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Chapter 12
Synchrony and consciousness

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Abstract: Modern neuroscience demonstrates that the emergence of consciousness requires the synchronous interaction of various brain mechanisms which are represented by specific brain areas. Therefore, studying the oscillatory behavior of neuronal networks provides insights into the functioning of the brain in order to fulfill mental tasks that are required to build up the functional frame in which consciousness as a human experience can take place. Thus, an experience of complex contents within one moment in time requires simultaneous activations and information exchange between numerous brain areas. This can be demonstrated in the study of dysfunctions of specific brain regions but also through the analysis of electrical brain oscillations in healthy people.

Consciousness however not only requires the brain itself. Moreover, the whole body is involved especially in the production of emotions. Damasio's theory of emotions is discussed in this context. The interaction between brain and other body processes also requires time-sensitive signal-flows. The coherence between heart and brain and possible synchronicities between biophoton emission in body parts and brain electrical processes are questions in ongoing research.

Further, possible synchronicities between consciousness-related body processes and phenomena outside the body are discussed. It is still questionable whether the brain waves interact with the electromagnetic field of the Schumann resonance, i.e. the natural resonance of the geosphere that vibrates with about 8 Hz, a frequency that is within the range of the brains theta waves. Finally, research trying to uncover possible synchronicities in distant brains of closely related people is presented that focuses on the question whether telepathic phenomena can be measured.

To summarize it can be stated that synchronicities between body functions especially brain processes are relevant for the neuronal basis of phenomena related to consciousness. However, the influence of electromagnetic phenomena outside the brain on brain states still remains speculative and needs further research.

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1. Introducing a mystery called consciousness

To illustrate the phenomenon of consciousness, we can use the picture of a very exclusive party, a dinner for only one, to which the other 7 billion people (and especially the scientists) are neither invited nor admitted. Moreover, everybody can throw their individual party in a nearly inaccessible space inside their head. However, scientists seem to be like curious neighbors, almost like spies. They have developed instruments and methods to spy upon what happens inside these secret rooms. The recent results of this enterprise have given rise to new rumors and hypotheses, (some of them quite unconfirmed) about the hidden procedures we are used to call "consciousness". Their interpretations are lined up in a wide range between the still much appreciated idea of an immaterial spirit and the somehow disappointing conception that our valued "self" might be nothing but an illusion created by the arbitrary neuronal fireworks of a horde of cells.

If we consider our consciousness and ourselves in an introspective way, we recognize a natural and likewise surprising state: unity and coherence. This experience prevails in spite of, and even against, our knowledge of the multitude and diversity of elements, which physically, chemically and biologically constitute our brain and form our mind (*e.g.*, perception, memory, cognition…). Furthermore, confronted with the enormous diversity of the perceived world around us, this brain or mind seems to create order and entity in an astonishingly easy and effortless way. For centuries the explanation of this experience seemed to be obvious: There had to be a pre-existing blueprint for the architecture of the world and an observing person-like, separate instance in our mind, which constructs and reflects unity and coherence inside and outside of man – an idea that can be traced back to the considerations of Descartes, John Lockes and even Thomas of Aquin. The homunculus-model was born and the best way to understand human consciousness henceforth seemed to elucidate the nature, work and localization of this enigmatic instance.

This model basically is dualistic and nowadays often criticized in general (Dennett, 1991). Even if it appears in new clothing as some kind of distributed neural network (Crick & Koch, 2003) or global workspace (Baars, 1988), the dualistic character remains. We should bear that in mind when looking at some of the impressive research linking brain functions to consciousness. On the other hand, none of the current theorists seem to really explain the qualia - the subjective qualities of experiences such as the redness of red or the painfulness of pain. How private subjective experiences can emerge from objective matter remains an unsolved question.

Let us apply the party picture another time to the occurrence of consciousness within our brains: However, now we have a very exclusive party with tenth of billions of neurons sitting together, chatting and communicating quite organized in order to create one single unique experience which we call consciousness. Therefore, to understand the phenomenon of consciousness, it is not enough to ask for the firing rates of single neurons but rather to ask ensembles of neurons about their connections and coherence and their contribution to the state of the whole system. One of the first essential findings in modern neuroscience regarding the activation of single neurons and its influence on coherent brain activations was formulated by Hebb in 1949. Hebb's rule says that neurons that fire together wire together, a dictum, which still is regarded as a basis for all learning processes and neuronal reorganization. This rule expresses the importance of connectivity, relationship and coherence of cell assemblies in order to generate a consistent conscious perception and personality.

Taking a closer look at the issues of unity and coherence, on the following pages we shall present a short overview of some insights in neural mechanisms under the special perspective of coherence of neuronal cells, oscillatory neural networks and temporal patterning of neuronal activity. We shall touch upon the question of how emotion and various body processes are related to the emergence of consciousness and we shall introduce some approaches and questions that might be interesting for future exploration.

2. Consciousness and coherence within the brain

2.1. An experimental paradigm illustrating the basic questions

Sometimes very simple experiences of everyday life lead to fundamental questions. Concerning the field of brain and visual awareness, ambiguous figures are a good example for an experience provoking questions on the nature of mind. The pictures of the famous painter Arcimboldo are well-known in this context since they show faces which are composed of fruits or the black silhouette, which can be perceived as a vase or as two faces. An even more astonishing figure is the Necker cube (Figure 1). Looking at it for some time the perception switches between the two representations. They are equally possible interpretations of one real object, obviously competing in consciousness. Moreover, one may even achieve to make this change happen deliberately (Blackmore, 2005).

This very simple figure provides a fine opportunity to reveal the neural correlates of a particular experience by imposing some basic questions. How are features of an object detected and bound together in the brain (a question which is known as binding problem)? Is there parallel unconscious information we can refer to when the representation changes? Which parts of the brain are activated and altered at the moment of the flipping information? What is the mechanism that makes this change happen? Following these and other questions, we can detect certain brain areas like e.g. V1 (the early part of visual cortex), V4 (later visual areas) and parts of the temporal cortex, which are related to the processing of visual information (Koch, 2005). But have we located consciousness in the brain this way?

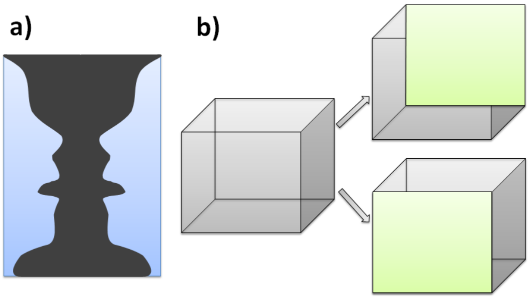

Figure 1. Two ambiguous figures are the vase on a) and the Necker cube (b) in which the surface can be seen as shown in the top or the bottom shape.

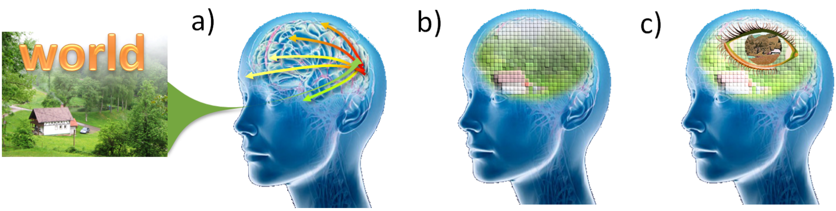

Figure 2. Model of conscious perception. a) visual information is guided to the primary visual areas in the occipital cortex first before it activates further cortical areas. b) the interconnectivity of large cell assemblies in the entire cortex as illustrated by the lines within the various brain areas contribute to an internal representation of the outside world. c) the subjective conscious experience of this representation is a second level process which is schematically illustrated by the eye in the middle of the brain.

Recent theories seem to let this expectation down. They regard consciousness as a far more complex "event", which is not rooted in a certain brain area or in some specialized cells, but is instead based on a widespread neural network. According to their view consciousness might be understood as a function of numerous interacting brain systems and circuits. Thus, for these new approaches, theories of binding and of neural synchrony and cross-system coherence are in the focus of interest (Engel & Singer, 2001). Figure 2 illustrates this picture of consciousness evolving through the interconnectivity.

2.2. The neural correlates of consciousness

The hypothesis (or "framework" as Crick and Koch prefer to describe it) of neural correlates of consciousness (NCC) was designed with two strategies. First: postponing or leaving aside the more difficult questions like the hard problem of qualia or aspects of consciousness such as emotion, memory or self-consciousness. Second: concentrating on the aspect of visual perception as an accessible and well-explored part of the brain system of primates. Their intention therefore was not to offer an overall solution, neither a theory on what conscious experience is, but to describe by what means and processes a coherent conscious experience is produced. In the following part we give an abbreviated and simplified overview focused on the role of neural cells and their interplay in neural networks.

In the view of NCC hypothesis the smallest but at the same time most important "working units" are cells, the neurons. They are detecting and projecting features from the visual sensory input of the perceived objects. Connected in a neural network, firing neurons form coalitions in both, space and time. These do not only exist in certain localities of the brain, but are also interconnected across distributed brain areas. Initiated by a visual input, their neuronal activity travels as a net-wave up and down the visual hierarchy. Coalitions are sometimes in competition and only certain neuronal activity reaches consciousness. It is attention, either in the bottom-up or in the top-down mode, which in the end selects among the signals of the coalitions. The critical attribute of such a winner-coalition may probably be related to a specific way of firing, *e.g.,* with a special synchrony, at a sustained high rate or in bursts. Moreover, synchronized firing especially in gamma range (see below) might already be of importance at the early state of forming a coalition against a rival coalition (Crick & Koch, 2003).

Finally to complete the process of becoming conscious, Koch and Crick postulate the involvement of other neurons, which are influenced by the NCC. This "penumbra" provides the informational components concerning "meaning", so that the brain can know what the firing activity of the NCC represents (Koch, 2005).

To sum up, a coherent and stable representation of a visual object in consciousness seems to derive from coherence processes on a neuronal level.

The dynamics of self-organization in fluctuating spatio-temporal neuronal activity are a characteristic quality of these processes. Especially the coordinating and coding mechanisms of these oscillatory neuronal networks have been of great interest for the scientists (see below).

2.3. Coherence within brain waves

Several scientists, though with different emphases and partly in their own terms, have identified relations between binding, i.e. the theory of how a complex sensory input pattern is segregated in order to constitute a homogeneous conscious experience, and consciousness (for an overview see Engel & Singer, 2001) and thus connected the phenomenon of oscillatory activity with the emergence of conscious awareness and coherent conscious mental states in general.

Oscillatory activity seems to play a significant role in different processes of the brain (see Senkowsky et al., 2008) and is usually categorized into five frequency bands, namely the delta band (1–4 Hz), theta band (4–8 Hz), alpha band (8–12 Hz), beta band (12–30 Hz), and the gamma band (above 30 Hz). An important observation in coherence within neuronal brain activity is the existence and dominance of relatively slow, rhythmic oscillations between 1 and about 12 Hz, which are predominantly active in resting states but also during memory consolidation. These oscillations represent simultaneous activations of large cell assemblies measurable through the Electroencephalogram (EEG). Especially studies on beta and gamma band activity (20–80 Hz) provided remarkable evidence (for a review see Tallon-Baudry, 2009) that coherent neural signals establish high functional connectivity and that therefore synchronized neural oscillation might be a potential key mechanism for the binding problem and other processing of even cross-modal sensory information in the brain. Moreover, it is gradually becoming visible, that synchronous activity in beta and gamma frequency ranges seems to be related to a multitude of cognitive functions, “such as perceptual grouping, focused attention, maintenance of contents in short term memory, poly-sensory integration, formation of associative memories and sensory motor coordination” (Uhlhaas et al., 2009).

It is a special quality of the spatial distribution of neural populations to provide an enormous complexity of possible interaction, *e.g.,* between physically separated assemblies, in the relations of power and/or phase and also across different frequency bands. So gamma band synchronization is likely to be modulated by the phase of theta rhythm, to which the disintegration and reintegration of gamma synchronized assemblies is time-locked (Doesburg et al., 2009).

Recent publications (Uhlhaas et al., 2009; Cohen, 2011) emphasize the role of time as a factor, which may enable neural networks to code, process and transmit rich information. Temporal dynamics of neural activity depend at least partly on the oscillatory properties of electro-physical brain activity. These oscillations provide a remarkable bandwidth for the processing of information, as activity may take place independent of and parallel with other frequency bands. Thus, multiple functionally distinct networks (Cohen, 2011) can use many possibilities or dimensions of processing information and take advantage of complex spatiotemporal coding patterns (Akam & Kullmann, 2010).

At the moment, a basic field of investigation is the establishment of temporal relations between the neural discharges across locally distributed cell assemblies by oscillatory rhythms. Neurons that are phase-locked to oscillations synchronize their firing. Moreover, internally generated oscillation patterns can also provide stable relations by tiny systematic or additive delays of the oscillation cycles (near zero phase lag, Uhlhaas et al., 2009). Especially these are thought to offer possibilities of temporal encoding based on phase relations.

In this context, gamma rhythms of the brain raised sometimes an enthusiastic attention as a possible component of NCC. A common interest of latest research on this issue is therefore the demonstration of gamma influence on the timing of spike activity and of its affection of cortical computation (Jia & Kohn, 2011). So, *e.g.*, Masquelier et al. (2009) suppose a role of gamma as a temporal reference frame for the encoding of stimulus strength and Fries (2009), to give another example, underlines the role of gamma band synchronization for the interaction of neuronal assemblies. He emphasizes that effective network communication might rely substantially on precise temporal relationships.

A few publications (Ray & Maunsell, 2010; Burns et al., 2010) nevertheless seem to be skeptical about the role of gamma and the analysis of the temporal relationship between spikes and gamma presented until today. As a worst-case scenario rising from this criticism, Jia and Kohn (2011) claims the possibility that gamma is “simply a resonant frequency” and a mere epiphenomenon of neuronal network activity.

So at the moment we have to conclude, that there are some promising approaches to components of the NCC, which in the long run might help to constitute a naturalistic theory of consciousness. Yet, there is no complete and fully convincing conception up to now. Methodical and mathematical efforts in examining especially the temporal dynamics and information coding in electrical brain activity may be necessary (Cohen, 2011) before we can reach the safe ground of not only correlative but causal findings.

2.4. Brainwaves and dysfunctions

It is a nowadays commonly acknowledged fact, that the oscillations of brain activity correlate and change with different states of mind like awareness, rest or sleep and that their frequency and amplitude display discernible and reproducible features for each of such states (for a multitude of examples and review see Tassi & Muzet, 2001).

Taken the synchronization of neural activity within and across different brain regions for granted as a normal feature and functional property of cortical and subcortical networks, it is not devious to conceive, that mental dysfunctions or disorders may also be correlated with corresponding features of oscillatory brain activity. Indeed there is consistent evidence across many studies, which associates disorders like in schizophrenia and autism with altered neural synchrony not only in local brain areas, but also concerning long-range synchronization (for reviews, see Uhlhaas & Singer, 2006; Uhlhaas et al., 2009).

Current medical theories of pathological brain states such as schizophrenia or autism assume a disconnection syndrome as their basic pathophysiological mechanism, so the impairment of neural synchrony observed in these diseases is consistent with their medical explanation. Moreover it is remarkable, that some of the changes in anatomical conditions and neural transmitter systems, which are characteristic for the above-mentioned disorders, are strongly related with processes involved in the synchronization of neural responses. However, whether reduced neural synchronization is a cause or a consequence of the disconnection syndrome remains still difficult to say at the moment. But all in all it completes the picture and supports the view that normal mental functions depend crucially on the exact and appropriate tuning and the well-balanced and joint practice of all players in the "swinging brain orchestra". This probably opens a door for new forms of medical treatment: For future studies Uhlhaas et al. (2009) propose to consider the use of biofeedback signals as measures of neural synchrony, as biofeedback could provide means to alter brain states in disorders, which may be helpful for patients in the attempt of voluntarily controlling and changing aberrant activity.

3. Synchronization within various body processes

3.1. Body-emotion-mind synchrony

When talking about consciousness, the brain mainly is treated as the central organ determining one's states of consciousness. However, perceptions, feelings, emotions are provoked and dependent on the entire state of the innerved body. Thus, in the following we should pay attention to the correlations between body processes, emotions and consciousness.

Every breath we take, every move of a hand, even every thought we form happens in a state of emotion. We feel ourselves. Emotions are, though we are sometimes not aware of them, related with our basic body functions and their interoceptive perception, with the sensory input and our often automatically run response programs, and as well with a multitude of cognitive processes like attention, memory or judgment.

Surprisingly, language, as a high level property and capacity of developed consciousness, reveals an intimate connection between bodily states and emotion. So we refer to the fast pounding heart, to shivering hands or an outbreak of sweat, when we want to describe fear and derive metaphors from sensorial experiences when for example affection corresponds with warmth ("I am warming up to her"). Following the latter observation it was Lakoff and Johnson (1980) who promoted the thesis of embodied cognition, which supposes that our mind may be inherently embodied and cognition grounded in bodily experience. As a consequence we would have to understand brain and consciousness as only a part of a larger dynamic system, which comprises the wholeness of our bodily existence and experiences.

A recent advance, stressing the relevance of emotions for the emergence of consciousness, comes from Damasio (1999, 2010), who sees body and emotion strongly involved in "the making of consciousness". Damasio divides emotion into two components, a conscious experience of emotion, which he names feeling, and a behavioral and physiological one that has bioregulatory aspects (for him 'emotion').

This emotion is a primary evolutionary mechanism, which allows an organism to keep homeostatic balance and physical coherence, for example by adjusting its inner milieu or, in response to challenging conditions of the environment, by means of approach and avoidance. In this sense, emotion can be observed already on a protozoic and cellular level.

According to Damasio, human feelings are formed by emotions based on brain functions, which stem from a long evolutionary development. Individual learning and cultural influence however shape emotions in regard of their trigger and expression. The brain is perpetually receiving emotional information, which is processed in neural maps. These are then compiled in somatosensory centers. It depends on the reading of these maps of recorded emotional changes, when and how feeling occurs. The brain creates representations of these changes, which can be perceived in consciousness. This is what Damasio calls feelings.

In this way, feelings can be understood as rooted in processes of homeostatic regulation, which occur most of the time quite unconscious at the level of cells and neural activity. The interoceptive information they provide might constitute what Damasio names the core self, as a grounding of the personal autobiographic self (which is composed during personal history) and as a basis for our experience of invariance and continuity (Tsuchiya & Adolphs, 2007).

Damasio's notions on the correlation between body and conscious emotional experiences are here in touch with another fundamental issue of emotion theory, the concept of response coherence, which can be traced back to the work of Darwin (1872). It implies a crucial role of emotions in organization and synchronization of subjective, behavioral and physiological responses, so that an individual can cope coherently and successfully with the changing environmental challenges (Levenson, 1994, 2003).

The experimental findings on this theory are still inconsistent and sometimes contradictory, but a recent study (Sze et al., 2010), which is using a new within-individual approach, seems to provide at least some support for "*the important role that organs controlled by the autonomic nervous system play in emotion and the critical contribution that afferent feedback from these organs plays in the construction of subjective emotional experience*" (Sze et al., 2010).

What are the consequences of all these considerations? If we accept that feelings have their basis in the representations of the body, a broader view of consciousness is available. Combined with the NCC framework we have now some evidence that certain types of cells and their excitability, not only in brain but also throughout the whole body, play an important role for a unified behavior, for the emergence of a coherent consciousness and for the experience of coherence and unity itself.

3.2. Synchronization between heart and brain

An attempt that follows the above-sketched lines, but goes further and is more specific, is the "heart rhythm coherence hypothesis" proposed by McCraty et al. (2009). Based on findings in which positive emotions were related to physiological, emotional and cognitive synchrony, McCraty et al. postulate a core role of the heart in the synchronization of the psychophysiological network and also heart-brain synchronization. In this view the heart is the great generator of mental, emotional and physiological synchronous and harmonious interaction within and across systems. It both reflects and affects the dynamics of the body as a whole. Therefore, micro-and macro-scale temporal cardiac patterns are in strong relation to an optimal functioning of the human organism. Furthermore, McCraty et al. propose to regard the heart's electromagnetic fields as a medium of communication from the cellular to the systemic levels, capable to convey information between individuals and to interact with energy fields in the environment. Then, if we really want to follow McCraty et al., the heart would appear to be the source of a global signal of synchrony and interaction that might help to transform and improve the life processes not only of humankind but of the whole world. However, we should be very careful here. While there are serious indicators for a close relationship between the heart dynamics and emotions, from a physical and physiological standpoint there is no mechanism known that would allow the detection of an individual's heart process by another biological system apart from this individual's body.

3.3. Synchrony between biophotons and the brain

Besides the low-frequency electromagnetic body-processes measurable through the electroencephalography (EEG), electrocardiography (ECG), etc. there are processes of non-neuronal origin, *e.g.*, those emitting light within or close to the visible spectra. Such ultra-weak photon emission (UPE), also named biophoton emission reflects human oxidative status (van Wijk et al., 2008). Measuring this radiation requires single photon detectors, e.g. photomultipliers. The measurement process itself has to take place in a dark room because the measurement of biophotons, e.g. from the hand surface, results in only a few photons per 100 milliseconds. Studies with meditators have indicated that meditation might be a way for regulating the biophoton intensity (van Wijk et al., 2005, 2006). Investigations looking for a correlation between biophotons and the brain waves have demonstrated a weak but significant phase and frequency coupling between photon emission and the alpha rhythm of the brain (van Wijk et al., 2008). A debate about biophotons came up asking whether the photon emission is just a random process during a certain condition of the body or whether it is coherent to other body processes and thereby in a causal relationship. Analyzing the distribution of biophoton emission Popp hypothesized that the photons might not be emitted independently, but rather are coupled to another process probably similarly to the laser principle (Bischof, 1995). EEG waves are deeply involved with the basic functioning of the brain but the origin and the exact function of EEGs has remained a mystery. The EEG waves show coherent changes of large cell assemblies even in distant brain areas. Therefore, the brain has to be seen as a coherent system (Rahnama et al., 2011, Salari et al., 2011a, 2011b, 2012). Neurons incessantly emit biophotons (Bókkon et al., 2010, 2011a, 2011b; Isojima et al., 1995; Kobayashi et al., 1999), and the intensity of biophotons is in direct correlation with neural activity, cerebral energy metabolism, EEG activity, cerebral blood flow and oxidative processes (Isojima et al., 1995; Kobayashi et al., 1999). The subject of biophoton emission in the brain is still in an early stage of development and needs more accurate experimental methods for proper analysis. It has, nonetheless, been demonstrated that EEG activity has a significant correlation with biophoton emission in the human brain (Dotta et al., 2012; van Wijk et al., 2008; Kobayashi et al., 1999). The claim of biophoton coherence from different biological systems has been repeated in a couple of scientific articles, but it is still not definite and requires concrete experimental proof (Salari &

Brouder, 2011). Furthermore, it has been suggested that biophysical pictures may emerge due to redox regulated biophotons in retinotopically organized cytochrome oxidase-rich neural networks during visual perception and imagery within early visual areas (Bókkon, 2009). One recently obtained result by Sun et al. (2010) is included in the experimental evidence for the above hypothesis. It demonstrates that neurons can conduct photon signals. Moreover, Wang et al. (2011) presented the first experimental proof of the existence of spontaneous and visible light induced biophoton emission from freshly isolated rat's whole eye, lens, vitreous humor and retina. They proposed that retinal phosphenes may originate from natural biophotons within the eyes (Bókkon, 2008; Wang et al., 2011). Unregulated free radicals and excited species can produce a transient increase of biophotons in different areas of the visual system. If this excess of bioluminescent photon emission exceeds a threshold, they can appear as phosphene lights in our mind. It appears that seeing a brilliant light in near death experiences (NDEs) may be due to bioluminescent photons simultaneously generated in the recovery phase of numerous areas of the visual system (Bokkon & Salari, 2012). Stemming from the pioneering experiments of Gurwitsch in 1920s, some researchers confirmed that cellular interactions can be mediated by electromagnetic fields e.g. biophotons (Fels, 2009). The overwhelming majority of these experiments focused on the study of electromagnetic cellular interactions examined in the optical region. A good review of the historical and recent theories and experiments on electromagnetic cellular interactions has been done by Cifra et al. (2011). As a conclusion, it may be possible that in addition to electrical and chemical signals propagating in the neurons of the brain, signal propagation may take place in the form of biophotons, too.

4. Synchronization with the outside world

4.1. Schumann-Resonance and brain waves

Despite the brain functions and rhythms being generated within the brain, they are influenced through their connection to the outside world, usually and mainly through our sensory organs. One might ask the question whether there are external fields, which we do not perceive consciously but to which we are coupled in a synchronous way. The neuronal functionality is based on electro-chemical processes and the hereby-generated electromagnetic fields radiate through the scalp and can be detected through electrodes or magneto sensitive SQIUD sensors. This asks for the hypothesis whether there are external fields, which could be strong enough to influence or even synchronize our brain with the environment.

Such an electromagnetic field is given by the resonance of a wave travelling around the earth between the surface and the ionosphere. It was discovered in 1952 by W.O. Schumann and therefore is called Schumann-Resonance (Schumann, 1952; Schuman & König, 1954). Determined by the geometry of the earth and the speed of light, several modes with frequencies of 7.8 Hz, 14.1 Hz, 20.3 Hz, and higher modes are excited predominantly through the more than 100 thunderstorms occurring each second on our planet. Nevertheless, the power density of the Schumann radiation is quite small and due to the big wavelength it requires a large coil to make them measurable.

Interestingly, as the most dominant frequencies lie in the range of the most dominant brain oscillations, e.g. 7.8 Hz is in the upper theta band, several researchers have tried to look for possible interactions. Persinger in 1989 for example tried to evoke altered states of consciousness through stimulation of the temporal lobe with ultra-weak electromagnetic frequencies in the range of the Schumann resonance and he reported great success. However, as he had no double-blind setting, many scientists rather attributed the observed effects to the psychological experimental setting than to the electromagnetic stimulation. Other studies could not replicate Persingers entrainment effect and a recent replication into which the author is involved does not show a clear entrainment effect either. This is supported by the fact that in order to evoke neural discharges in the brain one requires magnetic pulses as strong as one Tesla as done by the transcranial magnetic stimulation (TMS). Therefore, the question of whether and how the Schumann resonance may have an influence on humans' state of consciousness is still unclear and doubtful even if the frequency distributions show a nice parallel and the theta band activity can be associated with a somnolent and receptive state of consciousness.

4.2. Synchronization between Human Brains?

A final question about consciousness and coherence results from a subjective experience many people report: it is a kind of extrasensory or telepathic connection between people, independently of their distance. Some take this phenomenon for granted, but unfortunately it has presented itself as a special challenge to prove its existence. Studies on so-called remote viewing have already demonstrated some evidence that such a connection through extrasensory perception might exist in specially gifted people (Persinger et al., 2002; Roll et al., 2002). In several neurophysiological experiments e.g., by Wackermann et al. (2003; 2004), Hinterberger et al. (2008), and Ambach (2008), researchers tried to demonstrate coherence between brain waves of closely related but spatially separated people. Hinterberger et al. measured EEG simultaneously in people more than 700km apart from each other. The experimental setting for investigating distant EEG correlations was realized between laboratories in Northampton (UK) and Freiburg (Germany) or Tübingen (Germany). EEG systems in the related labs were synchronized using the

DCF time signal broadcasted from Frankfurt (Germany). As a result of these studies several experiments could show a small but significant effect in the alpha band. However, taking together all experiments there is still no consistency and the effects found remain very small compared to the normal size of a neuronal evoked brain potential. From this perspective, we are still in the process of asking ourselves the essential question of human consciousness: how connected are we really?

5. Conclusion

Summarizing the results of this short introduction into synchronized processes influencing, provoking, or even determining phenomena and states of consciousness, an interesting threefold picture appears: 1) By focusing on the brain and its mechanisms, coherency might be an inherent and essential (perhaps evolutionary) property for creating conscious experiences. The detection and understanding of coherent characteristics may be helpful for the understanding of the phenomenon as a whole. 2) Expanding the search on synchrony between brain and other body functions also revealed significant relations between body functions and brain processes and its correlated states of consciousness. However, one should be aware that not all body processes show such relationships. We have demonstrated this exemplarily on the biophotons. 3) Even harder to show experimentally are the interplays of coherence between consciousness-related processes with external processes, which might be perceived through other channels than the primary sensory system. While the induction of states of consciousness through stimulation of the sensory system can be an everyday experience (*e.g.*, through such trivial acts like listening to music, enjoying the scenery of a landscape, meeting people, etc.) the effects of extrasensory perceptions are very hard to demonstrate scientifically. This was shown exemplarily on the Schumann resonance and on telepathy research. Therefore, it is still challenging (and at least on a human level) to explore the synchronization of an inner and private process of consciousness with the outside world.

Finally, one can observe a decrease in synchrony and interconnectedness of consciousness with the distance from the brain. This is a natural rule of all objects in this world. However, there might be a pinhole within the brain opened up by quantum physical entanglement phenomena. Here, one might find an interconnectedness and coherence beyond spatial limitations through non-local correlations. Then, we might have to get used to the idea that consciousness is embedded in and emerging from a much larger background or unity than we thought before. However, theories connecting consciousness and quantum physics are still subject to a hot debate (see researchers like Penrose, Hameroff, etc.) and it would be a huge step further if one came up with experiments that bring light into the mystery of our unknown interconnectedness with the world.

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