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REVIEW/MISE AU POINT

Neurophysiology of hypnosis

Neurophysiologie de l'hypnose

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Summary We here review behavioral, neuroimaging and electrophysiological studies of hypnosis as a state, as well as hypnosis as a tool to modulate brain responses to painful stimulations. Studies have shown that hypnotic processes modify internal (self awareness) as well as external (environmental awareness) brain networks. Brain mechanisms underlying the modulation of pain perception under hypnotic conditions involve cortical as well as subcortical areas including anterior cingulate and prefrontal cortices, basal ganglia and thalami. Combined with local anesthesia and conscious sedation in patients undergoing surgery, hypnosis is associated with improved peri- and postoperative comfort of patients and surgeons. Finally, hypnosis can be considered as a useful analogue for simulating conversion and dissociation symptoms in healthy subjects, permitting better characterization of these challenging disorders by producing clinically similar experiences.

MOTS CLÉS
Hypnose ;
Réseau du mode par défaut ;
Réseau externe ;
Perception de la douleur ;
Hystérie ;
Symptômes de conversion

Résumé Nous proposons de discuter des études comportementales, électrophysiologiques et de neuroimagerie investiguant l'hypnose comme un processus de conscience ou comme un outil pour moduler les réponses cérébrales au repos ou lors de stimulations douloureuses. Différentes études ont mis en évidence une modification de l'activité cérébrale au niveau des réseaux interne (conscience de soi) et externe (conscience de l'environnement). Par ailleurs, les mécanismes cérébraux qui sous-tendent la modulation de la perception de la douleur sous-hypnose comprennent des régions telles les cortex cingulaire antérieur et frontal, les ganglions de la base et le thalamus. Combinée à une anesthésie locale et une sédation consciente chez les patients subissant une chirurgie, l'hypnose est également associée à une amélioration péri- et postopératoire du confort des patients et des chirurgiens. Enfin, l'hypnose peut être considérée comme un outil utile pour créer des symptômes de conversion et de dissociation chez des sujets sains, ce qui permet de mieux caractériser ces troubles en mimant des observations cliniques similaires.

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Numerous studies have highlighted the interest of hypnotic procedures in various clinical situations, such as pain management, treatment of phobia, depression, dissociative and psychotic disorders and so on. Some researchers believe that hypnosis is related to an altered state of consciousness, while others assume that these phenomena can be explained by psychological concepts such as clinician-patient expectations. Hypnosis can be defined as ''a procedure during which a health professional or researcher suggests that a patient or subject experience changes in sensations, perceptions, thoughts, or behavior'' [60]. Hypnosis is seen as a state of focused attention involving focal concentration, and inner absorption with a relative suspension of peripheral awareness and has three components [56]:

- absorption: tendency to become fully involved in a perceptual, imaginative, or ideational experience;
- dissociation: mental separation of components of experience that would ordinarily be processed together;
- suggestibility: responsiveness to social cues, leading to an enhanced tendency to comply with hypnotic instructions, representing a suspension of critical judgment.

We have shown that subjects in a hypnotic state reported a phenomenology of an altered state of consciousness: participants reported a higher degree of absorption and dissociation as compared to normal wakefulness and control conditions [12]. Other studies have also shown that hypnosis produces alterations in aspects of consciousness and is characterized by modulation of properties of the phenomenal self-consciousness such as mental ease (i.e. easy flow of thoughts), absorption, reduction in self-orientation and automaticity (i.e. responses are experienced as being produced without deliberation and/or effort) [47].

Measuring hypnosis in the brain

We here review neuroimaging and electrophysiological (EEG) studies of hypnosis as a state, as well as hypnosis as a tool to modulate brain responses to stimulation such as, for example, painful stimuli.

Hypnosis in the brain ''at rest''

fMRI and PET studies

In a first study, regional cerebral blood flow (rCBF) was shown to increase by 16% during hypnosis, with specific increase in occipital and right temporal regions [62]. Several years later, Maquet et al. [38] explored the brain mechanisms ''at rest'' underlying hypnosis in healthy volunteers and showed that hypnotic state was related to the metabolic activation of cortical areas involving left-sided occipital, parietal, precentral, premotor, and ventrolateral prefrontal cortices and right-sided occipital and anterior cingulate cortices, while a decrease of activity was observed in precuneus, bilateral temporal, medial prefrontal and right premotor cortices. In a functional magnetic resonance imaging (fMRI) study, we showed that self-related and external brain networks were modified under hypnosis [12]. The self-related network coincides with midline brain structures such as precuneus and mesio-frontal brain areas (also named default mode network — DMN) and is involved in self-related processes, while the external network encompasses lateral fronto-parietal regions routinely exhibiting activity increases during attention-demanding tasks and has been linked to cognitive processes of external sensory input [22]. In the normal awake state, we identified a negative correlation between external and internal awareness in healthy volunteers: explicit subjective reports for increased intensity of internal awareness were related to increased connectivity in the DMN, whereas increased external awareness scores were associated with increased connectivity in the external network [64]. Under hypnosis, the external network exhibited reduced functional connectivity, whereas the DMN showed reduced connectivity in its posterior midline and parahippocampal structures but increased connectivity in its lateral parietal and middle frontal areas [12], while other works showed opposite results with increased activity in posterior regions of the DMN as compared to decreased metabolic activity in anterior DMN areas [36,46]. Other fMRI studies have shown a hypnosis-related reduction in DMN connectivity [10,39], and increased activity in lateral prefrontal regions (involved in attentional/extrinsic systems) [10]. Subjects with high compared to low hypnotizability scores were shown to have greater functional connectivity between the left dorsolateral prefrontal cortex (involved in executive control processing) and the salience network (involved in detecting, integrating, and filtering relevant somatic and emotional information) [26]. The observed reduction in the DMN activity might reflect a decreased degree of continuous information being retrieved from the external world in terms of its relation to oneself [12]. The decreased connectivity observed by Demertzi et al. [12] in the extrinsic system might reflect a blockage of the sensory systems to receive stimuli as a result of hypnotic suggestion, while Deeley et al. [10] suggested that neural activity in DMN is inversely associated with attentional absorption and directly associated with spontaneous or stimulus-independent conceptual thought. Divergent finding obtained by these studies may be explained by distinct suggestion instructions used to induce hypnosis (e.g. pure/neutral hypnosis *vs*. experience of pleasant autobiographical memories) or the experimental fMRI designs used (e.g. block vs. continuous eyes-closed resting state design).

Finally, in a structural MRI study, Horton et al. [28] reported differences in brain structure size between low and highly hypnotizable subjects: highly hypnotizable subjects demonstrated a larger (32%) rostrum of the corpus callosum than subjects with low hypnotizability. This area is known to be involved in the allocation of attention and transfer of information between prefrontal cortices. The authors suggested that these results provide support for the neuropsychophysiological model that highly hypnotizable subjects have more effective frontal attentional systems implementing control, monitoring performance and inhibiting unwanted stimuli from conscious awareness (Table 1).

Electroencephalography

Highly hypnotizable subjects (as compared to medium and low) have been shown to demonstrate different EEG phase synchronization rhythms: high subjects demonstrated less phase synchronization in frontal brain areas [4]. In