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HYPNOTIZABILITY AS AN ADAPTIVE TRAIT

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Abstract

This paper reviews our studies on the hypnotizability/hypnosis-related modulation of the mind-body connection during relaxation and mental stress, considered as the extremes of the wakefulness cognitive-autonomic arousal. The concept of relaxation is discussed according to the observation that similar self-reports of relaxation and autonomic states may correspond to different EEG patterns in low (Lows) and highly hypnotizable subjects (Highs). Results obtained during mental stress are discussed in the light of a possible adaptive role of hypnotic susceptibility as a natural protection against cardiovascular hazard; in fact, only Highs can actively suppress the cardiovascular responses evoked by a moderate mental stress. All together, findings show that the body can differentially act to similarly experienced relaxation and mental stress and suggest for hypnotizable individuals an evolutionary advantage.

Key words: autonomic system, EEG, hypnosis, hypnotizability, relaxation, stress

Introduction

Our first approach to the modulation of autonomic activity by hypnotizability and hypnosis[1] was by mere chance. In fact, we were studying the possible role of the hypnotic trait and state in motor control (Santarcangelo, Busse and Carli, 1989, 2003; Santarcangelo, Rendo, Carpaneto, Dario, Micera and Carli, 2004; Danziger, Fournier, Bouhassira, Michaud, De Broucker, Santarcangelo, Carli, Chertock and Willer, 1998; Carli, Rendo, Santarcangelo, Sebastiani, Carpaneto, Dario, Micera, 2003) through the evaluation of the soleus muscle monosynaptic reflex, and, during the elicitation of H-M recruitment cycles (Hoffman, 1922), we observed that Highs lowered their direct motor response (M) threshold, at variance with Lows. Since we were using a constant current stimulator, according to Ohm's law this effect should be due to physical changes in the stimulated tissues, such as an increased skin resistance (Santarcangelo 1989) possibly related to the greater relaxation capabilities of Highs (Harris, Porges, Carpenter and Vincenz, 1993; De Benedittis, Cigada, Bianchi, Signorini and Cerutti, 1994; Gruzelier, 1998).

Furthermore, working with subjects trained in Vipasana, a meditation technique requiring a 'diffuse' attention (Ornstein, 1972; Naranjo, 1974), we observed that during meditation non hypnotizable individuals increased their skin resistance more than hypnotizable ones. The one highly susceptible meditator of the group decreased it during both meditation and hypnosis and showed no change during simple relaxation (Santarcangelo, Cerrini and Carli, 1990). Since Vipasana requires a 'diffuse' attention (in contrast with the focused one requested by hypnosis), we argued that different relaxation techniques could be effective in subjects with different cognitive strategies and thus techniques should be chosen according to individual psychological attitudes.

These observations prompted a systematic investigation on the influence of the hypnotic trait and state on autonomic activity.

Studies on cerebral metabolism (Critchley, Corfield, Chandle, Mathias and Dolan, 2000; Critchley 2002; Patterson, Ungerleider and Bandettini, 2002) show that self-reports of relaxation are associated with cerebral blood flow changes in some of the same regions involved in the control of arousal/consciousness and of autonomic activity. Thus, our hypothesis was that the Highs' peculiar cognitive flexibility (Crawford, 1989; Crawford, 1994; Crawford, Clarke and Kittner-Triolo, 1996; Evans, 1999) could be associated with autonomic flexibility. The aim of our research was to detect differences between Highs and Lows in this respect and to assess whether definite autonomic and/or EEG patterns could reflect different subjective experiences.

In the present paper, we review our findings concerning the cardiovascular physiology of relaxation and stress, namely extremes of cognitive-autonomic arousal during wakefulness, as a function of hypnotizability and hypnosis.

What is relaxation? (Does relaxation exist?)

Benson's 'relaxation response' (Benson, Arns and Hoffman, 1981), usually considered synonymous with 'relaxation', describes some autonomic and metabolic changes associated with an increment of cerebral alpha activity. Yet new contributions to the understanding of the functional role of cortical rhythms (Mann, Sterman and Kaiser, 1996; Shaw, 1996; Pulvermuller, Birbaumer, Lutzenberger and Mohr, 1997; Klimesch, 1999; Rodriguez, George, Lachaux, Martinerie, Renault and Varela, 1999; Cooper, Croft, Dominey, Burgess and Gruzelier, 2003) do not allow either the identification of relaxation with every condition of an alpha activity increment (Ota, Toyoshima and Yamauchi, 1996) or its exclusion in the presence of an alpha decrement (Shaw 1996; Klimesch, 1999).

As for the relationship between hypnotizability/hypnosis and relaxation, EEG studies have considered only short rest periods between suggestions as relaxation periods (De Pascalis, Ray, Tranquillo and D'Amico, 1998), or they did not investigate the possibly related changes in autonomic variables (Sabourin, Cutcomb, Crawford and Pribram, 1990; Perlini and Spanos, 1991; Graffin, Ray and Lundy, 1995; Williams and Gruzelier, 2001; Cooper, Croft, Dominey, Burgess and Gruzelier, 2003). On the other hand, the modifications in autonomic and metabolic variables considered in Benson's definition are rather non-specific, because they can be observed in other conditions, i.e. at bed rest, without any congruent subjective experience of relaxation. Thus we chose to investigate autonomic and EEG modulations during long-lasting sessions following an explicit, standardized instruction to relax.

Previous results on hypnotizability-related relaxation were equivocal. In fact, some authors have reported a higher heart rate and a lower vagal tone in Lows (Harris et al., 1993), but others have failed to detect any trait difference (Sturgis and Coe, 1990; Ray, Sabsevitz, De Pascalis, Quingley, Aikins and Tubbs, 2000; Jorgensen and Zachariae, 2002). Furthermore, while some studies reported a sympathetic prevalence in Highs, suggesting for them a higher cardiovascular risk (Wickramasekera, 1999), others described a correlation between relaxation capabilities and absorption, instead of hypnotizability (Zachariae and Jorgensen, 2000).

Our results (Sebastiani et al., submitted for publication) indicate that subjects with different cognitive strategies obtained relaxation through partially different mechanisms. In fact, similar reports of a satisfying relaxation and a similar autonomic state (see Table 1) were associated with partially different EEG patterns, since during a long-lasting relaxation we observed an increment of gamma activity in Highs and a decrement in Lows, who also decreased their theta 1 power. In addition, we found that the increment of the parasympathetic component of the heart rate variability (HRV) occurring in Lows did not correspond to better subjective relaxation.

In hypnotized Highs (Sebastiani et al., submitted for publication), reporting deeper relaxation with respect to wakefulness, the heart rate decrements observed were associated with theta1 activity decrements and frontal gamma power increments, while no changes in alpha1 alpha2, beta2 and theta2 were present. Thus the deeper relaxation experienced was apparently in line with heart rate modifications but the corresponding EEG pattern was not a typical ‘relaxation’ one. Such results suggest considering hypnotic relaxation (relaxation?) as a higher integrative state compared with a condition of waking rest without a specific instruction.

We had already described neutral hypnosis as an activation phenomenon on the basis of preliminary findings on the heart rate variability of hypnotized Highs (Santarcangelo, Emdin, Picano, Raciti, Macerata, Michelassi, Kraft, Riva and L’Abbate, 1992). These had shown an increment of the HRV total power and of both its sympathetic (High frequency, HF) and parasympathetic (Low frequency, LF) components, leading to the decreased LF/HF ratio responsible for the observed bradycardia (see Figure 1).

However, results on HRV are not univocal (De Benedittis et al., 1994; Ray et al., 2000) and should be considered cautiously, because of theoretical and methodological problems. The former concern the functional interpretation of LF, which also includes a

Table 1. Autonomic and EEG variables during simple relaxation

Variable	Highs	Lows
HR	=	↓
RF	=	=
SR	(↑)	(↑)
LF	=	=
HF	=	↑
theta1	=	↓
theta2	↓	↓
alpha1	↓	↓
alpha2	↓	↓
beta2	↓	↓
gamma	↑	↓

Note: Autonomic variables: HR, heart rate; RF, respiratory frequency; SR, tonic skin resistance; LF and HF, low and high frequency component of the heart rate variability. EEG rhythms relative power: theta1 (4–6 Hz), theta2 (6–8 Hz), alpha1 (8–10 Hz), alpha2 (10–12 Hz), beta2 (16–20 Hz) and gamma (36–44 Hz). ↑,↓: increments/ decrements throughout the session; (↑,↓): non significant changes. Differences between groups are emboldened.

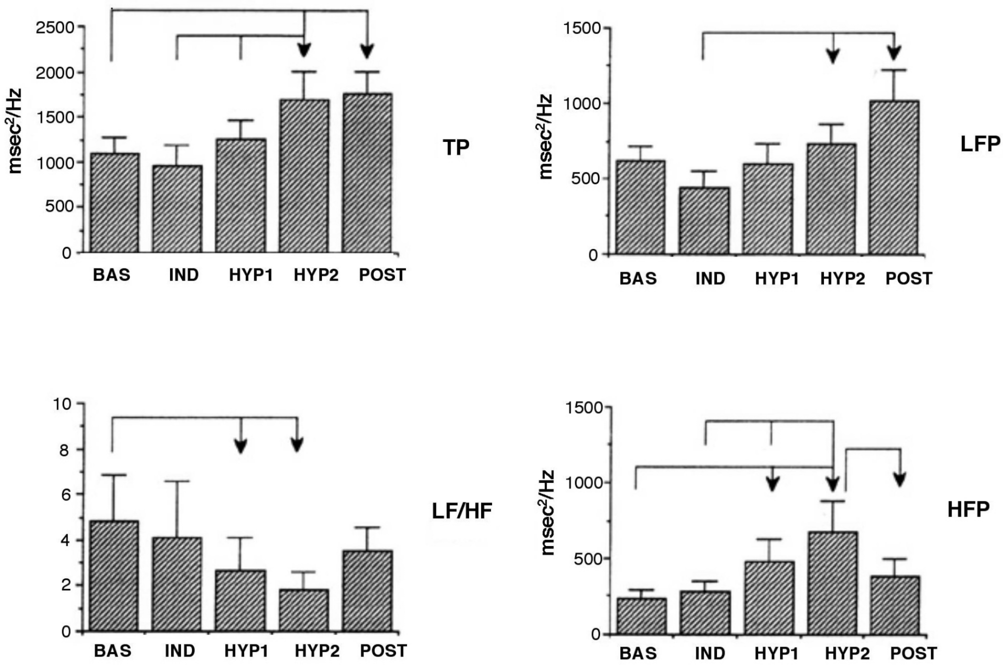

Figure 1. Upper left: increase in total power (TP) exhibited by highly susceptible subjects during a recording session including a hypnosis period. Upper right: behaviour of LF power. Lower left: decrease in LF/HF ratio during the hypnosis period. Lower right: increase in HF power during hypnosis. Arrows indicate significant changes ($p < 0.05$). (From Santarcangelo et al., 1992)

part of non-sympathetic activity (Berntson, Bigger, Eckberg, Grossman, Kaufmann, Malik, Nagaraya, Porges, Saul, Stone and van der Molen,1997), while the latter refer to the different underlying physiological models. Some of the studies could have biased results because of the assumption of a necessary HF-LF balance, which is now considered only one of the possible configurations of the 'autonomic space' (Berntson, Cacioppo, Quigley and Fabro, 1994).

In conclusion, after the instruction of relaxation, the EEG patterns indicated different cognitive strategies implying increased integrative activity (Rodriguez et al., 1999) in awake and hypnotized Highs and decreased integrative activity in Lows. It could be suggested that an 'active' cognitive mechanism was involved in the experience of relaxation in the Highs and a sort of disengagement from the cognitive task of relaxation was present in the Lows. Since autonomic changes, self-reports and the EEG activity have not always been congruent, we hold that the unique acceptable definition of relaxation could be 'a condition perceived as relaxation' and that many 'relaxations' are possible. This could be due to the different influences of the subjects' frontal executive control system (Norman and Shallice, 1986; Shallice and Burgess, 1991; Gruzelier, 1998; Woody and Farvolden, 1998) on the cerebral regions responsible for both the representation and control of the autonomic system (Critchley, Corfield, Chandle, Mathias and Dolan, 2000). Thus, choosing a technique homogeneous with the subjects' cognitive strategies could make relaxation easier (Santarcangelo et al., 1990) and, in this respect, the evaluation of hypnotic susceptibility may become a useful tool in the clinical field.

Can the body act differentially to a similarly experienced stress?

At the very beginning of our interest in the influence of hypnotizability/hypnosis on autonomic activity, we observed that the skin resistance of subjects performing successfully autogenic relaxation did not decrease when they were asked to imagine or recall an unpleasant situation (Santarcangelo 1989). We interpreted this as the effect of hypnotic relaxation on the imagery content, but the lack of other autonomic correlates and of EEG recordings did not allow a more sophisticated interpretation. Thus we recently began a systematic investigation on this topic through the verbal administration of moderately aversive cognitive stimulation to Highs and Lows.

In spite of the similar self-reports of moderate unpleasantness collected from awake Highs and Lows (Sebastiani, Simoni, Gemignani, Ghelarducci and Santarcangelo, 2003a), and of the unexpected lack of any cardiac response in both groups, Highs and Lows did show some EEG differences. The former exhibited an EEG pattern indicating that their imagery-attentional capabilities had really induced an unpleasant experience, reflected by the increased beta2 relative power (see Table 2) and by a trend towards gamma increments, while the latter exhibited a de-activation pattern consisting of decreased gamma and unchanged beta2 activity.

Our conclusions were that Lows did not show any cardiac reaction to the aversive stimulation, which was likely to be because of their poorer imagery-attentional capabilities or their attempt to manage the unpleasant stimulation through a disengagement technique. Yet, this was not highly effective, because their respiratory frequency increased and their skin resistance decreased. On the contrary, Highs performed an active suppression of their cardio-respiratory output (see Table 2). This ‘escaping’ mechanism was prevented by the induction of hypnosis (Sebastiani et al., 2003a); in fact hypnotized Highs did exhibit the autonomic changes expected during unpleasant stimulation. In our opinion, such a difference between awake and hypnotized Highs represents strong evidence in favour of a state-theory of hypnosis and suggests that at least a part of hypnotic phenomenology does not develop along a continuum from wakefulness to hypnosis.

Table 2. Autonomic and EEG variables during a moderately aversive cognitive stimulation

Variable	Lows	Highs
HR	=	=
RF	↑	=
SR	↓	↓
theta1	=	=
theta2	↓	↓
alpha1	↓	↓
alpha2	↓	↓
beta2	=	↑
Gamma	↓	(↑)

Note: for details, see Table 1.

Is hypnotizability also an advantage at the peripheral level?

In order to extend our investigation to the vascular system, we studied the changes of the brachial artery post-ischaemic flow-mediated vasodilation (endothelial function, % FMD) through a non-invasive ultrasound technique (Corretti, Anderson, Benjamin, Celermajer, Charbonneau, Creager, Deanfield, Drexler, Gerhard-Herman, Herrington, Vallance, Vita and Vogel 2002; Morelos, Amyot, Picano, Rodriguez, Mazzone, Glauber and Biagini, 2001; Palinkas, Toth, Amyot, Rigo, Venneri and Picano, 2002) in awake (Jambrik, Santarcangelo, Ghelarducci, Picano and Sebastiani, in press) and hypnotized Highs and Lows (Jambrik, Sebastiani, Picano, Ghelarducci and Santarcangelo, in press). FMD is transiently reduced by acute mental stress and its impairment outlasts the stress with a peak after 10–90 minutes, which is likely to be attributable to the accumulation of catecholamines, endothelin-1 and angiotensin-II (Ghiadoni, Donald, Cropley, Mullen, Oakley, Taylor, O'Connor, Betteridge, Klein, Steptoe and Deanfield, 2000; Mangiafico, Malatino, Attina, Messina and Fiore, 2002). It has been considered a key pathophysiological variable in triggering cardiovascular events (Celermajer, 1997; Ghiadoni, Donald, Cropley et al., 2000) and has an emergent prognostic value.

We used a mental calculation (serial subtraction and multiplication) as a stressor. In order to include a motivational component into the stimulation, subjects were falsely told that the results of their computation would be evaluated to classify them according to their logical-attentive capabilities. Results confirmed our previous findings (Sebastiani, Simoni, Gemignani, Ghelarducci and Santarcangelo, 2003b) as to a possible natural protection of Highs against stress, and enlightened the relevance of stressors' different motivational/emotional features in autonomic system modulation. In fact, while the fear-like aversive stimulation (Sebastiani et al., 2003b) elicited an active mechanism preventing the expected increments of heart rate in Highs, the mental computation, even if associated with a motivational component, did not. Indeed, both Highs and Lows exhibited HR increments during calculation (see Figure 2), possibly because the computation-related stress did not represent a sufficient stimulus to activate homeostatic mechanisms.

Since stress-related FMD concurrent decrements were observed only in Lows, we argued that Highs were also protected against cognitive stress at the peripheral level and that the vascular system is differentially controlled with respect to the heart. In fact, repeated spontaneous episodes of relaxation, which are likely to occur in Highs, could have induced persistent vascular changes, i.e. receptor adaptation or desensitization, making Highs less responsive to stress (Jambrik, Santarcangelo, Ghelarducci, Picano and Sebastiani, in press). Also, in hypnotized Highs and Lows heart rate and endothelial function changes induced by mental stress were differently modulated (Jambrik, Sebastiani, Picano, Ghelarducci and Santarcangelo, in press). In fact, similarly to what we observed in awake subjects, during mental stress in both groups heart rate increased with respect to neutral hypnosis. Pre-occlusion artery diameters increased in Highs throughout the session and post-ischaemic flow-mediated dilation decreased only in Lows.

In conclusion, hypnotizability also represents a protective factor against stress at vascular level; the endothelial function appears more sensitive than heart rate as a generic stress indicator; heart rate seems to be differentially affected by the motivational/affective components of the stressor; and hypnotizability and hypnosis exert a separate control on heart rate and endothelial function.

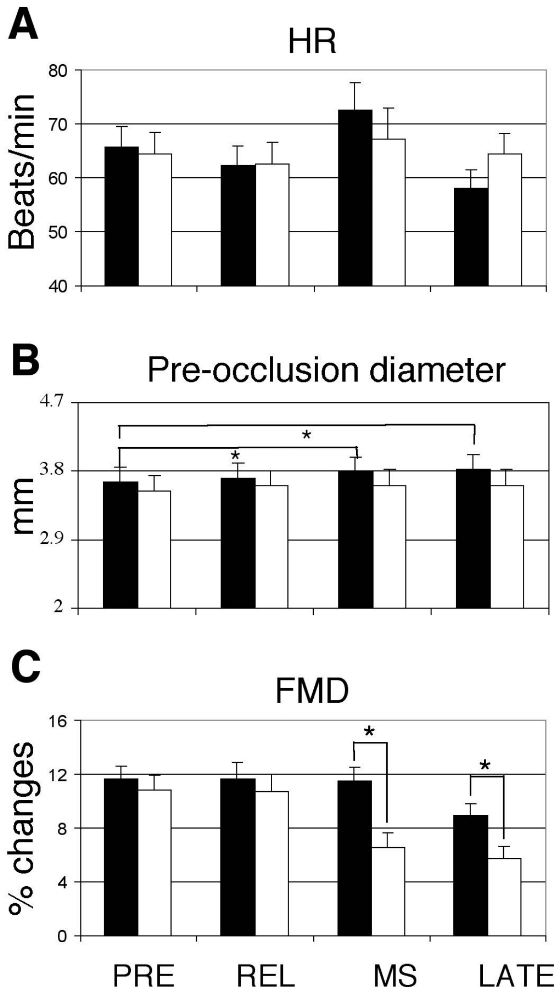

Figure 2. Modulation of the stress-related endothelial dysfunction by hypnotizability. A- Heart rate (HR), B- Pre-occlusion artery diameter, C- Endothelial function during baseline (PRE), simple relaxation (REL), mental stress (MS) and after MS (LATE) in awake Highs (black bar) and Lows (white bar).

Conclusions

- Hypnotic susceptibility could be considered an adaptive mechanism, since Highs' mind-body relationship appears more flexible than Lows' and allows hypnotizable individuals to modulate their cardiovascular activity in order to prevent the negative effects of moderate mental stress.
- High cognitive-autonomic flexibility represents a favourable prognostic factor in the therapy of stress-related diseases and evaluation of hypnotic susceptibility could direct choice of an appropriate relaxation technique, when this is required.

- Hypnotizability modulates the brain-body axis through top-down mechanisms. However, down-up controls are likely to be brought to light by the repeated spontaneous elicitation of relaxation. This could modify the vascular receptors' sensitivity leading to a modified mental representation of stress (Critchley et al., 2000).
- A reliable description of psychophysical states must always include evaluation of subjective reports, autonomic and cortical activity.

In conclusion, our results on the natural protection of highly hypnotizable individuals against stress-related cardiovascular effects suggest for them an evolutionary advantage. In this perspective, the possible differences between Highs and Lows in their responses to highly stressful stimuli (i.e. implying a risk of death) and in their choice of a fight or flight reaction are under investigation.

Note

1 All subjects joining the experiments had signed an informed consent, approved by the local ethics committee (Pisa or Siena University), excluding the use of any drugs. In all experiments, hypnotic susceptibility was evaluated through the Stanford Hypnotic Susceptibility Scale (SHSS), Forms A and C (Weitzenhoffer and Hilgard, 1959; 1962). The hypnotic induction was performed through the SHSS (B) procedure (Weitzenhoffer and Hilgard, 1959).

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