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The role of hypnotizability in the construction of individual sensori-motor selves

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ABSTRACT

Part I (Hypnotizability: calling for physiologists) analyzes our earliest findings concerning spinal cord excitability in not hypnotized subjects with high (Highs) and low (Lows) hypnotizability. Results showed that hypnotizability-related differences can be detected also out of hypnosis and without specific suggestions and prompted further investigations on the relation between hypnotizability and sensori-motor integration. Part II (Hypnotizability and postural control: sensory alterations) describes the results of studies on postural control. In particular, the results concern the different set points for postural control and the different responsivity to various sensory alterations in Highs and Lows. Part III (Hypnotizability and postural control: imagery of sensory alterations) concerns the characteristics of imagery abilities allowing Highs to enbody the imagery contents for both obstructive (anaesthesia) and constructive (head rotation) sensory imageries which are able to modify postural control. Part IV (Conclusions) suggests that the findings already obtained may unify the ericksonian and experimental perspectives on hypnosis and that hypnotizability is an important variable to take into account in the selection and set-up of neuro-rehabilitative treatments.

Key words

Hypnotizability • Hypnotic susceptibility • Imagery • Sensori-motor integration • Postural control

Hypnotizability: calling for physiologists

An appropriate sub-title for my contribution to the meeting dedicated to Professor Moruzzi and his role in the scientific perspectives of the latest two centuries might be “The unexpected consequences of a wrong definition”. The wrong definition is the one generally applied to the phenomenon of animal hypnosis.

I began my training in physiology in the early Eighties in the laboratory of Professor Pompeiano, where I developed a deep interest in motor control, quite far from psychological contamination. Some years later, I was encouraged by Professor Carli, my PhD supervisor in Siena, to plan experimental protocols aimed at defining a physiological reference frame for the study of hypnosis. I was very much perplexed. Carli had been working on animal hypnosis in Moruzzi’s lab for some years in the Seventies (Carli, 1982a,b); his interest in human hypnosis was triggered by the consideration that the word ‘hypnosis’ did not define the same phenomenon in humans as in animals.

At that time, the studies on human hypnosis relied on two different views: the clinical view, supported mainly by Milton Erickson and originated from psychoanalytic assumptions, that targets as “hypnosis” any technique enabling the hypnotist to reach the patient/client’s unconscious mind (Erickson and Rossi, 1989), and an experimental view, supported, among the others, by Ernest Hilgard, Andrè

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Weitzenhoffer, Timothy Barber and Martin Orne. The latter researchers felt the necessity to identify the hypnotic state through objective parameters and to provide a measurement of hypnotizability – the ability to enter hypnotic trance – by appropriate scales which consist of hypnotic induction followed by a number of items exploring the ability to accept suggestions aimed at the alteration of perception, memory and movement (Sheehan and McConkey, 1982; Weitzenhoffer, 1997). They proposed an operational definition of "hypnosis" as the effects obtained in some individuals after hypnotic induction such as the alteration of perception/memory and the consequent behaviour. This definition implied many different questions: was the hypnotic induction actually required to elicit responses appropriate to the administered suggestions?; did the individual cognitive/emotional traits play a role in the shift from waking to hypnosis?; did hypnosis actually exist? (Hilgard, 1986; Bowers, 1992; Spanos and Coe, 1992; Woody and Bowers, 1994; Zamansky and Ruehle, 1995; Ruehle and Zamanski, 1997; Lynn et al., 1997; Kirsch et al., 1999; Wagstaff, 1999; Dienes et al., 2009). In those seminal years of the scientific research on hypnosis, Carli received a sort of commitment from Martin Orne who, being skeptical about the existence of the "hypnotic state", called for physiologists to join the courageous army of researchers engaged in the field. Indeed, when I began my PhD course in Siena, in the Eighties, hypnosis was still a matter for psychologists, psychiatrists and psychoanalists.

To tell the truth, my earliest approach to hypnosis was an attempt to go on with research on motor control without giving too much consideration to my supervisor's interests into hypnosis. Yet, unexpectedly, the results of our studies on the H reflex (Hoffmann, 1922) and F waves (Eccles, 1955) inspired me better feelings and novel ideas about my PhD program. The subjects of our experiments were young males and females grouped in Highs and Lows according to the high and low scores obtained on the Italian version of the Stanford HypnoticSusceptibility Scale (De Pascalis et al., 2000). During long lasting relaxation session without any suggestion, only in Highs (both in and out of hypnosis) we found a reduced amplitude of the H reflex (Hoffmann, 1922) elicited in the *soleus* muscle after stimulation of the *tibialis posterior* nerve and a reduced frequency of occurrence of the F wave (Eccles, 1955) in the *abductor digiti minimi* of the right hand after stimulation of the ulnar nerve at the wrist (the F wave is an index of post synaptic motoneuron membrane excitability, being elicited by ortodromic stimulation of the motoneuronal pool soon after its antidromic activation). At variance, no hypnotizability related change in the F wave occurrence was observed in the lower limbs *abductor hallucis* after stimulation of the tibial nerve (Santarcangelo et al., 1989; Carli and Santarcangelo, 2002; Santarcangelo et al., 2003). The results on H reflex may be accounted for by different characteristics of habituation in Highs and Lows (Busse, 1991). The reduced frequency of occurrence of F waves – that indicates reduced excitability of the motoneuron membrane of the *abductor digiti minimi* of the right hand – might be interpreted according to the theory of hypnosis proposed by Gruzelier (1998). This theory indicates a pre-eminent left hemisphere EEG activity in the awake state in Highs, which has been recently confirmed (Naish, 2010), and a progressive shift toward a pre-eminent right hemisphere engagement when the subjects pass from waking to hypnosis. Yet, the shift might have occurred also in relaxing not hypnotised Highs.

Altogether our findings pointed to a different supraspinal control of the motoneuron excitability in Highs and Lows. In fact, during long-lasting relaxation sessions, only Highs exhibited inhibitory/dysfacilitatory influences acting postsynaptically on the motoneurones of the right upper limb extensor (as indicated by a decreased F wave frequency of occurrence), and presynaptically, on both lower limb extensor motoneurones (as indicated by a decreased H reflex amplitude without changes in the F wave). Most importantly, the results of these experiments indicated that hypnotisability, and not the state of hypnosis, is responsible for the effects and that physiological correlates of hypnotizability in the sensori-motor domain are also in absence of specific suggestions. This leads to conclude that, if hypnotizability reflects peculiar physiological characteristics, then physiologists must be engaged in these studies.

Hypnotizability and postural control: sensory alterations

I decided to focus my research on the differences between not hypnotized Highs and Lows. I believe, in fact, that the hypnotizability-related physiological differences existing out of hypnosis may account for aspects of the variability observed in the general population in daily life.

We chose the posture as a model to study the hypnotizability-related sensori-motor integration because in both phenomena – postural control (Balasubramaniam and Wing, 2002; Woollacott and Shumway-Cook, 2002; Vuillerme and Vincent, 2006; Fraizer and Mitra, 2008) and hypnotizability (Raz, 2005) – attention plays a relevant role. Attention is expecially required for postural control during sensory alteration such as eyes closure and/or ischaemic or vibration induced alteration of the leg proprioceptive information (Redfern et al., 2001). Therefore, we investigated the postural effects of the suppression of visual input (eye closure) and of the alteration of the leg proprioceptive information obtained through a foam placed between the platform and the subject's feet in not hypnotized Highs and Lows. The two groups of subjects provided similar self-reports of body sway. However, when vision was occluded and/or the leg proprioceptive input was altered, the Highs' body Centre of Pressure (CoP, the projection of the application point of the foot-to-ground reaction force on the horizontal *inter-feet* plane) exhibited larger and faster sway than the Lows' one (Santarcangelo et al., 2008a). The stabilogram diffusion analysis (Collins and De Luca, 1993) suggests that the finding is not symptom of poorer postural stability; it rather reflects a pre-eminently centrally driven control that allows the Highs looser adjustments of the body sway. Indeed, the Highs' and Lows' set point for postural control is different. We believe that these differences between Highs and Lows can be entirely ascribed to different processing of the sensory information, since purely cognitive load (i.e. mental computation not associated with sensory alteration) affects equally the two groups of subjects (Santarcangelo et al., 2009). However, a less strict peripheral control of the posture does not represent a disadvantage during highly demanding postural tasks. In fact, in Highs standing on a see-saw platform, the postural control shifts from the very "economic" functioning mode, pre-eminently centrally-driven, to an efficaciously periphery-controlled mode (Caratelli et al., 2010) and Highs and Lows behave similarly.

In contrast with what occurs during the visual and leg proprioceptive alteration, the asymmetrical tonic alteration of the neck proprioceptive information (induced by prolonged head rotation) affects the CoP movement at a lesser degree in Highs than in Lows (Santarcangelo et al., 2008b), while the impairment of vestibular input (obtained through backward head extension) does not elicit any difference between Highs and Lows. These results suggest a hypnotizability-related hierarchy of the sensory inputs required for postural control.

The occurrence of different modes of sensory-motor integration has been recently reported in animals. Activity of the rotation-responsive neurons of vestibular nuclei is modulated by both vestibular and neck proprioceptive inputs in the Squirrel monkey (Gdowski and McCrea, 2000), but only by vestibular inputs in the Rhesus monkey (Roy and Cullen, 2001) possibly to comply with arboreal or terrestrial habitat. Even two species belonging to the same genus (Macaca) have been found different in the integration of vestibular and neck information (Sadeghi et al., 2009).

A hypnotizability-related hierarchy of sensory information is confirmed by studies of locomotion. They show that Highs, compared to Lows, may be more tolerant to alteration of the visual and neck proprioceptive information during locomotion (Menzocchi et al., 2010a), whereas impairment of the vestibular input does not affect differentially the two groups.

The structures and mechanisms that may account for hypnotizability-related differences (Fig. 1) have been discussed in detail elsewhere (Carli et al., 2008; Menzocchi et al., 2010b; Santarcangelo et al., 2010). In short, we suggest that the functional relations between the cortical regions directly involved in hypnotizability/attention (prefrontal cortex, anterior cingulum) and the structures responsible for multisensory integration and postural/locomotion control (motor cortex, sensory/associative areas, vestibular nuclei, locus coeruleus, cerebellum) are differently modulated in Highs and Lows.

Hypnotizability and postural control: imagery of sensory alterations

Hypnotic suggestions are requests to imagine sensory contexts different from the real ones, yet their efficacy is not predicted by imagery questionnaires and, sometimes, it is not even correlated with the vividness

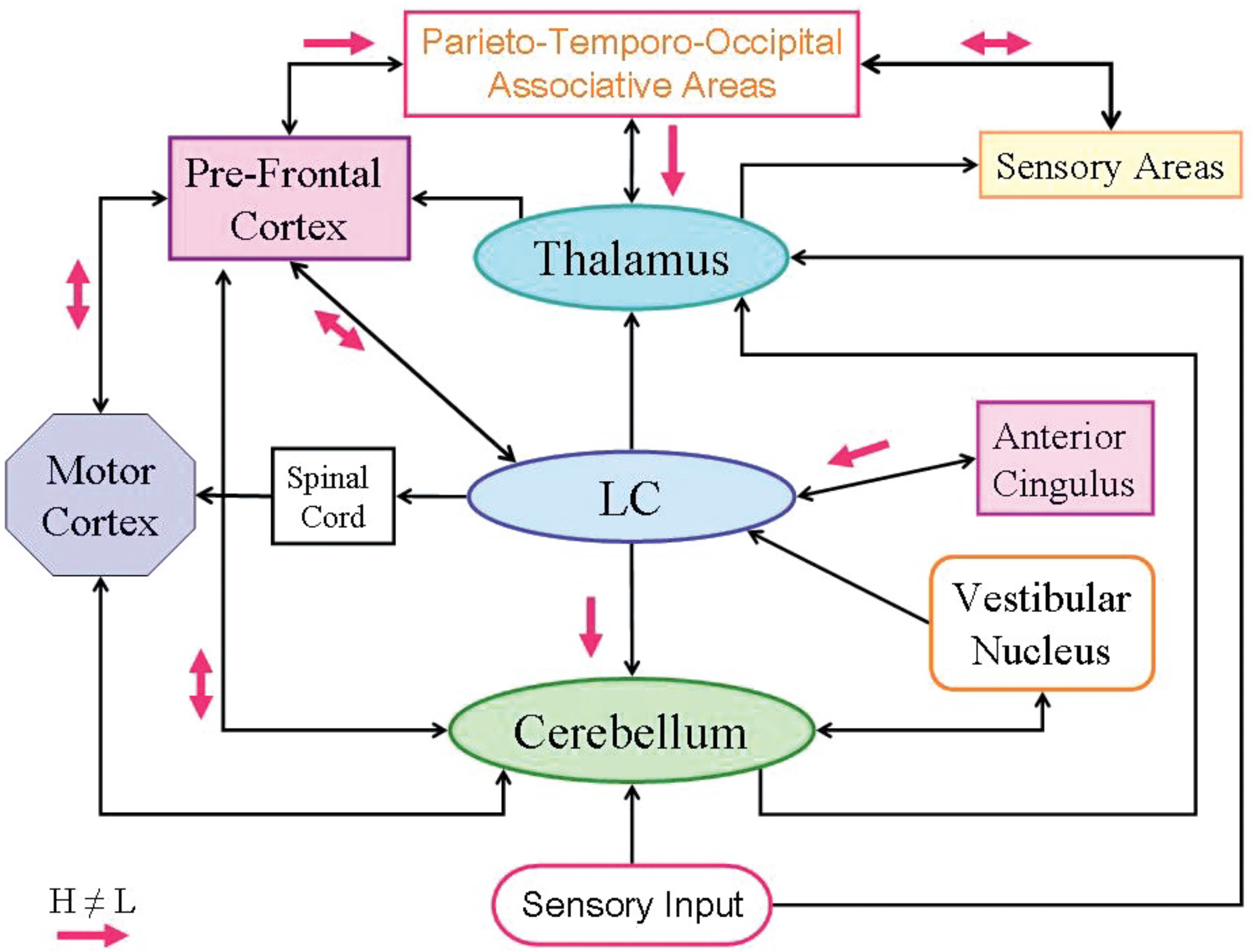

Fig. 1. - Brain structures possibly involved in the postural differences observed between Highs and Lows during real and imagined sensory alterations. The functional modulation of the relation between the prefrontal cortex and the anterior cingulus is responsible for hypnotic phenomena. On a morphofunctional basis, these structures can modulate all sensori-motor processes relevant for sensori-motor integration and, particularly, postural control (see text). Black arrows indicate the uni-or bidirectional functional connections of the structures involved in the described findings on spinal reflex, posture, locomotion and imagery effects. Red arrows refer to the possible hypnotizability-related differences (modified from Scattina E., PhD Thesis, 2010).

of the subjectively experienced imagery (De Pascalis et al., 1993; Carli et al., 2007a,b; Santarcangelo et al., 2010). Hypnotic suggestions characteristically elicit a behaviour which is congruent with the suggested sensory alteration (for instance, suppression of both pain perception and flexor reflex during nociceptive stimulation of a foot associated with suggestions for analgesia) (Kiernan et al., 1995; Danziger et al., 1998) and is accompanied by an experience of involuntariness in action. Hypnotic involuntariness has been one of the war-horses of the research on hypnotic state and has been widely discussed in the light of the current theories of hypnosis. The neo-dissociative theories of hypnosis (Kirsch and Lynn, 1998) refer to dissociated experience (Hilgard, 1986) or dissociated control of behaviour (Bowers, 1992; Woody and Bowers 1994) depending on the activity of the executive control system (Fuster, 1997; Knight et al., 1999) that allows the Highs to enact behaviors in line with the suggestions received (Gruzelier, 1998; Woody and Farvolden, 1998). In this light, the perceived involuntariness of behaviour could be attributed to an active suppression of the awareness of the effort (Hilgard, 1986) by the same attentional circuits involved in the selection of suggestion-specific behavioural schemata (Norman and Shallice, 1986; Shallice and Burgess, 1991; Woody and Farvolden, 1998). Socio-cognitive theories interpret the hypnotic behaviour as an effect of the experienced imagery only (Lynn et al., 1990). It may be influenced by individual cognitive characteristics of the subjects (Zamansky and Ruehle, 1995; Ruehle and Zamanski, 1997) and by their expectancies (Comey and Kirsch, 1999; Lynn et al., 1997; Kirsch et al., 1999) and may become somehow automatic, thus being perceived as effortless-involuntary. Finally, the "role-playing" approach (Spanos and Coe, 1992; Wagstaff, 1999) considers the experienced involuntariness, like all hypnotic phenomenology, as the result of subjects' compliance towards the experimenter's request.

We suggest that the feeling of involuntariness, experienced by Highs also out of hypnosis, may derive from a more effective top-down control of the neural circuits underlying the embodiment of suggestions content. Indeed, when standing Highs receive a sensory suggestion ("the carpet under your feet is being pulled forward") that does not describe the expected motor response, the subjects' behaviour is the same as that produced by the corresponding explicit suggestion ("you are falling backward") and by real stimulation (Carli et al., 2006). Similarly, the suggestion of pain in one leg leads to body displacements similar to those produced by a nociceptive reflex (Scattina et al., 2010). In spite of the self reports of involuntariness in action, both these results could be simply explained by expectation and conditioning. In order to exclude voluntariness we studied, in standing subjects, the vestibulo-spinal (VS) responses following labyrinthine stimulation (Santarcangelo et al., 2010). We focused our study on the earliest component of the vestibular reflex which is not modulated by either volition (Reynolds, 2010) or expectation (Guerraz and Day, 2009). The labyrinthine stimulation induces a reflex body sway which occurs in the frontal plane when the head is in face-forward position and in the sagittal plane when the head is rotated toward the shoulder owing to the interaction between neck and vestibular inputs (Lund and Broberg, 1983). In subjects with their face forward, the effective suggestion for anaesthesia was expected to reduce the amplitude of VS reflex in the frontal plane; in subjects with the head rotated, the same suggestion was expected to elicit sway in the sagittal plane, similar to that observed when the head was really rotated. The results showed that the effects of the "obstructive" imagery of anaesthesia were different from those induced by the "constructive" imagery of head rotation. Indeed, both Highs and Lows having their face forward and reporting high vividness of imagery experienced anaesthesia and showed reduced amplitude of the VS reflex in the frontal plane; only Highs, however, changed the plane of body sway according to the imagined head rotation, that is from the frontal to the sagittal plane. A possible interpretation of the greater success of the constructive suggestion in Highs is that they preferred the proprioceptive modality of imagery (feeling the contraction of neck muscles) respect to the visual modality (seeing the chin directed toward the shoulder) and that the somesthetic modality of imagery is more effective in the construction of the body schema. Other experiments show that Highs can obtain effective imageries through either visual and proprioceptive modality in provocative conditions (upright stance), while Lows are limited to the visual one (Carli et al., 2007a,b). In conclusion, the sensory modality chosen for suggestions may influence their effectiveness by interacting with hypnotizability. Most importantly, sensory alterations are likely to be compensated more easily in Highs that in Lows, possibly because of the Highs' ability of translating sensory imagery into real stimulation/perception. Since the tuning of vestibular reflexes depends on the integrity of the cerebellum (Kammermeier, 2009), Highs might rely on a more effective cerebellar activity/plasticity with respect to Lows (Santarcangelo et al., 2010).

Conclusions

According to our findings, hypnotizability should be considered not only as a cognitive trait, but as a complex constellation of highly pervasive physiological characteristics responsible for the construction of individual "sensori-motor selves". In addition to the functional interaction between dorsolateral prefrontal and anterior cingulate cortex, involved in the shift from wake to hypnosis (Gruzelier, 2006; Faymonville et al., 2006), other functions depending on other brain structures may be modulated by hypnotizability, and/or co-modulated with it. This hypnotizability-related variability may sustain the physiological differences observed between Highs and Lows in the postural response to real and imagined sensory alteration (Carli et al., 2008;

Menzocchi et al., 2010b; Santarcangelo et al., 2010). Although our approach does not contribute directly to define the nature and mechanisms of hypnotic state (and might be considered "heretical" in the hypnosis arena), we claim the role of our findings in the classical debate between clinical and experimental hypnosis about the importance of hypnotizability in the response to suggestions. The clinical view assumes that everybody can be hypnotized because everybody has an unconscious mind that can be reached "somehow"; the experimental view shows that hypnotic behaviour depends on hypnotizability as measured by scales and that only some individuals can be hypnotized. Our results reconcile the two views.

It is stated that in Highs under hypnosis the specific formulation of suggestions modulates their effectiveness (Groth-Marnat and Mitchell, 1998; Barabasz et al., 1999); our findings enlarge the perspective by showing that, out of hypnosis, the sensory modalities used for sensory imageries are differentially effective in Highs and Lows (Carli et al., 2007a,b; Santarcangelo et al., 2010). This means that, regardless of hypnotisability, a hypnotic behaviour may be induced by appropriate induction. Incidentally, this is in line with the observation that many techniques (dervishes dance, Christian prayer, oriental meditation) allow entering altered/alternate states of consciousness (Tart, 1975).

For the sake of honesty, I must express my regret for our approach being still considered with prejudice by part of the scientific community. While interactions among disciplines once considered very far apart become deeper and deeper, it is still hard to convince physiologists that we are not a sort of wizards and psychologists that our physiological findings are worth of attention, even though they cannot be easily framed into well-established theoretical systems. However, now I am pleased to be engaged in studies which inspire profound interest for the human being as a whole and allow better understanding of how psychology may help medicine. I believe, in fact, that the evaluation of individual cognitive/emotional characteristics can be useful in patients requiring relaxation/imaginative training (Carli et al., 2007a,b; Santarcangelo et al., 2010; Scattina et al., 2010) and assessment of the hypnotizability can improve the selection and the set up of neuro-rehabilitation protocols (Santarcangelo et al., 1989, 2003, 2008a,b; Menzocchi et al., 2010).

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