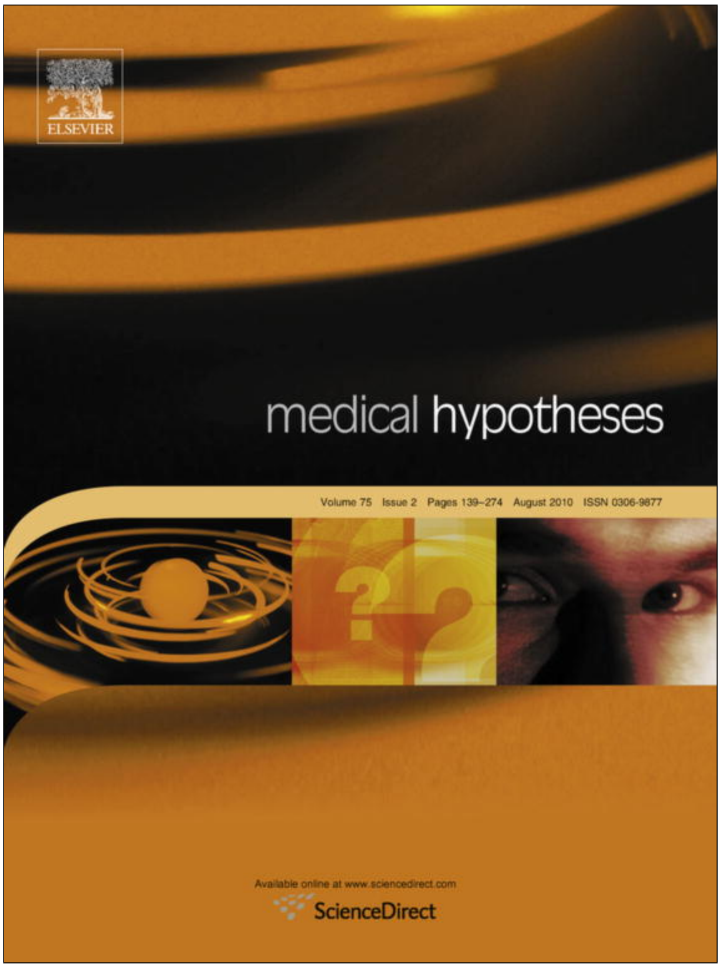
ELSEVIER
medical hypotheses
Volume 75 Issue 2 Pages 139–274 August 2010 ISSN 0306-9877
Available online at www.sciencedirect.com
ScienceDirect

Medical Hypotheses 75 (2010) 218–224

Contents lists available at ScienceDirect

Medical Hypotheses

journal homepage: www.elsevier.com/locate/mehy

From alpha to gamma: Electrophysiological correlates of meditation-related states of consciousness

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ARTICLE INFO

Article history:
Received 16 February 2010
Accepted 21 February 2010

SUMMARY

Meditation practice is difficult to access because of its countless forms of appearances originating from the complexity of cultures it has to serve. This makes a suitable categorization for scientific use almost impossible. However, empirical data suggest that different forms of meditation show similar steps of development in terms of their neurophysiological correlates. Some electrophysiological alterations can be observed on the beginner/student level, which are closely related to non-meditative processes. Others seem to correspond to an advanced/expert level, and seem to be unique for meditation-related states of consciousness. Meditation is one possibility to specialize brain/mind functions using the brain's immanent neural plasticity. This plasticity is probably recruited by certain EEG patterns observed during or as a result of meditation, for instance, synchronized gamma oscillations. While meditation formerly has been understood to comprise mainly passive relaxation states, recent EEG findings suggest that meditation is associated with active states which involve cognitive restructuring and learning.

Introduction

In recent years, an increasing number of studies attempted to explore neurophysiological processes occurring during altered states of consciousness resulting from meditative training. These studies abstracted from the cross-cultural differences between meditative practice in different religious contexts and focussed on common mechanisms arising from this voluntary alteration of conscious states, which is characterized by both deep relaxation and increased internalized attention. A number of studies revealed the influence of meditation practice on autonomic parameters such as breathing patterns, heart rate, skin conductance and blood volume pulse [1–3]. In this article, we will concentrate on the neurophysiological correlates of meditation, in particular effects observed in EEG experiments.

The basic thought behind these studies is the premise that an altered state of consciousness is always accompanied by an analogously altered neurophysiological state (so-called psychophysical isomorphism, e.g. [4]). If meditation is used as a repetitive influence on consciousness, certain measurable qualitative and quantitative effects should develop on the neurophysiological side, which may be either transient or permanent.

A large number of studies aimed at classifying and categorizing observed effects but were only able to assess certain general changes of the EEG which are not directly related to meditation practice (for a review, see [5]): As conscious states can only be accessed introspectively, they depend on subjective descriptions, which are difficult to inquire during meditation practice. Moreover, the enormous bandwidth of not clearly circumscribed meditation styles and the lack of a commonly accepted phenomenal classification of waking states of consciousness do only allow one to conclude about general findings and rough tendencies. Thus, even though meditation research has produced a large number of studies during the past years, there is still a strong need for clear and standardized definitions, in terms of meditative techniques, as well as in terms of the involved states of consciousness.

Hence, we will first have to discuss the use of the term 'meditation', explain the difficulties arising from the need of clear definitions, and point out why the large field of meditation research still lacks clear and practicable categorizations. With regard to these problems, we will change our perspective by trying to describe meditation practice from a more general point of view. We will suggest hypotheses which will allow us not only to arrange the electrophysiological findings, but also to predict in which way certain meditation-related states of consciousness may be reached. In the following sections, we will describe EEG findings on meditation-related states of consciousness supporting our hypotheses. We will ask how, according to present knowledge, meditation practice is manifested in oscillatory EEG activity.

What is meditation?

The word 'meditation' can be derived from the Latin word 'meditatio', which referred to an exercise originally not predefined between intellectual or physical. In both ways it points to the

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doi:10.1016/j.mehy.2010.02.025

center (lat. 'medium' = 'center') of either the body or the mind. The word 'medium' again is rooted in the Indo-Germanic stem '*me(d)', meaning 'to ambulate' or 'to measure'. Today, 'meditation' is related to various practices aiming to alter the state of consciousness, hence belonging to a more spiritual context closer associated with the term 'contemplation'.

'Meditation' as used in a modern sense, does not refer to a specific spiritual practice, but involves various meanings depending on the tradition it is used in. In Christian spirituality a form of meditation can be found, for instance, the "contemplation on the suffering of Christ", although nowadays the term is in most cases associated with eastern traditions. Hinduism, Buddhism or Taoism, found their way to Europe in the late 19th century and brought along a complex terminology that highly influenced our parlance. In these cases meditation only refers to a purely religious purpose, but a close look illustrates, that implications of meditation can reach far beyond that. Not only religious movements such as the Hatha Yoga, but also more secular schools like eastern martial arts employ meditation. Furthermore, seemingly non-spiritual activities, like dancing, e.g. the whirling dance, which is the spiritual practice of the Moulavi-Order of the Sufi tradition in Turkey, or singing, like Christian chorales or Buddhist chanting, can be used as a meditative technique. In some traditions, like the 'red tantra', even sexual impulses and activities are part of the meditative spectrum. Thus, one could try to achieve a definition of meditation through its effects on the meditator, but that will not clarify the picture either.

Depending on the tradition we study, meditation is a way to establish a sense of calmness and serenity; a method to concentrate and focus on a single point; a way to stop the constant verbal thinking and relax the mind; a way to relieve stress and alleviate depression; a way to reduce anxieties and to build up self-esteem. It may be only used to benefit the health, like stabilize the cardiovascular system or, to the other extreme, to seek to get in contact with god, or to reach hard to define 'peak experiences' like 'samadhi', 'nirvana' or 'oneness'. This divergence is reflected in the scientific studies of meditation. One instructive example is to compare studies on Indian Yogis and Japanese Buddhist monks. In the early sixties, a couple of studies showed that Yogi masters, while in meditation, exhibited no response to external stimuli, e.g. to pain when their hand was placed in cold water. Even auditory stimuli showed no effect on the simultaneously recorded EEG as in control subjects [6,7]. These findings are consistent with the theory of certain Yogi practices, which are supposed to cut off every sensory input and reach a state of complete internalized attention with extremely reduced body functions.

On the other hand, studies from the sixties and seventies on the meditation of Japanese Zen Monks demonstrated, that these meditators showed an EEG response to repetitive auditory stimuli that did not habituate as in control subjects [8]. Again, these findings correspond nicely to the demands of Zen meditation, namely a state of highly concentrated mindfulness, just witnessing whatever goes through the mind, without trying to suppress external stimuli. Both studies referred to the state of their subject as 'meditation'.

Having these first approximations to the term 'meditation' in mind, it seems that a clear definition of the field including all its variations must fail because of its high diversity. Nevertheless, it is fundamentally necessary for scientific research on meditation to use at least a basic form of categorization. In most of the current studies, meditation techniques are divided into two groups, depending on the way the meditator employs her/his attention [9]. If it is focussed on a single point, whether this point is abstract (like a imagined picture, or a feeling about something or somebody) or concrete (like a mantra or a specific part of the own body), the technique is categorized as a concentrative form or, in other words, a focussed attention meditation. The other end of the spectrum involves a concept which is referred to as the mindfulness form or, in other words, an open monitoring meditation. This type of meditation aims at reaching a state where upcoming thoughts and emotions are just passively observed, without judging, analysing, or even following them. From this phenomenal definition, we get a first hint why this form of meditation is not only very difficult to reach, but also why previous reviews found a high variability within the results.

In the meditation literature the very same distinction is used and commonly accepted. In most traditions, a beginner typically will start with a rather concentrative form of meditation and will then proceed to an open monitoring form. Of course, there are many techniques, which cannot unequivocally be assigned to one of those categories and incorporate both aspects, like for instance the mindfulness of breathing. Knowing all this raises the serious question how a scientist should distinguish between the various forms of meditative practice. Here, we argue that despite the many forms of meditation practice and the difficulties of categorization, empirical studies indicate similar steps of development in terms of their electrophysiological correlates. In the following, we will therefore suggest a new view upon meditation practice.

A new approach to describe meditation practice

Our main hypothesis is that long-term practice of different forms of meditation is associated with similar developments. By this idea, we do not intend to state that various kinds of meditation exhibit similar mental states and neurophysiological correlates regarding *all* mental/neurophysiological aspects. We rather suggest that during the development of meditation practice some common characteristics are shared and passed through. This view is supported by the experiences of meditation experts of different traditions, who coherently report similar mental states – although often with a quite diverse vocabulary [10–12]. In neuroscientific terms, this hypothesis means that due to continuous meditation practice, in some aspects, similar mind/brain states are reached, i.e. states with adjacent locations in a suitable mental/physiological state space (see chapter 6). We further hypothesize that the initial mind/brain states occurring during meditation, in some aspects, are similar to, and overlap with, "regular" states experienced outside meditation. Only after long-term meditation practice, new mind/brain states may be reached which do not overlap with regular states. These hypotheses will now be explained in greater detail.

Hypothesis 1

Every meditative training, independent from its cultural background or practiced technique, involves a similar scheme of development. This development is being carried out in several consecutive steps starting from the status of an average healthy brain/mind. Every developmental step has correlates on the neural processing level. High inter-individual variability must be expected, due to different investments of time and effort, the individual resources, and the general flexibility in the integration of new concepts. Not every meditation style integrates all possible steps; some will even restrict themselves to the first levels in order to benefit the health by slowing down and by calming certain body functions.

Hypothesis 2 (steps of meditative development)

The first step will always involve mostly physical demands. The beginner is requested to get used to a new and uncomfortable posture and will concentrate mainly on the performance of the technique. Her/his attention will be cursory and restless. The alterations on the neurophysiological side should be relatively small and transient.

With increasing experience, the student will be able to internalize her/his attention, focussing on a rather simple object which is easily accessible, e.g. a simple mantra, a picture, a part of the body, or her/his own breath. By doing this, (s)he will experience the slowing and relaxing physical aspect of meditation with all its physiological effects that are easy to measure and to reproduce. On the internal side, a slowing of the mind's automatically produced internal dialog will be observed, accompanied by a deep sense of calmness and serenity which is the basic condition for any form of meditative work. In principle, this second step is within the reach of every beginner and thus still closely related to non-meditative processes. Therefore, the neurophysiological changes should be reminiscent of those occurring during other non-meditative tasks.

The third step is characterized by the correct performance of the meditation technique, which means that the advanced student is able to focus her/his attention completely on the object of meditation. The first alterations in perception and in processing of sensory input occur, and the advanced student realizes, for instance, a basic change in the relationship between thoughts and feelings. The student starts to experience the constantly and automatically generated mental processes as temporary and transitory. Corresponding neurophysiological alterations may be less comparable to non-meditative tasks, but still transient.

The most advanced step of meditation practice, which is only reached by experts, is associated with certain peak experiences, described with terms difficult to define, like 'samadhi', 'nirvana', 'kensho', or the experience of 'oneness'. These experiences come along with permanent changes of individual properties and alterations of states of consciousness lasting outside meditation practice. Because usually a large amount of time is spent to reach this step (at least many years, typically several decades), the availability of suitable subjects for research is substantially reduced. In electrophysiological recordings, new and unique oscillation patterns may be observed on this expert level of meditation.

In the following chapter, we will describe the results of EEG studies related to meditation, and will discuss the hallmarks of these findings with respect to our hypotheses.

Oscillatory EEG correlates of meditation

Alpha activity

The most dominant effect standing out in the majority of studies on meditation is a state-related slowing of the alpha rhythm (8–12 Hz) in combination with an increase in the alpha power [8,13,14]. These findings are relatively robust, because they do not depend on either a certain meditation tradition or the experience of the meditator. Subjects engaged in meditation of various styles were reported to demonstrate increased alpha power [15–18], which is localized mainly over frontal regions [19–22]. Since this effect is independent from meditation technique and degree of experience, it may be regarded as a first basic change in the course of meditative development.

With regard to our hypotheses, these first self-induced alterations correspond to a beginner/student level and should thus fulfil two criteria: First, the underlying neural pattern should be closely related to a common process related to simple non-meditative mental tasks. Second, these first basic alterations should be easily accessible even by the unexperienced student of meditation, and should be even within reach of our everyday experience.

Alpha oscillations fulfil these demands. They are known to arise from an increase of internal attention [23], which of course does not only occur due to meditation. Various studies showed an increase of alpha power related to internally driven mental operations, like the imagery of tones [23–25], or working memory retention and scanning [26,27]. Furthermore, EEG biofeedback studies indicate that alpha activity is the brain rhythm, which can be most easily controlled [28]. Subjects can be trained to either produce or suppress alpha activity [29,30]. The baseline activity shifted according to the instruction, and furthermore these trends proved to be continuous, as if the subjects continued to do what they had been trained to. Interestingly, subjects reported to find it more difficult but also more pleasant to increase than to decrease alpha activity.

These findings gave a first hint on the possible positive effect on emotional management that can arise from a training closely related to a meditative approach. Further clues concerning emotional implications and alpha activity come from studies focussing on the laterality of anterior EEG activity. A recent study using mindfulness meditation reported significant decreases in left-sided anterior alpha power (corresponding to an activation) in the meditators compared with the non-meditators [31]. Other studies reported that the same regions are related to certain positive emotions in subjects with 'more dispositional positive affect' [32]. Furthermore, patterns of asymmetric frontal EEG activity have been reported in pathological processes. Groups of subjects with current episodes of depression and those with a history of depression showed greater left than right frontal alpha activity compared with control subjects [33,34], and a greater right than left parietal alpha activity [35,36]. These findings suggest that the resting frontal EEG-asymmetry may serve as a stable trait-like marker to distinguish depressed individuals from never depressed individuals [37]. In general, the prefrontal activation asymmetries seem to be plastic and susceptible to changes upon appropriate training [38].

Theta activity

Appearance of the theta rhythm (3–8 Hz) is a characteristic for the transition from wakefulness to sleep, which is classified as sleep stage I [39]. In meditation and related contexts, theta band activity has been found to increase due to different relaxation techniques [40,41]. People highly trained in self-hypnosis show increased theta activity not only during hypnosis, but also while they are awake [42]. Besides alpha, theta activity is also mentioned in neurofeedback studies, e.g. as an effective treatment of anxiety disorders (for a review, see [43]).

A general increase of theta activity during meditation has been reported in a large number of studies and appears to be unrelated to a specific meditation technique or the subject's experience level (for a review, see [5]), although some studies attempted to demonstrate theta activity increases as a specific outcome of enhanced mindfulness [19]. This divergence may be related to the occurrence of theta band activity during a variety of different tasks. In contrast to alpha band activity, theta may arise without internalizing the attentive focus, for instance, due to relief from anxiety [16]. Anterior theta rhythms have been reported during short-term memory tasks (reviewed in [44]), and both neocortical and hippocampal theta activity are closely related to the formation of declarative long-term memory [45–47]. It has been speculated that hippocampal theta activity might reflect a state of readiness, waiting for incoming signals to process [48]. These findings are supported by the results of animal studies indicating that theta activity also appears in the rodent cortex during memory encoding and retrieval (for a review, see [49]), in particular during spatial navigation [50]. And of course, theta activity may be simply related to tiredness and the transition to sleep. Although this trivial interpretation is often not consistent with the subjective reports of meditators, it is difficult to exclude in the absence of behavioural data. These different types of theta rhythms occurring throughout the brain are probably produced by completely different mechanisms and are not necessarily functionally related.

Despite its great variability, theta activity in meditators shows some mentionable characteristics. Several studies describe increasing theta activity in form of sharp burst or theta trains, which are preceded and followed by alpha rhythm [8,51,52]. For some authors, these findings distinguish theta activity found in meditators from the more irregular forms that appear during drowsiness [53], i.e. when the world of external stimuli recedes and imaginations come to the fore [54]. The separation between a deep state of meditation and a period of stage 1 sleep only based on EEG data is difficult. Meditators may deliberately stay in a mental state related to increased theta activity over longer time periods, which looks similar to the deep relaxation state of sleep stage I. However, this state may not be equivalent with stage I sleep, because subjects showed ongoing theta activity even after meditation when they had already opened their eyes and were alert [8,13].

A recent study demonstrated that meditation-related changes of theta characteristics are indeed relevant for cognitive processing [55]. Meditation novices and practitioners were tested in an attentional blink paradigm before and after a three-month meditation retreat. Performance in this task significantly increased in the practitioner group and was associated with an enhanced theta phase-locking, i.e. a reduced inter-trial variability of theta phases. Since theta phase has been shown to be related to the timing of neural activation [56], this finding may indicate a more stable execution of neural processing steps in meditation practitioners.

Taken together, the general findings of theta activity related to meditative processes do not provide sufficient evidence to correlate its form of appearance with a specific step of meditative development. One may speculate that theta activity occurs after the specifically altered alpha patterns related to the beginner/student level have already been established in the brain [57,58], possibly as a correlate of increased relaxation. In our framework, theta activity would then be closer associated with an advanced level of meditative practice.

Gamma activity

Usually an oscillatory frequency around 40 Hz is referred to as gamma activity, but the range can vary substantially between 20 and 200 Hz across different studies. This lack of precision occurs mainly for historical reasons, since early studies on humans focused on gamma activity around 40 Hz [59–61], while recent studies include higher frequency ranges as well [62–64].

Activity in high frequency ranges was already observed in the very first studies on meditators [6,51]. These studies aimed to investigate whether EEG changes during different levels of meditation correlated with the experience of the subjects. They involved both beginners and advanced students of a certain Yoga style (Kriya-Yoga, Kundalini-Yoga) and Trancendental Meditation (TM). Both studies reported fast activity with peaks around 40 Hz in both hemispheres. Interestingly, both studies describe these peak-activities only for the highly advanced meditators. Nevertheless, these findings should be considered with caution because of several methodological deficits (discussed in [65]).

Later research on meditators focused mainly on the lower frequency ranges and lost track of the activities in the high frequency band. With the development of improved EEG amplifiers, as well as more efficient recording techniques and computer-based analysing strategies, high frequency EEG activity re-attracted the interest of neuroscientists, and recent studies again deal with the occurrence of gamma activity during meditation.

Two recent studies report high-amplitude gamma band oscillations during meditation. Both studies were conducted on advanced Buddhist practitioners, some with more than 20 years of meditation experience. One study investigated four different forms of focused meditation in a Buddhist Lama [66], which resulted in different patterns of gamma band activity. The authors interpreted these findings as evidence that altered states of consciousness are associated with distinguishable patterns of brain activation.

The other study concentrated on a meditation of non-referential compassion [67]. The authors observed that voluntarily induced gamma band oscillations were sustained and showed an increased phase synchronization during meditation. The patterns in meditators differed from those of the control subjects specifically over lateral frontal and parietal electrodes. The largest amplitude increases of gamma band activity were found for the long-term practitioners: Even before meditation, the ratio of oscillatory activity in high (25–42 Hz) and low (4–12 Hz) frequencies was higher for meditators compared to control subjects. These differences increased sharply during meditation. Furthermore, the authors describe that the amplitude of gamma band activity in meditators was higher than any other gamma band activity previously observed in healthy human subjects. They speculate that the level of meditative training can alter the spectral distribution of the EEG in terms of possible permanent baseline changes. Of course, further studies are needed to corroborate this interpretation. In the framework of our hypotheses, these changes are closely related to an expert level of meditation practice.

In the next chapter, we will describe the relevance of gamma activity for cortical plasticity and the formation of neural circuits. We will discuss, how these functions may contribute to the goal of meditative practice: the development of new states of consciousness.

Synchronized gamma oscillations and cortical plasticity

Neural plasticity comprises the creation of additional neurons and new synaptic connections, as well as the expansion and shift of functional areas. These modifications are most evident in patients with brain lesions or in subjects who have been trained in specialized cognitive functions such as musicians for the control of sensory-motor abilities, taxi drivers for spatial navigation, and so on. Similarly, meditation training may be accompanied by alterations of neural structures. Indeed, it has been shown by magnetic resonance imaging that long-term meditation practice is associated with an increase of cortical thickness [68] and of gray matter volumes of different brain structures [69,70].

Although the brain/mind contains and provides the general possibility to realize these changes, it may be restricted by both inherited and acquired factors. Neural plasticity depends on processes ranging from the molecular level to the level of neural networks. Members of neural assemblies which are phase synchronized in the gamma frequency range fire action potentials in a highly time locked manner with a precision of a few milliseconds [56,71,72]. When these action potentials are propagated to common target neurons, the corresponding synaptic inputs can cooperate in elevating the membrane potential above firing threshold [73]. Such rapid depolarizations depending on synchronized excitatory synaptic inputs were shown to result from voltage-gated Na^+ and K^+ conductances [74]. This cooperation does not occur for incoming action potentials that are not time locked, since the membrane potential meanwhile decays depending on membrane time constants. Thus, synchronized neural assemblies can reliably trigger activity in target neurons. Moreover, this results in the firing of several target neurons with little jittering, thus again enabling the synchronization of target assemblies [75]. Synchronized oscillations in the gamma range were shown to be associated with such precise spike timing [56,71,72] and may thus represent a mechanism for the precise activation of target neurons, and thus for controlling the flow of neural information [76]. If synchronization, for example, occurs between neurons belonging to different feature maps, which project to higher-order neurons in the associative cortex, these higher-order neurons could be reliably triggered (bottom-up). On the other hand, top-down influences from higher-order areas might also be propagated by synchronized gamma activity [77].

As long ago as 1949, Hebb [78] proposed a flexible mechanism for the formation of functionally associated neural assemblies. Hebb postulated an increase in synaptic efficacy in the case of correlated activity of the presynaptic and the postsynaptic neuron, which was later experimentally verified [79,80]. The best investigated examples for Hebbian plasticity are long-term potentiation (LTP) and depression (LTD), which provide the basis for models of learning and memory.

The required delay times for effective Hebbian modification of synaptic connections by correlated firing of the pre- and postsynaptic neurons are of the order of less than ±10 ms [81]. Synchronized high frequency EEG rhythms like gamma activity thus could provide an optimal condition for the establishment and modification of Hebbian neural assemblies and therefore may be a crucial mechanism in associative learning and memory formation. This view is supported by several recent memory studies [47,82–86].

To conclude, these data suggest that synchronized gamma activity is highly relevant for neural plasticity and the implementation of new processing circuits (for a review see e.g. [87]). The findings of strongly increased synchronized gamma activity in meditation experts may thus be related to processes of cortical restructuring and learning. These processes may provide a permanent neural basis facilitating specific meditation-related states of consciousness, as well as altered perception and cognition outside meditation practice.

Are meditation-related brain/mind states unique?

A response to this question requires a clarification of what is actually meant by a "unique" brain/mind state. One may consider a mind state, in other words a state of consciousness, as a point or a small area in a state space describing all possible mind states [4]. The variables defining the axes of the mental state space (i.e. the co-ordinate system) are then different psychological properties. For instance, Vaitl and colleagues [88] have suggested a state space for the classification of altered states of consciousness defined by four variables: activation, awareness span, self-awareness and sensory dynamics. In principle, such a state space should enable to separate different states of consciousness, i.e. states that are subjectively perceived as different. If such states of consciousness cannot be separated, additional psychological variables have to be added to the state space. In the same manner a neural state space may be constructed, where the variables represent different physiological measures. The statement that meditation-related states are unique, in this description, means that those states do not overlap with other states.

The basic assumption underlying psychophysical research is that a one-to-one correspondence between mind and brain states exists (often called psychophysiological isomorphism, e.g. [89]). This implies that in case a certain state of consciousness is unique, the corresponding neural state should also be unique. Conversely, for the same state of consciousness, the neural characteristics should always be the same, at least with regard to those neural variables which are linked to the mind domain (not all neural variables are associated with consciousness).

In the present article, we argue that brain/mind states related to meditation practice on the beginner/student level, in some aspects, may overlap with brain/mind states that regularly occur outside meditation practice, for instance, states associated with moments of relaxation. In other words, we suppose that, in some aspects, there is no qualitative difference between meditation-related brain/mind states of beginners and some "regular states". But unlike the regular states, meditation-related states may be prolonged and may occur more reliably. However, we suppose that brain/mind states related to an advanced/expert level of meditation training are unique. Such unique states may be reached, because meditation training may not only be associated with the occurrence of certain electrophysiological signatures, but may also stimulate cortical plasticity and involve changes in neural structures. In other words, the constituents of the brain, i.e. the dynamical systems supporting neurophysiological processes, are modified. These modifications may supply the neural basis for unique brain/mind states associated with new electrophysiological signatures (see chapter 5).

The above differentiation is supported by reports of meditation beginners indicating a more reliable and prolonged occurrence of psychological states sometimes perceived outside meditation. On the other hand, experts often report about states of consciousness which they perceive as new and unique [10,11]. After these states have occurred once (during or outside of meditation practice), they may be experienced more regularly afterwards.

But is there evidence for the suggested differentiation on the physiological side? As described in chapter 4, meditation-related brain states at the beginner/student level were often found to correspond to an increased power and synchronization of low frequency activity, in particular, alpha and theta activity. Such alterations are rather unspecific, because they are also observed during relaxation and transition to sleep, as well as during several so-called altered states of consciousness [88]. On the other hand, the few empirical data on meditation experts available tentatively indicate that expert states may imply both, an increase of power/synchronization of low frequency oscillations, as well as an increase of power/synchronisation of gamma activity. Such a combination of EEG changes is rather uncommon because increased relaxation and transition to sleep are normally associated with a decrease of gamma power/synchronization [90–92]. However, it is not clear yet, whether such an electrophysiological pattern is indeed unique for meditation-related brain/mind states of experts or whether it may also occur during other altered states of consciousness.

Conflicts of interest statement

None declared.

Acknowledgement

We would like to thank Ulrich Ott for helpful comments and suggestions.

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