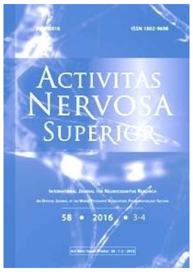

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IDEAS AND PERSPECTIVES

THE "HIDDEN OBSERVER" AS THE COGNITIVE UNCONSCIOUS DURING HYPNOSIS

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Abstract

The question of how to define and explain hypnosis is still not completely answered. Most of the theories of hypnosis are based on describing it as an altered state of consciousness; others focus on intrapersonal and interpersonal aspects, sociopsychological, neurocognitive or sociocognitive processes. More detailed explanation of hypnosis requires a synthesis of these various perspectives – a task for future research. Recent experiments are in agreement with Braid's concept of hypnosis (published already in 1843) defining hypnosis as a process enhancing or depressing neural activity as well as changing functional connectivity among brain regions; the brain regions involved in mental imagery are thought to be central for hypnosis. In the present article we suggest that the "hidden observer" under hypnosis might be due to the cognitive unconscious and that this special state emerges principally in highly susceptible subjects. Explicitly, the "hidden observer" might be nothing other than the cognitive unconscious.

Key words: *Hypnosis; Cognitive unconscious; Hidden observer; Precuneus; Visual areas*

1. INTRODUCTION

One of the fundamental characteristics of hypnosis is that the hypnotized subjects experience involuntarily actions by themselves (Spanos & Barber, 1972; Bowers, 1981) — a condition frequently considered as necessary for a real hypnotic experiences. The outcomes of procedures aiming to induce hypnosis can vary considerably from the initiation of relaxation to deep hypnosis. Kallio and Revonsuo (2003) pointed out that there are several seemingly contradicting characteristics concerning hypnosis. The hypnotic state as well as its description depend on several factors, such as the various types of hypnotic procedures and suggestions, the hypnotizability scales used to measure the hypnotic depth, the hypnotic ability of the subject, etc. Thus, the description of the hypnotic state in studies can be affected by several confounding variables (Kallio & Revonsuo, 2003). However, the hypnotizability has a central role as a predictor of responsiveness (Barabasz & Perez, 2007).

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In the present work we explain a hypothesis as a state in which the "hidden observer" might be due to the self-dissociation of the cognitive unconscious, and that this special state is essentially emerged in subjects particularly susceptible to hypnosis.

2. THE PRIMARY VISUAL CORTEX AS THE LOCUS OF MULTISENSORY PROCESSES

The visual cortex is the largest system in the human brain that is responsible for processing visual information. The vision system is the most widely studied sensory system in human and nonhuman primates. A large surface area of the cerebral cortex (e.g., about 50% in macaque monkeys and about 30% in humans) is involved in visual processing (Van Essen, 2004; Van Essen & Drury, 1997).

The neocortex essentially performs multisensory processes and signal integration; this integration is not restricted to higher-order brain areas but also take places within lower-level and sensory-specific regions (Murray et al., 2016; Ghazanfar & Schroeder, 2006). The primary visual cortex (V1) can act as the locus of multisensory processes (Murray et al., 2016). In addition, there is growing experimental evidence for the existence of connectivity between the primary visual cortex and primary auditory cortex (A1), as well as between other higher-level visual and auditory cortices (Beer, Plank, Meyer, & Greenlee, 2013). Moreover, the visual cortex process not only auditory but also tactile information (Sadato, 2006; Vetter, Smith, & Muckli, 2014; Iurilli et al., 2012; Snow et al., 2014; Lacey & Sathian, 2014). There is also a cross-modal circuitry between auditory and somatosensory regions (Dehner, Keniston, Clemo, & Meredith, 2004). Sound can induce phosphene light perception (a kind of optical illusion) (Lessell & Cohen, 1979). Thus, the phosphene phenomenon can also be associated with multisensory processes and signal integration between the primary visual cortex and the primary auditory cortex (Bolognini, Convento, Fusaro, & Vallar, 2013).

3. AUDITORY STIMULATION AND ASSOCIATED IMAGERY INDUCE INFORMATION PROCESSING IN THE EARLY VISUAL CORTEX: THE INVOLVMENT OF V1 IN HIGHER COGNITIVE FUNCTIONS

Recent studies using functional magnetic resonance imaging (fMRI) revealed intriguing results regarding the processing of non-retinal information by early visual areas, and the involvement of these areas in multisensory imagery (Vetter, Smith, & Muckli, 2014; Petro, Vizioli, & Muckli, 2014). It has been shown that the early visual cortex gets category-specific feedback signals from non-retinal associated brain areas such as the areas involved in auditory processing, multisensory processing, memory and imagery also in the absence of visual stimuli. The imagined sounds could be decoded in the precuneus and in posterior superior temporal sulcus (pSTS). Vetter et al. (2014) proposed that the content-specific information from sounds (when heard and/or imagined) was conveyed from the auditory cortex to the early visual cortex through the pSTS and precuneus. In addition, an auditory stimulus and the associated imagery could produce a shared and meaningful information feedback to the early visual cortex, carrying abstract and semantic information. There is emerging evidence that human V1 is a locus (hub) of multisensory processing at both anatomical and functional levels with convergent and integration mechanisms (Murray et al., 2016) (a similar conclusion regarding convergence and integration can also be applied to the low-level auditory cortex of human).

In addition, fMRI findings support that V1 is involved in higher cognitive functions (Muckli, 2010). The size of V1 takes a key role acting as a gatekeeper in constraining the richness of working mental function (Bergmann et al., 2016). Nauhaus et al. (2016) performed two-photon calcium imaging to reveal an alternative arrangement for ocular dominance (OD) and spatial frequency (SF) maps in macaque V1. Their results revealed a precise microretinotopy and a fine tuned and precise connectivity within V1 at the level of individual neurons.

4. THE CENTRAL ROLE OF THE PRECUNEUS FOR CONSCIOUSNESS

The precuneus belongs to the associative cortices. The precuneus is the postero-medial portion of the parietal lobe forward of the occipital lobe (cuneus) and interconnected with both cortical and subcortical regions. There is an increasing interest about the functional role of the precuneus; this area is one of the less properly revealed parts of the total cortical surface. This region is hypoactive in mental states characterized by a decreased or lack consciousness (i.e., sleep, the hypnotic state, pharmacological sedation and the vegetative state) Neuroimaging studies revealed that the precuneus, which is a richly connected multimodal associative area, is essential for various aspects of cognitive functions such as visuo-spatial imagery, episodic memory retrieval (i.e., autobiographical memories recall), self-processing (i.e., reflective self-awareness) and consciousness (i.e., conscious experience) (Cavanna & Trimble, 2006; Kjaer, Nowak, & Lou, 2002; Lou et al., 2004).

Autobiographical memories (AM) can be retrieved either from a first-person perspective, in which individuals see the event through their own eyes, or a third-person perspective, in which individuals see themselves and the event from the perspective of an external observer. Recent memories are usually retrieved from a first-person perspective but older memories are frequently recalled from a third-person perspective. Freton et al. (2014) revealed the role of the precuneus in egocentric spatial processing in the context of AM retrieval among healthy voluntaries. Studies indicated that the precuneus is an important area for visual memory and imagery (Cavanna & Trimble, 2006) and that it is involved in the storage and recall of visual information (Rothmayr et al., 2007).

Converging evidence suggests that the precuneus may play a central role in the modulation of conscious processes and in the integration of information from numerous neural circuits producing a conscious self-perception. The precuneus is activated during episodic (autobiographic) memory retrieval and spatial orientation of the body (Fletcher et al., 1995), whereas the dorsolateral prefrontal cortex is active during working memory (Carpenter & Just, 2000). The interaction between the precuneus and the dorsolateral prefrontal cortex is essential for self-awareness and consciousness per se, and this interaction is task elicited or a state dependent processes (Kjaer et al., 2001).

The precuneus possesses extensive connectivity which involves connections to higher association parts, suggesting essential functions in integrating internally and externally processed information. The precuneus has the highest resting metabolic rate among the default mode network (DMN) (the DMN consists of a set of brain areas that are typically more active during rest than during active task performance) requiring about 35% more glucose than any other area of the cerebral cortex in humans and in other species (Harley & Bielajew, 1992; Gusnard & Raichle, 2001). According to Utevsky et al. (2014), the precuneus serves as a specialized hub (a core region) within the DMN that presents state-dependent interactions with the right frontal-parietal network (rFPN) as well as with the DMN. In the recently published study by Bruner et al. (2016) it was claimed that the „ precuneus is a major hub of brain organization, a central node of the default-mode network, and plays an essential role in visuospatial integration." According to Fletcher et al. (1995) positron emission tomography (PET) studies, the precuneus plays a key role of the neural substrate of visual imagery occurring in conscious memory recall. In addition, the precuneus is activated once a human takes a third-person versus first-person visual point of view (Vogeley et al., 2004). Vogt and Laureys (2005) proposed that together with the posterior cingulate, the precuneus is fundamental for conscious information processing in the brain.

5. THE NEUROSCIENCE OF HYPNOSIS: WHAT ARE NEUROIMAGING STUDIES TELLING US?

Interestingly, recent functional neuroimaging studies support Braid's old (1843) concept of hypnosis as a process involving the upregulation or downregulation of neural activity and changes in functional connectivity (and in activity) between brain regions whereas also the mental imagery brain areas seem to play an central part facilitating hypnosis (Del Casale et al., 2012). Halsband (2006) observed in a PET study a significant increase in the activation of the occipital area during encoding retrieval and an increased activation of prefrontal areas under hypnosis. These results are in agreement with the results of the experiments by Kosslyn et al. (2000). According to Spiegel and Kosslyn (2004), under hypnosis, the order in which the judgmental character of the frontal region affect the occipital lobe might be reversed. This makes it easier to transfer verbal cues into inner mental images, which finally produces a change in the perception of reality, i.e. top-down processes may reinterpret the sensory reality.

In electroencephalography (EEG) experiments Tambiev and Medvedev (2005) found a considerable increase in the special synchronization of brain potentials in occipital regions. In a recent study by Cojan et al. (2009) voluntaries with strong susceptibility to hypnosis participated in a fMRI study where they had to perform a "go/no go" task which was similar to those used to study inhibitory processes in the brain. The authors revealed that the corresponding premotor and motor regions were activated normally under hypnotic state. However, after the "go" command the motor area become less connected to these motor intention circuits and more connected to other areas in the brain, particularly in the visual cortex and in the precuneus.

The anterior cingulate cortex (ACC) has a special location in the brain, with connections to the (emotional) limbic system and the (cognitive) prefrontal cortex (Stevens et al. 2011). The dorsal ACC (dACC) is connected with the parietal cortex, the prefrontal cortex, the motor system and the frontal eye fields. The ventral ACC (vACC) is connected with the nucleus accumbens, amygdala, hypothalamus, and anterior insula. Recently, Jiang et al. (2016) conducted a fMRI study in 31 healthy subjects who consistently scored high on tests for hypnotizability compared to 21 control voluntaries who scored on the extreme low end of the scale. Their findings indicated that cross-network coactivation patterns are modulated by hypnosis. Explicitly, they found that the high hypnotizable subjects presented a decreased activity in the dACC, increased connections between the dorsolateral prefrontal cortex (DLPFC) and the insula, and reduced connections between the DLPFC and the DMN. During hypnosis of the high hypnotizable subjects (Jiang et al., 2016), the increased functional connectivity between the DLPFC and the insula is also remarkable, since the insula is involved in selfmonitoring, self-reflection, self-regulation (Herwig et al., 2012), the body control, empathy, emotion its widespread neural connections to cortical and subcortical limbic regions (Menon & Uddin, 2010). In addition, the insula is also involved in pain processing (Roder et al. 2007), as well as empathic perception of pain in others (Menon & Uddin, 2010). Jiang et al. (2016) proposed that during hypnosis, the increased connectivity between the insula and DLPFC may be related to the dissociation of aspects of somatic experience typical in hypnosis, and that it might also reflect special ability to engage in tasks with lowered anxiety about possible alternatives.

Despite methodological differences converging evidence emerge that the hypnotic state involves the ACC, insular cortex, the thalamus, the ponto-mesencephalic brainstem, as well as increased activation in occipital and DLPFC and decreased activation in precuneus (Rainville et al., 2002; Del Casale et al., 2012). According to Del Casale et al. (2012), hypnosis "shifts action control from usually involved voluntary circuits to internal representations generated through suggestion and imagery". A process that seems to be "mediated by activity in the precuneus and reconfigures the executive control of the task implemented by frontal lobes".

It is remarkable that both the precuneus and occipital areas (i.e., cuneus) acts as special hubs in the brain and also seem to play central roles in hypnotic state. The precuneus is a major hub of brain organization (Bruner, Preuss, Chen, & Rilling, 2016), similar to V1 that is a hub of multisensory processing at both anatomical and functional levels with convergent and integration mechanisms (Murray et al., 2016). V1 is also involved in higher cognitive processing (Muckli, 2010).

6. COGNITIVE PROCESSES IN THE UNCONSCIOUSNESS

Recently, we proposed that the self-consciousness in humans might be a phenomenon that intermediates between implicit nonconscious/unconsciousness and the external environment through feedback and feed-forward interactions (Bókkon, Vas, Császár, & Lukács, 2014). We also suggested that our self-conscious thinking, and every decision made at a given moment, may be a coherent and convergent dynamic manifestation of our unconscious processes. Herzog et al. (2016) proposed that a percept can be emerged when unconscious processing reaches an attractor state. According to their model, "The conscious percept represents the output of unconscious processing, which has relatively high temporal resolution. Unconscious processing evolves over time, whereas conscious perception is discrete." The global workspace theory (GWT) (Baars, 1988, 2005) is a cognitive model about how the consciousness could develop from the unconscious. This model proposed that conscious contents are widely distributed within the brain and that the conscious could emerge by the parallel and coherent activation of multiple modular brain networks with frontoparietal associative cortices as key regions.

There is increasing evidence (Hassin, Bargh, Engell, & McCulluch, 2009; Hassin, 2013) that subliminal information processes, problem solving, motivation, decisions mechanisms or working memory, etc. can take place and operate unconsciously, outside of conscious awareness, and that computationally conscious and unconscious processes are very similar. The unconscious processes can carry out the same fundamental and high-level functions that conscious processes can perform (Hesselmann & Moors, 2015; Hassin, 2013).

According to van Gaal et al. (2008), "unconscious stimuli can influence whether a task will be performed or interrupted, and thus exert a form of cognitive control." While the neural correlates of consciousness a traditionally seem to be located in the prefrontal cortex, current neuroscientific studies have revealed that the prefrontal cortex can be also activated unconsciously (van Gaal et al., 2008), which challenges the elementary function of the prefrontal cortex in consciousness (van Gaal & Lamme, 2012). Creswell et al. (2013) provided some of the first evidence that the brain areas responsible for making decisions continue to be active even when the conscious brain is distracted with a different task. Namely, it shows that the brain areas that are important for decision-making remain active while one is simultaneously engaged in unrelated tasks, such as thinking about a math problem. However, the participants Creswell's study did not have any awareness that their brains were still working on the decision problem while being engaged in an unrelated task. In addition, specific brain areas (cognitive modules) can support specific cognitive roles, but that consciousness is independent of this (van Gaal & Lamme, 2012). In addition, Horga and Maia (2012) raised that conscious and unconscious processes may share common mechanisms and differ mostly in the quality of the representations.

There is also increasing experimental evidence that neural activity precedes a decision by seconds and that neural activity predicts what action a subject will perform (Huang, Soon, Mullette-Gillman, & Hsieh, 2014; Huang, Tan, Soon, & Hsieh, 2014; Soon, Brass, Heinze, & Haynes, 2008; Soon, He, Bode, & Haynes, 2013; Libet, Gleason, Wright, & Pearl, 1983; Rolls & Deco, 2011). Soon et al. (2008) suggested that frontopolar cortex can be the first cortical period where the actual decision is made, while precuneus could be involved in storage of the decision until it reached awareness. Soon et al. (2013) revealed that medial frontopolar cortex as well as posterior cingulate/precuneus start to encode the specific outcome of the abstract decisions even before they enter conscious awareness. In addition, the medial frontopolar cortex is also involved in the unconscious preparation of abstract decisions. It seems that similar networks might be involved in conscious and unconscious preparation of decisions

7. THE "HIDDEN OBSERVER"

In the 1970s Hilgard developed the "neodissociation theory" which the key element that during hypnosis the conscious mind would dissociate from what happens during hypnosis (Hilgard, 1973, 1977). According to this theory, our cognitive architecture consists of a number of functionally autonomous, yet interacting, cognitive control systems. Hilgard also proposed the "hidden observer" idea: during hypnosis a separated consciousness is formed in an individual's mind which is capable of observing the individual. According to this concept, during hypnotic analgesia (pain reduction), the "hidden observer" is able to observe itself and the pain without directly experiencing it any without eliciting any negative feelings normally associated with the pain experience. Subsequent experiments (Hilgard et al., 1978; Perry & Laurence, 1980; Laurence & Perry, 1981; Nogrady, McConkey, Laurence, & Perry, 1983) suggested that only a relatively modest fraction of highly susceptible subjects show evidence for the "hidden observer", however.

8. DISCUSSION

Based on the findings discussed above the following summary points can be summarized:

- The neocortex performs essential multisensory processes and integration, and this integration is not restricted to higher-order brain areas but also take places within lower-level and sensory-specific regions of the brain (Murray et al., 2016; Ghazanfar & Schroeder, 2006).
- There is emerging evidence that human V1 is a locus (hub) of multisensory processing at both an anatomical and functional level with convergent and integration mechanisms (Murray et al. 2016). The visual cortex processes auditory as well as tactile information (Sadato, 2006, Vetter, Smith, & Muckli, 2014; Iurilli et al., 2012; Snow, Strother, & Humphreys, 2014; Lacey & Sathian, 2014).
- fMRI findings event support that V1 is involved in higher cognitive functions (Muckli, 2010).
- Recent functional neuroimaging studies support Braid's old (1843) concept of hypnosis as a process that can increase or decrease neural activity, and that the hypnotic phenomena is due to the changes in functional connectivity (and in activity) between brain regions; additionally, the mental imagery areas in the brain can be central under hypnosis (Del Casale et al., 2012).
- There is increasing evidence (Hassin, Bargh, Engell, & McCulluch, 2009; Hassin, 2013) that subliminal information processes, problem solving, motivation, decisions mechanisms or working memory, etc. can take place and operate unconsciously, outside of conscious awareness, and that computationally conscious and unconscious processes are very similar.
- It was revealed that brain areas important for decision-making remained active while voluntaries' brains were simultaneously engaged in unrelated tasks, such as thinking about a math problem (Creswell, Bursley, & Satpute, 2013).
- Recently it was hypothesized (Bókkon, Vas, Császár, & Lukács, 2014) that "human explicit self-consciousness may be an active executer that intermediates between implicit nonconscious and unconsciousness and the external environment by means of feedback and feed-forward interactions. This executive function makes it possible for self-consciousness to continuously develop in self-organized evolution. In the waking state, human self-consciousness may be an abstract, language-dependent manifestation of the unconscious. Our self-conscious thinking, and every decision made at a given moment, may be a coherent and convergent dynamic (discrete events) manifestation of our unconscious processes".

- Studies indicated that the precuneus is an important area for visual memory and imagery (Cavanna & Trimble, 2006), and that it is involved in the storage and recall of visual information (Rothmayr et al., 2007).
- During hypnosis, the high hypnotizable subjects presented a decreased activity in the dACC, increased connections between the DLPFC and the insula, and reduced connections between the DLPFC and the DMN (Jiang et al., 2016).
- Del Casale et al. (2012) proposed that hypnosis “shifts action control from usually involved voluntary circuits to internal representations generated through suggestion and imagery. This is mediated by activity in the precuneus and reconfigures the executive control of the task implemented by frontal lobes”.
- It is remarkable that both the precuneus as well as the visual areas (cuneus) acts as special hubs in the brain which seem to play central roles in hypnotic state.
- Hilgard’s “neodissociation theory” suggested that during hypnosis the conscious mind dissociates from what happens during hypnosis (Hilgard, 1973, 1977). Hilgard also proposed the “hidden observer” idea that states that during hypnosis a separated consciousness is formed in an individual’s mind which is capable of observing the individual.

These current studies seem to support the existence of cognitive unconscious processes, and that human self-consciousness may be an abstract, language-dependent manifestation of the unconscious. In addition, our self- conscious thinking, and every decision made at a given moment, may be a coherent and convergent dynamic (involving discrete events) manifestation of our unconscious processes (Bókkon, Vas, Császár, & Lukács, 2014). The “hidden observer” notion proposed that during hypnosis a separated consciousness is formed in an individual’s mind which is able of observing the individual (Hilgard, 1973, 1977). In particular, the ”neodissociation theory” states that the responses of hypnotized subject are due to the division of consciousness into two or more simultaneous streams of consciousness. These simultaneous streams are separated by an amnesic barrier that prevents access to suggestion-related executive functions, monitoring functions, or both.

Multisensory integration and higher cognitive functions can be emerged both in higher-order brain areas as well as within lower-level and sensory-specific regions. The precuneus simultaneously can interact with both the default-mode and frontoparietal networks to distinguish distinct cognitive states. In addition, the precuneus takes part in the processes of visual memory and imagery (Cavanna & Trimble, 2006; Rothmayr et al., 2007).

The dissociation (or special state) under hypnosis can be “computationally” closely related to the precuneus that reconfigures the voluntary (conscious) and unconscious circuits via internal multisensory representations generated through suggestion and imagery. The mental imagery can get the major role (especially the visual imagery) in the hypnotic state. The phenomenon of the “hidden observer” may be due to the self-dissociation of the cognitive unconscious or might be a special state of the cognitive unconscious generated mainly by multisensory visual areas.

The cognitive unconscious is continuously working in normal waking state as well as under (deep) hypnosis, but under (deep) hypnosis, the voluntary (abstract, language-dependent) self-consciousness —that would emerge from the cognitive unconscious in coherent and convergent manner— takes place in a task dependent special state. So the hypnotic state is not due to the division of consciousness in hypothesized subject but is due to the special state between the cognitive unconscious and normal waking consciousness, and “hidden observer” might be nothing else as the cognitive unconscious. We should also highlight that the real hypnotic special state is only easy to achieve in highly susceptible subjects. Hypnosis and meditation are differentiated in terms of sensory input, processing, memory, and sense of time as well as in neurophysiological changes (Halsband, Mueller, Hinterberger, & Strickner, 2009). Thus, meditation (relaxation), hypnosis and deep real hypnosis are different levels of states regarding the cognitive unconscious and normal waking consciousness. The hypnotic induction and experience then depends on several subjective and environmental factors.

Finally, as mentioned during hypnosis of the high hypnotizable subjects (Jiang et al., 2016), there is an increased functional connectivity between the DLPFC and the insula that is notable, as the insula is involved in self-reflection, self-regulation, the body control, emotion and empathy, among them. Wickramasekera II (2001) and (Wickramasekera II & Szlyk, 2003) presented the empathic involvement theory that defines hypnosis as: „an experience of enhanced empathy and phenomenological alteration with the self in which a hypnotic subject utilizes perspective taking, empathic concern, and empathic aspects of theory of mind to experience alterations in affect, behavior, consciousness, sensations, thoughts, and mind/body relationship that are suggested to him/her by a hypnotist and/or through his/her own creative and imaginative directions" (Wickramasekera II, 2015; Pekala, 2015). Regarding the roles of insula in emotion, empathy, self-reflection and self-regulation during hypnosis, we speculate that increased unique functional connectivity between the DLPFC and the insula makes it possible the emergence a special intrinsic self-empathy, which can help to process the painful past experiences of the subject.

9. CONCLUSION

Most of the notions about hypnosis related to state or non-state (debate has been about whether or not hypnosis involves an altered state of consciousness), intrapersonal or interpersonal, special process or social-psychological, neurocognitive or sociocognitive, single and multifactor theories (Yapko, 2003, Hasegawa & Jamieson, 2002). Most researchers claim that hypnosis is an altered state of consciousness. However, our paper suggested that hypnosis may be considered as special state of the cognitive unconscious (that only easy to achieve in highly susceptible subjects) instead as an altered state of consciousness. During hypnosis, this special state of the cognitive unconscious is due to the changes in functional connectivity among brain regions. The notion about the existence of the cognitive unconscious is not new (Kihlstrom, 1987) and as we could see above latest experimental results support this concept. This view of the cognitive unconscious may help us to better understand the mysteries of hypnosis.

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