Chapter

Inner Navigation and Theta Activity: From Movement to Cognition and Hypnosis According to the Sphere Model of Consciousness

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Abstract

EEG theta (4–7 Hz) activity is closely related to hypnosis and hypnotic analgesia, as well as to meditation and absorption. Research further indicates that theta oscillatory power is involved in different cognitive functions, such as spatial navigation, memory, creativity, and divided attention. The current manuscript will provide a synthesis of current knowledge regarding the importance of theta's different roles in relation to hypnosis and their connections to movement. Indeed, several movement paradigms, such as Quadrato Motor Training, have been found to modulate theta activity, significantly improving cognition and emotional well-being. The utility of such movement paradigms as a therapeutic vehicle closely related to hypnosis, and the underlying characteristics allowing these neuromodulations, will be discussed. Finally, the relationships between diagonal movement and other psychological phenomena, especially intentionality, attention, and the Sphere Model of Consciousness, will be highlighted.

Keywords: hypnosis, meditation, movement, theta, EEG, Sphere Model of Consciousness

1. Introduction

Considering the many positive effects of hypnosis, such as relief from chronic pain [1, 2], the ability to enhance hypnotizability has considerable clinical utility. Hypnosis can be defined as an altered state of attention, receptivity, and concentration during which the hypnotized person is immersed in a suggestion [3–5]. Hypnosis can modulate perceptual, motor, emotional, and cognitive processes by producing changes in subjective experience and in behavior, such as greater relaxation, changes in perception of the body and/or of the environment, and increased imagination [6–8]. While neurophysiological data may not completely resolve the debate around hypnosis as an altered state of consciousness (ASC) [9, 10], they do offer interesting clues regarding the role that intentionality and specific types of attention may play in hypnosis. Furthermore, the debate about hypnosis as an ASC could benefit from a reframing in light of current theories of consciousness, particularly the Sphere Model of Consciousness (SMC).

The Sphere Model of Consciousness developed by Paoletti [11–15] suggests that every experience of consciousness can be phenomenologically described as a movement within a spherical matrix. As will be illustrated in Section 4, the model provides that intentionality could be a means through which one can move from Narrative to Minimal Self and this, in turn, could allow deeper hypnotizability as well as other phenomena related to hypnosis, such as a reinterpretation of the nociceptive input underlying pain [16].

1.1 Movement and hypnosis

While different theories of hypnosis share the assumption that a hypnotic response is automatic and feels like it is happening by itself [17, 18], they do not necessarily agree on the level of intentionality and cognitive control processes that are involved. For instance, the response expectancy theory claims that expecting a behavior to happen can elicit that particular behavior; therefore, suggestions can be implemented without the involvement of intentional executive systems [19, 20]. However, expectations cannot fully account for the variance in hypnotic responding [21, 22], which is indicative of trait differences in both hypnotizability [23] and in hypnotic depth [24].

In parallel to intentionality and volition, there is a close connection between hypnosis and movement. Hypnosis may help patients to better achieve tasks of motor imagination and alter activity in the motor cortex [5]. In addition, while some argue that eye movement desensitization and reprocessing (EMDR) and hypnosis are qualitatively different, the two are often used in conjunction in therapy [25–27].

But what is the exact nature of the relationship between movement and hypnosis, and what are the possible mediating electrophysiological mechanisms between inner and outer movements and hypnosis? These are the main questions that will be addressed in this chapter. Specifically, we will discuss the possible underlying neuronal mechanisms mediating both movement and hypnosis, with a specific focus on theta activity. What we term "inner movements" and their relation to theta activity will be discussed in Section 2, focusing on hypnosis, meditation, and perceptual deprivation. This will be followed by external movement practices and their relation to such "inner movement." Consequently, we will embed our discussion within the framework of the Sphere Model of Consciousness [15] giving special attention to the Minimal Self and Narrative Self (for review see [28]). Briefly, the Minimal Self has a short temporal extension and is endowed with a sense of action, property, and first person nonconceptual content, while the Narrative Self involves personal identity and continuity through time and includes conceptual content. The SMC specifies the addition of a third state, called Overcoming of the Self, in which all sense of self disappears. Overcoming of the Self, which is parallel to consciousness without contents, has only recently been the subject of neuroscientific studies [29, 30]. It can further be compared with self-transcendence, absorption, and nondual states [31, 32].

1.2 Electrophysiological measures and hypnosis

Neural oscillations are divided into different frequency bands: both theta (4–7 Hz) and alpha (8–12 Hz) bands are associated with working memory and attention, while the gamma band (30–70 Hz) is associated with functions that include long-term memory storage and retrieval, as well as perceptual processing [33–35]. An increase in theta activity, quantified as spectral power, both frontally and globally, is a hallmark of hypnotic states [36], trance [37], meditative states [38–40], states of absorption [40], and of hypnotizability ([41]; but see [42] for an opposing view). Importantly, frontal theta activity correlates negatively with default mode network (DMN) activity [43], which is typically active during task-free resting states and is thought to represent neural processing related to mind-wandering [44, 45]. Keeping in mind that the DMN activity is automatic and is thus considered nonvoluntary, it is not surprising that electrophysiological studies based on predictive coding models[1] have focused mostly on theta activity [49, 50].

In addition, while hypnosis and hypnotizability are thought to be mediated electrophysiologically by theta activity and behaviorally by relaxation [51, 52], it is still under debate whether all hypnosis is actually autohypnosis (see for a review [53]), since motivation seems to play a central role in the process. For example, being motivated to participate in a hypnotic session and having a positive attitude about it correlates with the success of the hypnotic response and the effectiveness of the hypnotic experience [54]. This suggests that the levels of intentionality and attention could be related to the levels of hypnosis and participant susceptibility. Seemingly paradoxical, there may be a voluntary “letting go” that occurs in the hypnotic process [13, 55] related to *Overcoming of the Self*, which will be discussed further in Section 4.

At the electrophysiological level, it has been suggested that slow wave oscillations facilitate responses to suggestion, which in turn may help to explain the known variability in hypnotic responding between individuals [56]. This has been supported by findings of significantly higher levels of baseline theta activity in highly hypnotizable participants relative to those scoring “low” on hypnotizability [36, 57–61] and a tendency for hypnotic inductions to result in increases in theta activity, especially among highs [36, 62, 63].

Notably, an increase in both theta activity and alpha activity was reported among proficient meditators during meditation ([39], p. 191; [64]) and at rest ([39], p. 190), but not among those assessed for hypnotizability ([65]; note, however, that in their review, these authors only discuss the lack of a systematic relationship with alpha activity). However, the authors clarify that this increase in theta activity among proficient meditators was “the frontal midline theta generated by the anterior cingulate, dorsal, and medial prefrontal cortices” and not the “theta typically seen at the transition from Stage I to Stage II sleep…[which] originates from more widespread source” ([39], p. 202). Thus, some evidence suggests that the notion that a meditative state is essentially a hypnagogic state (the transitional state between wakefulness and sleep) or even sleep itself [66] should be replaced by the notion that a meditative state can be an intentionally prolonged hypnagogic state ([67], pp. 99–100; [68], p. 403; [69], p. 158); this, itself, would be considered to be a trance state [70]. Furthermore, as Holroyd ([71], p. 115) suggests, “a distinction is drawn between low range theta (4–6 Hz) which is associated with reverie and high range theta (5–7 Hz) which, in the frontal cortex area, is associated with loss of executive control.” Mitchell, McNaughton, Flanagan, and Kirk ([72], p. 179) also suggest, “The meditation data make it possible that FM [frontal-midline]-theta is a sign that attentional resources are more internally than externally focused.” Turning to change in gamma activity in the low range (25–45 Hz) in these states, there is a

[1] Predictive coding suggests that the brain generates hypotheses about the possible causes of forthcoming sensory events and that these hypotheses are compared with incoming sensory information and enables the motor system to “select appropriate responses” before an anticipated event is realized [46]. Similarly, predictive timing can be defined as the “process by which uncertainty about ‘when’ events are likely to occur is minimized in order to facilitate their processing and detection” [47]. At the neurophysiological level, anticipating sensory events resets the phase of delta and theta activity before the stimulus occurs [47]. Llewellyn [48] argues that REM dreaming has an elaborative role for encoding during sleep, suggesting that REM dreaming constitutes prospective coding because elaborative encoding enables inferences which, in turn, generate predictions.

decrease in frontal power [73] and an increase in posterior power [38, 73] and/or a decrease in central power [40].[2]

It is noteworthy, then, that an increase in theta activity during hypnotic induction has been found in various studies ([36, 56, 62, 63]; for review, see [78]. From [79]). Frontal theta has been found to increase with working memory load, indicating a role of theta oscillations in working memory maintenance (for review, see [43]). Theta activity increases with increasing task demands and is related to orienting, attention, memory, and affective processing mechanisms [35, 80]. Theta activity is highest at frontal midline electrodes in the resting state, indicating that the frontal theta rhythm is also detectable during rest conditions [81].

While hypnosis has been most closely linked to power in the theta band, reports suggesting changes also in gamma activity have been considered [56]. Jensen et al. [56] proposed a link between theta oscillations and hypnosis, whereby theta oscillations facilitate hypnotic responding. They further speculated that theta-gamma phase-locked oscillations may provide a physiological explanation for hypnosis by suggesting the linking of limbic and neocortical circuits [56]. However, gamma activity is known to be at possible risk of contamination from muscular activity [82] or saccade-related spike potentials (SP) due to eye movements [83].

While acknowledging that theta is associated with a large number of cognitive activities and states (including, among others, attention, orienting, decision-making, feelings of drowsiness, and emotional arousal, as noted above), it is important to emphasize that the most commonly identified roles for theta are those concerned with declarative memory coding and retrieval (for a review, see [78]) and navigation, such as maze navigation [84–86]. In parallel to navigation in the external environment, which is electrophysiologically mediated mostly by theta activity [84–86], we will suggest that:

1. Hypnosis and other "internal movement" paradigms may be regarded as mental navigation.

2. Hypnosis can be compared with external movement and navigation in space [82].

3. Internal movement paradigms, such as hypnosis and meditation, are electrophysiologically mediated, among other bands, by theta activity and require greater intentionality and attention [15].

The following section will introduce several "internal movement" techniques related to both hypnosis and meditation, as well as absorption and theta activity.

2. Inner movement

2.1 Hypnosis and absorption

Trait absorption has relevance for the study of imagery, hallucinatory or pseudo-hallucinatory experiences of altered states of consciousness, and

[2] It is noteworthy to remember that in many conditions, gamma power is phase-locked to theta activity and that both work in coordination of hippocampal networks during both waking and REM sleep [74, 75]. In addition to gamma, also beta activity is evident during both waking and REM sleep [76]. Gamma activity is further related to sensory perception, problem-solving, and memory and is thought to contribute to "binding" of sensory information (for review see [76]) and problem-solving with insight [77].

elaborate imagination [87–89]. Individuals scoring high on trait absorption will have a markedly different experiential profile compared to those scoring low on trait absorption [89, 90], and these two groups will perform differently on tasks of attentional demand [91, 92]. The overlap between high trait absorption and (1) high hypnotizability [23, 93, 94] and (2) proficiency in meditation [95] may indicate that the correlation between the two is either "significant only when both scales are administered in the same context, thus allowing the subjects to become aware that the experimenter expected to find an association between them" ([96], pp. 849–850; see also [97], but also [98], who do not find such a context effect), or the position we support that "absorbed attention may be an important prerequisite for successful long-term practice of meditation" ([69], p. 188), and that "a deeper state of absorption seems to facilitate the entrance to a deeper ASC" ([99], pp. 126–127).

The trait-state approach to hypnosis [100] suggests that the *trait* of absorption will interact with situational *context* in producing *state* absorption or a hypnotic state of consciousness. Consider what Kihlstrom ([101], p. 366) terms the "canonical design for hypnosis research," which "involves administering a standard hypnotic induction, or a control procedure, to subjects classified (on the basis of the standardized scales) as low, medium, or high in hypnotizability… Such a design permits assessments of both the correlates of hypnotizability (in the absence of hypnotic induction) and the effects of the induction procedure (independent of hypnotizability). Of particular interest, of course, is the interaction of these factors—i.e., how highly hypnotizable subjects behave following a hypnotic induction, compared to some control condition." Replace hypnotizability with absorption (the two being modestly correlated), and one can see how those scoring high on absorption behave differently from those scoring low on absorption, in much the same manner. Note further, that "Although there is acceptance that there is a general trait of hypnotic susceptibility, as measured by conventionally used standardized scales… susceptibility is also modifiable… Additionally, hypnosis in susceptibles is not a unitary state ([102], p. 62). Hence, the trait-state approach must consider a dynamic, unfolding, modifiable, interaction.

Furthermore, one can investigate concomitant electrophysiological changes in theta power in this trait-state interaction. For example, Graffin et al. [103] concluded from their study that "that the high-susceptible individuals displayed a decrease in EEG theta activity from the baseline period immediately preceding the hypnotic induction to that immediately following the induction, whereas the low-susceptible individuals showed an increase in EEG theta activity. This is consistent with the view that the high- and low-susceptible individuals are indeed in different cortical states prior to and following the hypnotic induction, that is to say, the induction procedure itself would be assumed to differentially affect high- and low-susceptible individuals." Kihlstrom ([101], p. 367) has a different take on this. He comments: "Graffin et al. interpreted the changes in theta as indicative of heightened concentration among hypnotizable subjects, but the fact that theta activity decreased in hypnotizable subjects and increased in insusceptible subjects suggests that, following the induction of hypnosis, both groups of subjects were actually in very similar cortical states." Either way, what is important here is the interaction of trait with condition in producing these shifts in theta activity.

Given that theta activity can be indicative of either the induction of a hypnagogic-like state of consciousness (which, in the present context, is closely affiliated with both meditation and hypnosis), or of highly concentrated attention [104], such shifts in theta power can be indicative of either of these. Schacter ([104], pp. 74–75) warns us that "It is not yet know whether the two "classes" of psychological events related to theta activity are essentially different processes, or whether they are different aspects of the same process … This is a critical problem for future research. …we might question whether it is plausible to accept that theta activity observed during zazen concentration in experienced meditators indexes psychological processes that are similar to those observed in college-age volunteers when concentrating on a mental arithmetic problem." Thus, even though, as White, et al. ([105], p. 98) have noted, the "correlation between baseline theta and hypnotizability has been described as a robust finding in the literature, proposed to result from attentional differences between high and low susceptibility groups," without a close analysis of how such theta activity is related to the actual performance of those scoring low or high on absorption, we will remain with the problem underlined by Schacter [104]. What is promising is that "findings showing differences between highs and lows in both the *patterns* of associations between EEG-assessed bandwidth activity and subjects' phenomenological experience of hypnosis … and in the brain *areas* (source locations) associated with theta and beta activity…." ([56], p. 44).

Speaking of beta, it was further found that the hypnotic depth and increased imagery and exceptionality of the hypnotic experience in highly suggestible individuals were related to fast frequencies, including beta and gamma, while the lows exhibited negative correlations between imagery on the one hand and theta and beta on the other [106].

In this context, it should also be kept in mind that beta oscillatory activity is likely to have a functional role in response selection, resembling attentional modulation of alpha activity [107]. Beta modulation was found also following "animal hypnosis," also known as "tonic immobility" or "immobility reflex".

The modulation depended on type of induction and session number [108, 109], supporting previous evidence that beta power has also been implicated in broader cognitive processes [107] in addition to movement and response inhibition [107].

2.2 Meditation

Meditators have been found to score higher on trait absorption than controls [95, 110]. In addition, increased theta and alpha power, reflecting activity of multifunctional neuronal networks and differentially associated with orienting, attention, memory, affective, and cognitive processing, is evident in meditators [80]. Altered theta and alpha activity has consistently been reported following meditation [111]. In fact, numerous studies conducted with Western meditators, usually having less than 10 years' experience, have reported increased power and coherence in the alpha and theta frequency bands during meditation practice [39, 111, 112]. Increased gamma power has also been reported in studies with advanced meditative practitioners [38, 73, 113, 114].

Consistent with previous meditation research (for review see [115]), also Berman and Stevens [116] found increased delta (0–4 Hz), theta, and alpha activity during meditation. When differentiating between general meditation and nondual states (in which the participant transcends the separation between self and other), the opposite trend was observed for gamma, which was higher during the meditation sessions in entirely compared to the nondual state [116]. Similarly, Berkovich-Ohana et al. [73], who examined three levels of mindfulness expertise and controls, found that mindfulness practitioners generally exhibited reduced resting-state frontal low gamma power as compared to controls, as well as decreased resting-state gamma functional connectivity representing DMN deactivation in the long-term practitioners, suggesting a trait/long-lasting effect of reduced mind-wandering and self-related processing [73, 117]. In addition, creativity, as measured by ideational fluency and flexibility, which were higher in the long-term practitioners than short-term practitioners and control participants, was negatively correlated with gamma interhemispheric functional connectivity [118]. Thus, one should keep in mind that different mediation techniques can produce different electrophysiological results, depending among others on the depth of the experience and the experimental design [116].

2.3 OVO Whole-Body Perceptual Deprivation (OVO-WBPD)

As we will see in the current section, studies examining perceptual movement, where movement is absent and stillness is the main feature, were also found to be related mostly on delta waves. While delta has historically been associated with sleep and pathological processes, it has recently been found to be related to both autonomic and metabolic processes, suggesting that it is involved in integration of cerebral activity with homeostatic processes, as well as in motivation and reward, as delta also increases during hunger, sexual arousal, and sustained pain [119]. Delta activity is further related to attention, salience detection, and subliminal perception, consistent with meditative states and absorption [116, 119, 120], such as in the case of Yoga Nidra [121][3].

In-line with previous research linking delta waves in meditative states [125], a recent study examined the effects of the OVO Whole-Body Perceptual Deprivation (OVO-WBPD) chamber effects on absorption in experienced meditators. The OVO, an altered sensory environment, is in the form of a human-sized egg ("uovo" means egg in Italian), within which the subject cannot easily perceive spatial coordinates. Based on the Sphere Model of Consciousness, the OVO-WBPD was specifically built with the aim of facilitating an immersive experience and an increased state of *presence* [11]. Ben-Soussan et al. [120], who studied participants who were instructed to "rest as best as they can" in the OVO chamber, found an increased state of absorption, which was accompanied by enhanced delta and lower theta activity, as well as beta (13–20 Hz) activity, peaking in the insula. These results may suggest an enhanced effort to sensory-integrate interoceptive signals.

In addition to the insula [120], theta was further linked to another main area of the salience network, namely, the anterior cingulate [126–131]. While DMN activity is negatively correlated with both hypnosis and theta activity [129–131], the salience network is thought to support the detection of subjectively important events and the mobilization of attentional and working memory resources in the service of goal-directed behavior [132–134].

[3] Yoga Nidra is defined as a "state in which an individual demonstrates all the symptoms of deep, non-REM sleep, including delta brain waves, while simultaneously remaining fully conscious [121]. In addition, it is important to note that while meditation spindles have similar amplitudes to those in sleep, all other parameters are significantly different, with more-experienced subjects displaying high-voltage slow waves reminiscent, but significantly different, to the slow waves of deeper stages of non-REM sleep [122]. In addition, they also differ from slow delta activity in anesthesia which is notably less rhythmic and coherent [122]. Most importantly, the main regions of interest are notably different to those in sleep [122, 123]. More specifically, the significant presence of limbic sources in meditation support the hypothesis of the effects of meditation on memory and spatial and temporal orientation, and consequently to the ventral and dorsal streams of attention and feeling- and salience-based, respectively [122]. The electrophysiological change induced by these type of training, together with the ability to remain consciously aware while producing delta waves, is believed to be associated with attaining a highly stabilized state of higher consciousness [121, 124] and the integration of transcendental experiences in both waking, dreaming, and sleeping [125].

As in the case of perceptual deprivation, different meditative states have also been found to be related to decreased DMN activity [73, 135–137]. Similarly, hypnosis was found to be related to decreased DMN activity [138] and suspending habitual modes of attention and achieving refined states of meta-awareness [139]. In fact, hypnotic induction increased subjective ratings of attentional absorption and decreased ratings of mind-wandering. Moreover, these changes were associated with decreased DMN activity and increased activity in prefrontal attention networks [138].

3. External movement

As indicated above, according to Jensen et al. [78], hypnosis can be viewed as a use of suggestions for creating changes in thoughts, feelings, or behaviors when the clinician views the client as having enough theta power to be able to respond to those suggestions. Jensen indicates that "hypnotic strategies, then, could include (1) *any* strategy that enhances slow oscillations (using traditional hypnotic inductions, but also any technique that has been or is ultimately shown to increase slow oscillations) and/or being aware of behavioral signs indicating an increase in or adequate level of theta, coupled with (2) suggestions that enhance existing connections among neuron assemblies (e.g., those consistent with the subject experiencing of himself or herself with useful images or having a positive view of the future) or that create new ones" ([78], p. 15). It is, therefore, relevant to note that there is an increase in theta activity and a corresponding increase in either alpha activity or a global increase in spectral power (including within the alpha and theta bands) during exercise [140, 141]. Fascinatingly, there is even evidence of a higher degree of both alpha and theta activity during eyes-closed restful wakefulness in proficient athletes [142].

These converging lines of thought together with Dietrich [143, 144] support the connection between hypnosis, meditation, and acute exercise, which all result in prefrontal hypoactivation. Consequently, we now address the presence of increased theta activity following specifically structured bodily movement, focusing on several specific examples involving different degrees of diagonal movement.

3.1 Diagonal movement

It has been suggested that rhythmical bilateral diagonal body movement improves motor and cognitive functions [145, 146], such as creativity and cognitive flexibility, similar to findings for hypnosis/mediation. However, no study that we are aware of has actually examined electrophysiological changes during diagonal body movements. The diagonal axis has the role of a metaphorical rule-breaker in relation to *the way of thinking*, as suggested by the definition of "diagonal thinking" as a mixture of logical (i.e., vertical) and creative (i.e., lateral) thinking [147]. Diagonal movements are widely used in disciplines based on whole-body movements such as tai chi, and recent paradigms such as Quadrato Motor Training, which will be discussed below.

Shapiro [148, 149], in her original description of EMDR, proposed that its directed eye movements mimic the saccades of rapid eye movement sleep (REM), known to be electrophysiologically related to synchronous theta waves [75, 150]. In addition, Stickgold [151, 152] proposed that the repetitive redirecting of attention during EMDR induces a neurobiological state similar to that of REM sleep. Additional study findings have supported the hypothesis that EMDR promotes the transfer of episodic memory to semantic memory, which will then be consolidated during REM-like (4–6 Hz) states [153][4,5].

As mentioned above, activation of frontal areas and especially the anterior cingulate that occurs during hypnosis matches well with the behavioral changes occurring in hypnotic state, such as the intensification of focused attention (for review see [159]). Importantly, the anterior cingulate has known anatomical connections with the frontal eye field and supplementary eye field and thus plays a prominent role in regulating eye movements, such as maintenance of visual fixation and suppression of reflexive saccades [159]. For example, classical behavioral marker of hypnosis, namely, the *hypnotically induced stare*, *is* a glazed look in the eyes accompanied by a highly reduced eye blinking rate and inimitable changes in the patterns of eye movements and pupil size [159]. Pupil size was recently found to be closely related to a variety of cognitive processes, such as decision-making [160]. In turn positive correlations were only found in the high-gamma band (60–100 Hz) and were similar in both wake and sleep conditions.

Only a few recent studies have examined electrophysiological changes during diagonal movements. A rare pioneering study [161] has found increased frontal theta activity during the initiation of diagonal movement, compared to purely vertical movements, which were also studied. The increased frontal theta was possibly due to greater computational effort [86, 95, 140]. Source localization further showed that the increased frontal theta activity was generated in the middle frontal cortex. In addition, the authors found a biphasic pattern of frontoparietal alpha/beta modulations during vertical movements.

Rimbert et al. [5] reported modulation in sensorimotor beta and theta activity during real movement and motor imagery; Marson et al. [161] also found biphasic modulation of alpha activity related to the second part of vertical movements (*each movement was composed of two parts, a forward and comeback period, the biphasic response in the comeback period during vertical movement)*. More specifically, the decreased alpha activity was observed immediately after the start of the comeback period, and, consequently, there was an increase in the same frequency band tied to the end of the movement. The decreased alpha activity observed immediately after the end of the second movement could reflect a decrease in internalized attention, as decreased alpha activity is classically related to decreased focus on internal states and amplified processing of environmental information through sensorial inputs,

[4] More specifically, as Pagani et al. [154] detail, delta activity is related to slow wave sleep, which in turn is related to transferring edited memories from the hippocampus to the neocortex, as well as to stimulating the integration of these into neocortical neuronal networks, while theta activity is related to REM sleep. Bilateral stimulation typical of EMDR causes immediate slowing of the depolarization rate of neurons from the dominant waking state frequency of around 7 Hz to about 1.5 Hz. Interestingly, as Pagani [154] further noted, animal research has demonstrated that low-frequency (5 Hz) stimulation can cause a depotentiation of amygdala AMPA receptors involved in the retention of traumatic memory and 900 stimuli at 1–5 Hz depotentiated synapses mediating memory, suggesting that memories aroused during therapy are reactivated, replayed, and encoded into existing memory networks. Interestingly, delta activity occurs as waves during bilateral stimulation in other frequency waves (such as beta) and is related to eye movements. Lastly, Pagani et al. [154] suggested that the consolidation of emotional memory in the neocortex during an EMDR session, which often results in a sudden symptoms disappearance, is associated with periods in which slow (1.5 Hz) and faster (theta-alpha) activity are elicited by the alternation of bilateral stimulation and improved cognition.

[5] Similarly to EMDR, also binaural beat, which requires bilateral stimulation, by presenting two slightly different wave forms to each ear via stereophonic headphones, thus generating a third "beat" frequency, was found to be related to hypnotic susceptibility and theta activity ([154–156], yet see [42]), suggesting in turn also complex dynamic interactions between the two hemispheres [157]. For example, beat frequencies in theta and alpha range both increased interhemispheric coherence selectively at alpha frequencies [158].

especially the visual system [159, 160]. Similar to Rimbert et al. [5], Marson et al. [161] further found post-movement beta rebound [162] between consecutive trials, namely, increased beta activity both in diagonal and vertical movements.

3.2 Quadrato Motor Training (QMT)

Quadrato Motor Training is a mindful movement practice based on the Sphere Model of Consciousness. Participants are asked to move within a square (*quadrato,* in Italian), according to a specific sequence of instructions. QMT requires a high level of attention divided between the body and the spatial coordinates incorporated in the quadrato space, as well as silent waiting for the next instruction. Previous studies showed that QMT enhances theta activity and improves cognition (for a recent review, see [163, 164]). At the behavioral level, these changes have been associated with improvements in cognitive and psycho-emotional functioning [162, 165–167], considered important aspects of health and well-being.

What appears to make QMT different from other forms of physical activity is its impact on interhemispheric functional connectivity in the theta and alpha bands. In contrast to studies of other types of physical activity that focused on local changes in activity and have usually not reported changes in long-range connectivity, studies of healthy populations engaging in QMT have demonstrated both increased EEG power [168, 169] and coherence [170–173], especially in the theta and alpha bands. Indeed, both single sessions and protracted periods of QMT were found to result in increased intra- and interhemispheric functional connectivity in the theta and alpha bands [170–173]. Increased theta and alpha functional connectivity is thought to reflect improved cognitive functions and higher states of consciousness, due to better integration of information and communication across brain regions [174–176]. As such, these findings provide additional evidence relating to QMT's capacity to promote cognitive and psycho-emotional well-being.

Moreover, Ben-Soussan et al. [170] also found improved spatial cognition and reflectivity in groups who underwent a single session of QMT, in comparison to two control groups that underwent either simple motor or verbal training. The improvements were thought to stem from changes in functional connectivity, as evidenced by changes in intra- and interhemispheric coherence in theta and alpha bands [170].

Until recently, there has been a paucity of studies that investigated neural modulation during meditative movement. In a recent pilot study, De Fano et al. [163] examined five volunteers performing a single session of QMT characterized by three "blocks" which are rounds of the QMT routine. Since QMT requires executive control, which involves frontal theta activity, higher frontal theta power toward the last of the three QMT blocks, compared to the starting one, is expected. Indeed, a trend of increased theta activity was observed toward the last two blocks compared to the first one, which may reflect not only the cognitive control required by QMT performance but also the increase in cognitive effort that occurs overtime [163].

Going back to the theme of navigation and its connection to attention and salience dorsal and ventral streams discussed above, which are further related to the superior and inferior longitudinal fasciculi [177], 6 weeks of daily QMT was further found to increase white matter integrity as indicated by increased fractional anisotropy in the superior and inferior longitudinal fasciculi, as well as in additional tracts related to sensorimotor and cognitive functions [165].

3.3 Tai chi and qigong

Another meditative movement paradigm, tai chi, has been more heavily studied. Several electroencephalography EEG studies have reported that tai chi can produce changes in mental state or electroencephalogram patterns associated with other alterations of cognitive or physical indices. An early study by Pan et al. [178] examined the difference in EEG theta between concentrative and non-concentrative qigong states, demonstrating that the frontal midline theta rhythm was related to the concentrative qigong state. As the theta rhythm has been suggested as one of the normal EEG patterns occurring in mental concentration, the authors concluded that the theta rhythm is an indicator of mental concentration during qigong. Notably, Field et al. [179] observed that performance on math computations significantly improved after a 20-min tai chi/yoga training course and was associated with increased frontal theta activity. Field et al. [179] further found a trend of increased theta activity and decreased self-reported anxiety, and the authors attributed this to the relaxation effects of tai chi. This increased frontal theta activity was replicated in a study of skilled female tai chi practitioners, showing a pattern typically occurring during states of relaxation and attention [180].

Additional support for the importance of external movement, in parallel to inner movement and their possible connection, related to theta activity, comes from the fact that frequent movement is preferable to one's health over sedentary behavior, making movement therapies, when applied correctly, beneficial to chronic pain conditions, by ameliorating pain and related symptoms [181]. Moreover, the reported benefits are not only strictly related to musculoskeletal or vascular function but also with the mental dimension of well-being. For example, mindful movement practices, such as tai chi, have been found to significantly help in chronic pain management, for conditions such as osteoarthritis, low back pain, and fibromyalgia (for review, see [182]).

4. The Sphere Model of Consciousness and the position within the sphere

The Sphere Model of Consciousness [15] aims to symbolize the phenomenology of consciousness utilizing the geometrical properties of spatial coordinates within a spherical framework (see **Figure 1**).

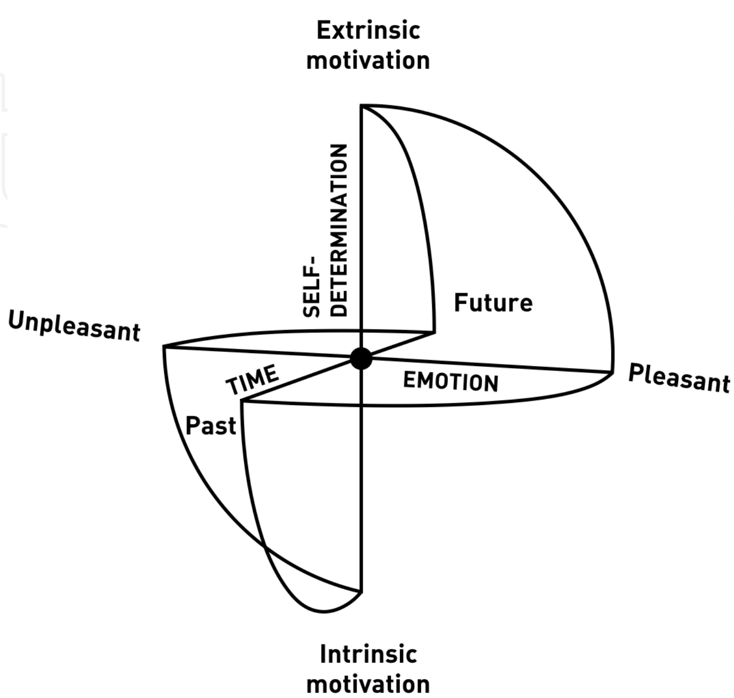

Figure 1.
The Sphere Model of Consciousness (adapted from [11, 13, 15]).

Each axis of the SMC represents the deployment and polarity of an aspect of experience, with an equilibrium point in the center of the sphere and a graduated scale indicating distance from the center. The center of the sphere represents an equilibrium point, with respect to three spatial coordinates, namely: (1) a horizontal *emotion axis* (e.g., representing the emotional polarities of unpleasant and pleasant), (2) a vertical *self-determination axis* representing the dimensions of value and aspiration [15], and (3) a *time axis* (e.g., representing the temporal deployment of past to future). The center can be considered a state of "Overcoming the Self," that is, a state of neutrality and detachment from the usual experiences of the Narrative and Minimal selves [15], which is crucial to hypnosis and different meditative practices [183]. Berkovich-Ohana and Glicksohn [28] suggested that experiences related to the Narrative Self are perceived as further away from the body, more abstract, and related to the future and the past. Narrative Self, Minimal Self, and Overcoming of the Self are represented in the SMC as concentric circles around the center of the sphere, with greater distance from the center signifying a more abstract experience of oneself. We shall now merge the electrophysiological and neuroanatomical findings in order to see how one can voluntarily move toward the center of the sphere.

5. The importance of attention and intentionally moving toward the center of the sphere

Movement, volition, and cognition are deeply related [188, 189] and, as seen above, are all related to theta activity. In fact, it has been suggested that the nervous system has evolved to allow active movement and provide a goal-oriented plan; as such, motivation and emotion represent facets of a common phenomenon. That commonality is the motivational-emotional system, which interacts with learning and higher-order cognition [184, 185]. In contrast to meditation practices, which are thought to involve and cultivate mindfulness (being aware of one's current mental state; about the problems in defining mindfulness, see [186, 187]), different theories of hypnosis posit that the hypnotic response is a form of strategic self-deception in regard to one's mental state [188]. Thus, it has been suggested that hypnotic response implies a lack of mindfulness, at least regarding particular mental states about which one is strategically deceived [188].

However, we suggest that it is also the combination of attention and intentionality (and not self-deception), which should be addressed in regard to hypnosis and other states of mind [13–15]. People often engage in meditation training because they believe it will result in a specific positive outcome, having received suggestions regarding its potential benefits [56]. Such suggestions—here in the form of self-suggestions, also known as outcome expectancies—are in-line with social cognitive views of hypnosis [10, 189] that posit that hypnosis can be viewed as a use of suggestions for creating changes in thoughts, feelings, or behaviors [56]. As such, self-suggestion implies both attention and intentionality.

Importantly, as noted earlier, frontal theta EEG activity correlates negatively with default mode network activity [43]. Recalling that high theta activity facilitates response to suggestions (e.g., [56]) and plays an important role in attention [80] and intention, such as intentional learning, and intentional movement [190, 191], we suggest that the combination of attention and intention may help to explain the known variability in hypnotic responding between individuals. This, in turn, suggests that the level of hypnotizability can be related to the participant's baseline position within the sphere [14, 15]. Together, these may have significant implications for the success of treatments.

Numerous studies have highlighted the importance of hypnosis in various clinical conditions, such as chronic pain [192]. Pain is a conscious experience, which can be considered an interpretation of the nociceptive input and potentially influenced by many factors, such as memories, emotions, and cognitions [16]. Decreased temporal-parietal theta (as well as alpha) activity during pain is consistent with a pain-related activation of the insula [193], which is known to be involved in pain processes [16]. Decreased theta connectivity was also found between the insula and the DMN in fibromyalgia, which may reflect persistent pain encoding associated with the chronic pain state in the disorder [194]. Maladaptive rumination and the re-experience of symptoms, which occur in many chronic pain conditions [195], and are known to be related to the DMN [196–198], were further found to be related to decreased theta band networks in post trauma [199]. Thus, finding ways to voluntarily move from the maladaptive and automatic narrative, which is predominant in these conditions, may aid in ameliorating symptoms.

In fact, studies found decreased DMN activation following hypnosis [138]. Decreased DMN activation, following different therapeutic approaches, is further linked to improvements in pain-related catastrophizing, which is generally self-referential, negative, and automatic [200]. In addition, there is growing evidence that mindfulness, as a volitionally initiated cognitive act, can significantly attenuate the subjective experience of pain [201]. Thus, cultivating experiential openness and acceptance, anchored in the embodied minimal self, and not in the narrative/default self, can reduce pain unpleasantness and lead to a reduction of symptoms in chronic pain patients [202, 203].

Emphasizing the importance of intentionality and its electrophysiological markers can further aid in differentiating hypnosis from "animal hypnosis" or "tonic immobility." "Animal hypnosis" has been found to effect electrophysiological state, such as altering beta, gamma, and alpha activities, depending on the method of induction, duration, and number of sessions [108, 109]. Nevertheless, one should keep in mind that while "animal hypnosis" can be induced in different ways, ranging from restraint to visual fixation, they are all involuntary [204], while the degrees of freedom in human hypnosis, although debatable, are greater. In fact, "tonic immobility" is physiologically quite different in physiological terms (i.e., defense and anti-predation reactions) [8, 205] and is controlled by a motor inhibitory system [204]. Thus, it is not surprising that in contrast to hypnosis, tonic immobility is more related to decreased theta activity and increased delta activity [108, 109], which are both inversely related to intentionality and volition [206]. Together these emphasize the importance of the intentionality aspect in human hypnosis. Nevertheless, it has been argued that hypnotic ability in humans may have evolved at least in part to allow for the control of pain and anxiety after injury, thereby reducing the likelihood of attack by predators [207].

In conclusion, although not a systematic review of this topic, this chapter offers three primary ideas for further consideration: (1) hypnosis and other "internal movement" paradigms may be regarded as mental navigation, (2) they can be compared to external movement and navigation in space, and (3) they are electrophysiologically mediated primarily by theta activity and require greater intentionality and attention. Based on the SMC, this may be related to an intentional shift away from DMN activity, which is anticorrelated with theta activity, and toward clear goal direction, represented by the center of the sphere. Thus, combined multidisciplinary examination of the connection between consciousness and hypnosis, encompassing cognitive psychology and motor and contemplative neuroscience, would produce greater theoretical understanding and implications on consciousness and hypnosis practice. First, in order to reach our personal and social aims, one can and should train to internally move intentionally from an automatic Narrative to the Minimal self, and eventually reach the state of Overcoming the Self, in order to know and better master one's own perceptions and mental processing. This idea is also related to the works of Charles Tart [208], who describes our ordinary everyday experience as being in a state similar to hypnotic trance, where we are not sleeping but neither are we truly awake. The solution to this state of affairs, similarly to current contemplative neuroscience results presented here, necessitates waking up to our true selves through a process of self-observation and self-remembrance [11, 12, 14, 208].

Second, the parallels between these two lines of research, namely, the similar electrophysiological modulation present in hypnosis, real movement, and motor imagery and the findings related to diagonal movement, can have a useful impact on the field; it can do so by helping to validate reliable electrophysiological effects of hypnosis and increase our understanding of the related biological mechanisms and connections to internal and external movement. If confirmed in future research, these ideas may have important implications for enhancing the response to hypnosis treatments and for customized, combined therapeutic modalities. In turn, emphasizing the importance of intentional inner and outer navigation and their electrophysiological signature can also aid in differentiating between the different techniques and their possible synergetic effects.

In summary, as we know, hypnosis has many benefits, including the relief of chronic pain. These benefits are possible due to knowledge gained related to how the mind works and thus the possibility of leading it into specific mental and neural states, as is the case with hypnosis. The investigation of the connections between hypnosis and theta activity, among others, further demonstrates an affinity between meditative practices and hypnosis, and that intentionality can play an important role in leading oneself into desired states. In these states we are able to know ourselves better and master our perceptions and the interpretation we give of them. Training ourselves in this direction can, therefore, improve our well-being and quality of life. Future studies should combine behavioral, neuroanatomical, and electrophysiological measures to help in distinguishing different types of hypnotic states and practices, as well as to examine the role of the person's detached and attentive intentionality in reaching them.

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