatic reactions and implicit information processing—which generate early approach-avoidance reactions and bodily markers. In line with Damasio's theorization on the somatic marker [28,29], indeed, even bodily automatic reactions implicitly help us to interpret affectively-connoted events and guide our responses to those events. Individual expertise and level of awareness of such automatic reactions and uncontrolled affective responses mediate the ability to de-automatize automatic patterns of responses, self-monitoring, and regulation skills [30]. Interventions that aim at empowering that form of self-awareness—such as self-observation and mindfulness-based practices—may then help to empower stress management skills as well as the ability to adaptively face negative emotions coming from everyday events and activities.

4. The Mindfulness Approach: Implicit Responses, Bodily, and Self-Awareness

Such increased attention on implicit reactions and covert bodily and mental responses to affectively-connoted situations has led empirical psychologists and neuroscientists to further investigate the basic mechanisms and potential effects of meditation and mindfulness-based interventions with respect to affecting thoughts, self-knowledge, and affective experiences of practisers [2,31]. Meditation practice can be defined as an individual mental training activity used to self-regulate the body and the mind as well as to reach self-knowledge by engaging a specific attentional set [32]. Mindfulness meditation is a particular form of meditation based on self-observation and awareness practices which focus on the present and are grounded in Buddhist meditation tradition. In particular, it emphasizes conscious intentional focusing on, and acceptance of, one's own mental states, thoughts, feelings, and their related consequences, moment by moment.

Many traditions in clinical psychology suggest how meditation practices may help in preventing the onset of specific pathologies caused by the presence of irrational thoughts, cognitive distortions, and pathological cognitive patterns [33,34]. Specifically, mindfulness has recently attracted much attention following its increasing application in psychological protocols aiming at the promotion of psychophysical well-being [35,36].

Mindfulness practice, indeed, allows the practiser to bring to consciousness, carefully perceive, and then accept their mental states and associated bodily sensations [2]. This practice does not attempt to modify or repress these states and sensations but, rather, foster the development of novel, efficient, and adaptive ways of reading dysfunctional emotional states and manage stressful events. In particular, the ability to intentionally access internal experiences allows the implementation of more functional, effective and appropriate behavioural responses to emotionally-connoted external or internal events, in agreement with one's own genuine goals and motives.

By making reference to access models of consciousness and the above distinctions between unconscious, pre-conscious and conscious processes and states, regular practice of mindfulness meditation may train practisers to be more sensitive to psychological and somatic signals as well as fringe feelings and contents. These signals, feelings, and contents can be defined as pre-conscious (and, thus, momentarily inaccessible) mental elements which lie on the outer borders of awareness and might become fully conscious if top-down attentional or monitoring mechanisms amplified their supporting neural resonant loops.

This sort of interpretation fits well with the Cleereman's model of human consciousness and implicit learning [37], which defines them as continuous, gradual, and dynamic phenomena. According to this model, the long-term process of skill acquisition and their intentional conscious enaction is ground on early, unaware information and implicit representations. These are gradually brought to conscious intentional control, up to becoming completely automatized and self-sufficient (i.e., free from the need of aware executive control).

What is also interesting about this model is that it does not consider early implicit representations as neutral but, rather, as capable of influencing performance and behaviour—notwithstanding their inaccessibility to conscious processing and control. The ability to exert control over these unaware, implicit representations and manage their impact on behaviour and everyday experience is then linked to mindfulness meditation practice and their conversion into explicit conscious representations. Moving to the domain of affective responses and experience, such theorization suggests that the empowerment of emotion regulation skills is then linked to a gradual increase in awareness of, and access to, implicit emotional reactions.

To improve such awareness and self-regulation abilities, two main abilities are trained during the mindfulness practice: the ability to control the attention focus and orient it to the present moment, and the propensity to do so [38]. Those functions allow people to relate consciously with their own experience. Specifically, neuroscience research has shown how awareness attention control is necessary during mindfulness practices [39–42] and improves during the activity [40,41]. Further, recent empirical investigations have highlighted that mindfulness practice also increases the ability to efficiently focus on subjective, ongoing experiences as individuals develop these skills [43]. Again, mindfulness practice involves significant, gradual changes in the use of attention, memory and executive functions [44,45], and is effective in enhancing and preventing cognitive decline [46,47].

From a broader point of view, mindfulness is considered to be a particular form of metacognitive insight or awareness that allows the practiser to perceive and experience mental content and emotions as decentralized [48,49]. The practiser is, thereafter, able to better manage their mental content and emotions as well as their related affective automatic reactions. Hence, mindfulness helps to perceive one's own mental states not merely from the factual, content dimension and their emotional connotation, but also from a metacognitive perspective, which depicts them as independent objects with respect to one's own self, ultimately leading to a change in perspective [41].

Such changes in the way mental states, emotionally-connoted situations, and affective reactions are interpreted is then corroborated by continuous practice of self-observation and exercise of meta-awareness, understood as the intentional orientation of attention towards explicit characterizations of what is currently being experienced—i.e., reflective conscious processing of one's own experience [24]. Meta-aware insight processes, de-automatization, and cognitive flexibility allow individuals to develop a clearer and aware perception of emotional events—namely, as transient mental objects that may relate to unpleasant and unwanted internal events [50]. Along with metacognitive insight processes, other components in mindfulness practices are also fundamental and concurrently improve emotion regulation skills: intentionality, attention, and attitude [51]. These components in combination lead the practiser to develop critical abilities, such as acceptance, awareness, openness to, and implementation of the most functional emotional regulation strategies [52].

As for neurofunctional correlates of mindfulness practices, neuroimaging studies highlighted that they associate to activations in a wide frontal–parietal network, which is constituted by cortical structures supporting the definition of the self, behaviour planning, goal-setting, problem-solving, and emotional regulation [53]. Specifically, with regard to the development of an integrated sense of self and its representations in the future, mindfulness practice might have a positive effect on the activity of the dorsolateral prefrontal cortex, which is implicated in social perspective-taking, self-monitoring, emotional regulation, and coding of affective responses and emotionally-connoted information [54–59].

Instead, regarding emotional regulation, increased activation of the medial and dorsolateral prefrontal cortex and the anterior cingulate cortex has been observed during the execution of mindfulness practices. Taking into consideration the implications of those neural structures in emotion processing and affective regulation [60–62], their increased activation during mindfulness practices may be due to an up-regulated cortical processing of emotions, associated to an improved ability to regulate emotional states. Indeed, it has been shown that the increased awareness obtained via mindfulness practice associates to a decrease of amygdala activation in response to emotionally-connoted stimuli [63,64].

As for the electrophysiological signature of mindfulness practice—quantified in terms of electroencephalographic (EEG) cortical patterns associated to mental relaxation states—some studies have observed an increase in alpha and theta activity in frontal areas [32]. An increase of frontal activity may be associated to the orientation of attention resources and increased relevance of attention focus during mindfulness practices. In addition, the therapeutic potential of mindfulness practices has been put in relation with increased left-side frontal neural activation, which primarily mediates the positive emotion experiences [65–67]. In recent years, therefore, the interest of psychological and neuropsychological research has focused on the effectiveness of mindfulness intervention to improve specific functions, such as attention, emotion regulation, and self-consciousness.

5. Integrating Meditation and Mindfulness Practices with Body-Sensing Devices

Reported effects of mindfulness practice, with regard to the management of affective reactions and the improvement of cognitive functioning, strengthen the considerations of its potential for promoting psychological well-being and intervening in clinical contexts. Nonetheless, such potential is hampered by certain methodological requirements of the mindfulness approach. Indeed, traditional mindfulness protocols (as well as meditation protocols overall) require a rather intense exercise and constant commitment, two aspects that often lead to a gradual decrease of motivation and, consequently, to the suspension of individual practices [68–70]. The impact of such limitations might be reduced by the support of external devices that are able to make the practice less demanding and track individual progress over time, thus lowering the requested effort [69].

Motivation and intention are two building blocks of the mindfulness (and, globally, meditation) approach and lie at the core of neurocognitive mechanisms supporting such practices and their effects [71]. Further, they are both necessary to attain continuity in exercise. Many technologies developed to support meditation, thus, actually promote motivation by providing tips, sharing of results and experience in dedicated communities, plotting statistics, tracking advances, giving rewards, and setting milestones to reach in practice [69]. Those kinds of explicit, highly-salient and informative sources of information help to maintain practisers' awareness of their progress and advancements, thus fostering commitment and reflective reasoning on the effect of practice in managing automatic processing and unwanted implicit reactions.

More recently, such increased investigation into new ways to make meditation more accessible, and to empower self-awareness skills, led to the development of novel protocols that integrate mindfulness-based practice and body-sensing devices, such as biofeedback and neurofeedback systems. The improvement of emotion regulation and self-regulatory skills is probably the primary reason why people become interested and start practising mindfulness [72]. The research and clinical tradition of neuro-/bio-feedback interventions might then strongly contribute toward this goal.

As a first example, the "Spire" [73] is a biofeedback and activity tracker system targeting the breathing pattern of the user. Namely, it is able to estimate the mental state of the person who wears it from his/her breathing activity, inform him/her in case of increased stress or elevated tension, and guide him/her through breathing exercises for relaxation. The system is also supported by an app that gives rewards based on calmness and focus periods and also sets daily goals. By increasing awareness of breathing habits as well as promoting insight to the user's mental states, the system builds on the well-established tradition of mindful practices based on the observation of the breath cycle and all associated bodily sensation. By making these observations more accessible to consciousness, due to easily-interpretable feedbacks, there is a greater awareness of implicit affective reactions as well as more efficient emotion regulation [74].

Another example of an integrated breathing biofeedback system devised to accompany and support mindfulness-based practices is the "Sonic Cradle" [75,76]. Born as an art installation, it uses breath-related signals to manipulate soundscapes and proved to be able to promote relaxation, though such evidence has been criticized [77].

In addition, the "Meditation Chamber" [78] is a complex system combining virtual reality and biofeedback technology to reduce stress, guide relaxation techniques, and support mindfulness practice. The system records arousal, breathing, and heart rate biosignals, translating this implicit information flow into informative feedback signals. Namely, the visual environment in which users are immersed is modified based on their breathing rate and arousal level. The authors report positive effects using the chamber, as mirrored by decreased electrodermal activity indices, deeper breathing patterns, and increased self-reported perception of calmness.

To conclude, it is, however, worth noting that, while recent progress in the development of affordable biofeedback devices, constituted by easy-to-use wearable sensors and supporting smartphone apps, has opened new and interesting pathways in the fields of health promotion and psychophysical well-being, systematic research is needed to test their effectiveness with regard to proper training protocols on emotion regulatory skills as well as the ability to adaptively integrate conscious/unconscious correlates of affective responses.

In particular, serious games and technology-mediated trainings have a naturally motivating appeal and intrinsically encourage engagement in mindful practices. However, present products still have to be refined to properly offer a long-term personalized experience. Further, narratives included in such products to guide meditation activities, when present, are often limited to breathing awareness, focus, or relaxation practices. While such activities are crucial to train and improve bodily- and self-awareness, the development of emotion regulation, empathy, and prosocial skills (which also represent relevant goals for the mindfulness approach) may be fostered by enriching the user experience. This enrichment could constitute awareness practices focused on positive thinking, or recognition and acceptance of negative thoughts and unwanted automatic reactions to stressful situations, a feature that can be found in more recent devices such as the Muse™ headband.

Finally, in the above-cited examples, the virtuous integration of mindfulness-based practice and body-sensing devices was limited to peripheral autonomic biosignals. Such first implementations have been necessary to prove the potential of making implicit information on automatic bodily reactions accessible to awareness. Now the time is ripe to test and consolidate the integration with central biosignals, such as EEG, which would allow researchers to receive informative feedbacks on the effect of different activities on neural information-processing, as opposed to only the final bodily outcome of cognitive and affective processing.

6. Technology-Mediated Mindfulness Intervention: An Applied Example

Keeping such methodological remarks in mind, we will briefly present a first set of results we obtained while formally testing the effect of intensive practice with the commercial brain-sensing headband Muse™ (InteraXon Inc., Toronto, ON, Canada), which was devised to support meditation and mindfulness-based practice. The study aimed at exploring the potential of the intensive technology-mediated intervention, based on awareness practices, and was supported by a wearable device monitoring cognitive-affective profiles and stress levels.

A sample of forty university students presenting mild-to-moderate stress levels took part in the study. None of them reported ongoing concurrent therapies based on psychoactive drugs that can alter central nervous system functioning, presented clinically relevant stress levels, or experienced significant stressful life events during the previous 6 months. People with preceding systematic meditation experience have been excluded from the sample so to avoid potential methodological biases and confounds in the interpretation of outcome measures of the intervention. The participants were randomly divided into an active control group and an experimental group. Both groups were involved in a structured intervention, which lasted four weeks and was constituted by brief daily activities that were characterized by gradually increasing commitment.

The experimental group underwent an intensive training using the Muse™ wearable device—namely an EEG recording system connected to a dedicated smartphone app that was devised to support meditation practices and help foster bodily and psychological awareness via regular activities based on mindfulness principles (see Figure 1). The active control group underwent a relaxation control intervention devised to be similar to the target intervention in its overall structure, in the amount of commitment it required, and in the modalities of fruition, but to critically differ in two core aspects of the Muse™ training: the active role of participants and the presence of informative real-time feedbacks on participants' mental states offered by the device and the app.

Short-term effects of the intervention on perceived stress, cognitive performances, and EEG profile have been explored by assessing participants before, halfway, and after the end of the interventions. Perceived stress has been measured via the Perceived Stress Scale (PSS-10; [79]). The impact of the interventions on cognitive abilities was measured via a challenging battery of standardized neuropsychological tests and computerized reaction time tasks [80]. Namely, during computerized testing, participants had to complete a series of tasks tapping into different aspects of attention functions, from simple reaction tasks to an effortful response inhibition task. Table 1 reports the whole battery of psychometric and neuropsychological tests that have been administered during the assessment sessions.

Resting-state and task-related EEG data have been collected via a 16-channel V-Amp amplifier (Brain Products GmbH, Gilching, Germany) and analysed via frequency-domain (power density for standard EEG frequency bands) and time-domain indices (event-related potentials—ERP), so to investigate potential modulations of the oscillatory profile and information-processing markers induced by the interventions. In particular, we focused on a measure of system responsiveness (namely, a quantification of the alpha-blocking phenomenon), on a measure related to the balance between brain correlates of relaxation and activation (namely, the alpha–beta ratio), and on event-related attention and executive control measures (namely, the amplitudes of the N2 ERP deflection).

Perceived stress, cognitive performance, and EEG/ERP data were finally used to compute modulation indices weighted on individual baseline levels. Modulation indices were obtained by rationalizing halfway and final values over baseline values for each of the above outcome measures, so to control for potential inter-individual differences in initial stress, cognitive, and electrophysiological measures.

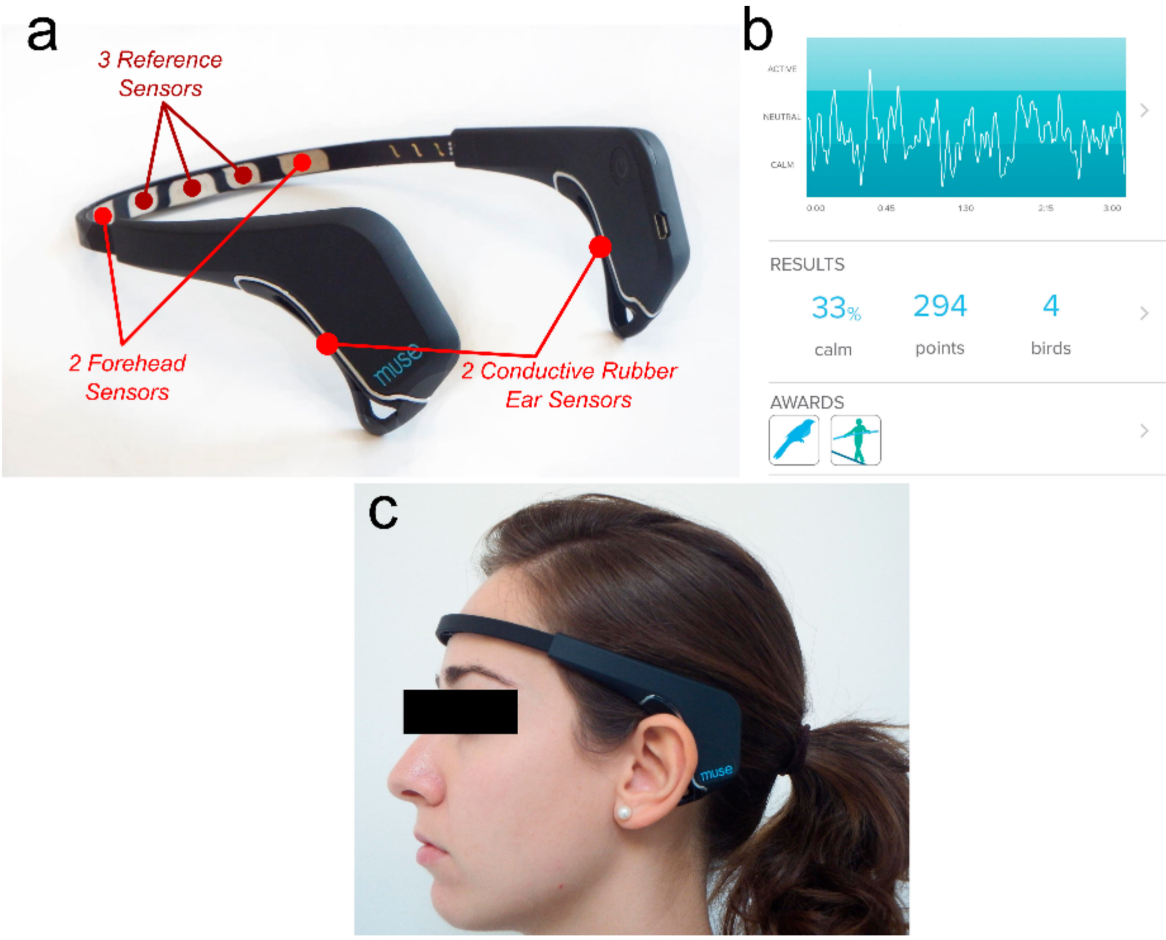

Figure 1. The Muse™ wearable device, a commercial brain-sensing headband devised to support meditation practices. The device pairs with a dedicated smartphone app and uses electroencephalographic (EEG) frequency data to provide the user with real-time acoustic feedback on his/her oscillatory brain activity. (**a**) The wearable device. Red dots mark the position of embedded EEG dry sensors; (**b**) An example of a post-session feedback screen; (**c**) Placement of the brain-sensing headband.

Table 1. Complete battery of psychometric and neuropsychological tests that was administered during assessment sessions.

Psychometric Measures	**Tests and Assessment Tools**
Personality and individual traits measures	Big Five Questionnaire (BFQ) Behavioral Inhibition System/Behavioral Activation System questionnaire (BIS/BAS) Coping Orientation to the Problems Experienced (COPE) State-Trait Anxiety Inventory (STAI)—*Trait subscale*
Clinical and subclinical state measures	Perceived Stress Scale (PSS-10) State-Trait Anxiety Inventory (STAI)—*State subscale* Profile of Mood States (POMS) Beck Depression Index (BDI) Brief Symptoms Inventory (BSI) Difficulties in Emotion Regulation Scale (DERS) Emotion Regulation Questionnaire (ERQ)
Mindfulness-related, self-observation and bodily awareness skills	Mindfulness Attention Awareness Scale (MAAS) Five Facet Mindfulness Questionnaire (FFMQ)
Neuropsychological Measures	**Tests and Assessment Tools**
Executive control and attention	Stroop test Attention matrices MIDA computerized test battery
Logic reasoning and cognitive fluency	Raven Standard Matrices Word-association fluency
Short-term memory	Disyllabic verbal memory span test Corsi block-tapping test

Preliminary analyses highlighted increased electrophysiological responsiveness indices and frequency profiles consistent with a relaxed mindset in the experimental group. Participants in the experimental group, in particular, showed enhanced electrophysiological markers (N2 deflection) of attention orientation, suggesting improved focus after the end of the intervention (see Figure 2). Even levels of perceived stress proved to be positively modulated by the experimental intervention, as well as cognitive efficiency as measured by a complex reaction times task tapping into response inhibition and executive control abilities. Here, we will briefly focus on stress-related data so to offer a first picture of preliminary project outcomes. The complete scenario of the effects of the experimental intervention on the three investigated levels of outcome variables will be disclosed at the end of the project.

Focusing on the level of stress—and related negative affective and motivational responses—reported by participants, the experimental group presented a decrease of 7% in perceived stress after two weeks of daily practice with the support of the Muse™ device and of 16% at the end of the intensive technology-mediated intervention, as shown in Figure 3. In contrast, the active control group only showed a limited reduction of perceived stress. Across-group statistical comparisons (unpaired *t*-tests; PASW Statistics 18, SPSS Inc., Quarry Bay, Hong Kong, China) confirmed that perceived stress levels after the end of the intervention were significantly lower for the experimental group than for the active control group (see Table 2).

Therefore, present preliminary findings represent the first evidence in favour of the potential of the investigated technology-mediated mindfulness intervention and of meditation-supporting brain-sensing devices as effective tools for promoting subjective well-being in people presenting mild stress levels.

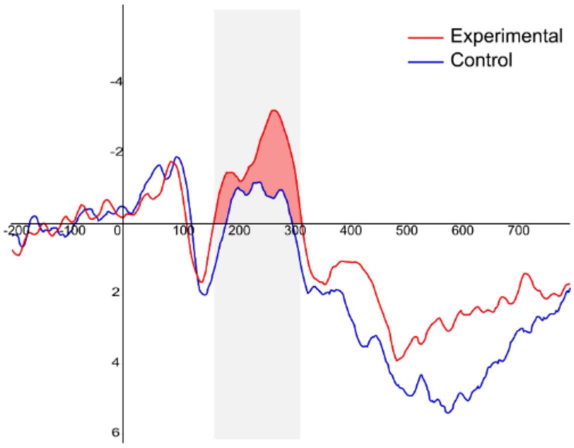

Figure 2. N2 event-related potential recorded during a challenging computerised task tapping into attention and executive control resources. EEG recording channel: Fz. Waveforms based on grand averages of the Control (blue line) and Experimental (red line) groups.

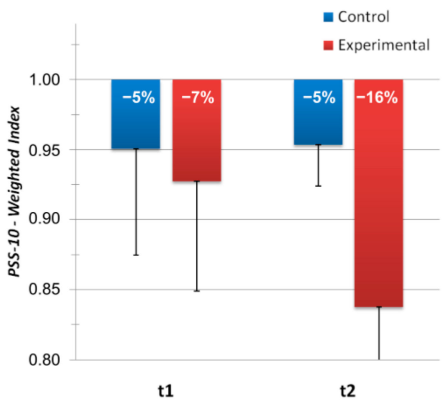

Figure 3. Modulation of perceived stress levels as measured by the Perceived Stress Scale (PSS-10) questionnaire (percentage changes weighted on individual baseline level of stress). Bars mirror mean changes of perceived stress for the Control (blue) and Experimental (red) groups, halfway through the interventions (t1) and at the end of the intervention (t2). Error-bars represent 1 SE.

Table 2. Group means, standard deviations, change scores, and data on between-group statistical comparisons of the modulation of the PSS-10 scores for the active control and the experimental groups. PSS-10: Perceived Stress Scale.

Assessment Step	Active Control Group		Experimental Group		Between-Group Unpaired *t*-Test	
	M (SD)	Change from Initial Values	M (SD)	Change from Initial Values	*t*-Value	*p*-Value
Intermediate measurement (2 weeks of practice)	0.95 (0.31)	−5%	0.93 (0.30)	−7%	0.18	n.s.
Final measurement (4 weeks of practice)	0.95 (0.12)	−5%	0.84 (0.15)	−16%	2.26	0.03

M = mean; SD = standard deviation; n.s. = not significant.

7. Conclusions

In the present paper, we discussed the interplay of conscious and unconscious mechanisms with reference to self-monitoring and emotion regulation skills. In particular, we focused on mindfulness practice as an example of an intervention that promotes self-awareness and enhances reflective attention towards automatic affective responses. Further, we discussed the potential of wearable sensors and body-sensing devices as supporting tools in meditation practice and as precious aids to promote awareness and control over unconscious bodily reactions.

To close the loop, we think that access consciousness models and, in particular, Cleereman's theorisation of human consciousness as a continuous, gradual and dynamic phenomenon [37] provide a valuable framework in understanding how the relationship between unconscious, pre-conscious, and conscious mechanisms change during interventions tapping on awareness. Among the authors' premises, awareness of a particular psychophysical state is an important trigger for learning and making adaptive changes in brain connectivity. Thus, bringing previously unnoticed information to consciousness may be seen as a necessary, primary step for proper learning and self-empowerment. Indeed, it is not possible to control what has not been perceived and identified as distinct from something else.

Consistently, brain-sensing—as well as body-sensing—devices may help such implicit information to become accessible to proper conscious processing and control by converting covert physiological markers of affective reactions into overt and easily-perceivable data. The informative real-time feedback on ongoing bodily activities may act as an additional accessible source of information on subjective internal states and might, thus, foster the development of more efficient emotion regulation skills and a more profound self-awareness. Further, it is worth noting that existing wearable devices can now gather this information and achieve these results non-invasively—due to the implementation of highly usable sensors, and simply due to recently-developed engaging and user-friendly software apps.

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