THE NEUROPHENOMENOLOGY OF HYPNOSIS

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ABSTRACT

From its inception, "animal magnetism" and hypnosis have been related to reputed psi phenomena. However, only until recently have phenomenological and neurophysiological approaches advanced enough to go beyond the proposal of a putative –and vague- hypnotic state. In this study we are following a neurophenomenological approach by analyzing in parallel experience and brain processes. We selected a group of individuals with high, medium, and low hypnotizability. While their cortical activity was evaluated, their responses to a baseline sitting down with eyes closed and then lifting an arm was compared to the same behaviors after a hypnotic induction (1st session); their spontaneous mentation during baseline and various prompts after an induction and a suggestion to go into their "deepest" state was also measured (2nd session). Results show that a between-subjects factor (level of hypnotizabity) and a within subject factor (baseline vs. other stages of the session) both had significant effects, as did their interaction. While the experience of low hypnotizables was characterized by "normal" mentation, that of "medium" hypnotizables was centered more on vestibular and other bodily sensations, and that of "highs" was characterized by positive affect and "exceptional" mystic-like phenomena. Spectral and source location EEG analyses corroborated various patterns of brain functioning differences across levels of hypnotizability and at different times during the sessions.

INTRODUCTION

Reputed psi phenomena have been observed in mesmerism and hypnosis throughout their history (Ellenberger, 1970). More recently, empirical studies and meta-analyses have strongly associated psi with hypnotic procedures (e.g., Stanford, 1992), although there has been almost no research trying to discern which aspects of the hypnotic procedure, the states produced by that procedure, and/or the trait of hypnotizability are related to psi functioning (Cardeña, 2006). Psi has also been related to specific cortical functioning (e.g., Don, McDonough, & Warren, 1998). Thus a neurophenomenological approach that aims to have a precise mapping of states of consciousness and their associated brain function (Lutz & Thompson, 2003) is called for in parapsychology. The first step, however, is to empirically determine what states of consciousness are being considered (most likely a trait by procedure interaction). In the case of hypnosis there is evidence that there are various discernible states of consciousness, not only one (Cardeña, 2005). How to characterize the brain correlates of such states depends on space and time considerations (e.g., Wackermann, 1999). Hypnotizability (the ability to respond to hypnotic suggestions) is related to anomalous phenomena including mystical, out-of-body, and psi-related experiences, but most of those findings have been correlational in nature (Cardeña, Lynn, & Krippner, 2000). Little research has focused on hypnotic phenomenology, especially among "ultraresponsive" individuals (Weitzenhoffer, 2000, p. 227). One of the problems has been to distinguish between the "artifact" of hypnosis (e.g., induction and suggestions, role playing), and the associated alterations in consciousness (Orne, 1959). A potential solution has been the rarely used approach of "neutral hypnosis" (no explicit suggestions after an induction; Kihlstrom & Edmonston, 1971), similar in spirit to Sheehan & McConkey's attempt to provide few cues on the nature of the hypnotic phenomena investigated (1982, p. 85). Another point to consider is that phenomenal experience is not a static "thing," but a dynamic process that is constantly changing. Using the concept of depth to characterize hypnotic experience is a metaphor that implies significant differences in experience within the same session. The validity of this characterization is supported by studies showing a positive correlation between reports of greater depth and changes in objective and subjective indices (Kahn, Fromm, Lombard, & Sossi, 1989; Laurence & Nadon, 1986; Tart, 1970b).

With regard to specific studies, Tart (1970a) studied the phenomenology of a hypnotic "virtuoso" who reported that the deepest hypnotic state was characterized by many noticeable alterations in consciousness. With a group of hypnotic virtuosos, Sherman (1971) corroborated Tart's description of deep hypnosis, adding that medium hypnosis involved emotional experiences, simple images, and body sensation, whereas a lighter state was characterized by ideas, worries, and "normal verbal thinking." These results were replicated and extended by Feldman (1976). The findings of these studies have been very consistent, but had various methodological limitations. Cardeña (2005) overcame a number of these methodological limitations in a repeated-measures study with hypnotic virtuosos. In a "neutral hypnosis" context in which participants were only given the suggestion to go as deeply into hypnosis as possible, volunteers reported greater alterations in body image, time sense, perception and meaning, sense of being in an altered state of awareness, affect, attention, and imagery. They also mentioned less self-awareness, rationality, voluntary control and memory. A typical experience consisted of mild alterations in body sensations and image during light to medium hypnosis. In a deep state of hypnosis, participants mentioned unusual experiences such as disembodied consciousness, utter darkness and voidness, brightness, a sense of potentiality, and being in contact with everything. This study also had some limitations. Because only hypnotic virtuosos were studied, the effect demand characteristics was not controlled.

For a long time, it has been almost a truism that hypnosis cannot be considered a different "state of consciousness", because it does not entail specific cortical activity, unlike sleep states. In the last fifteen years or so, this view has been challenged in a number of ways by studies showing significant anatomical and physiological differences between high and low hypnotizable individuals. For instance, high hypnotizability and the related ability to control pain has been associated with a considerably (31.8%) larger rostrum and, presumably, enhanced allocation of attention (Horton, Crawford, Harrington, & Downs, 2004). As compared with low hypnotizables, high hypnotizables manifest greater EEG hemispheric asymmetries and hemispheric specificity for tasks (Crawford et al., 1996), higher EEG global dimensional complexity (Isotani et al., 2001), and different sources for EEG activity (Lehmann et al., 2001). Hypnotic suggestions to reduce the affective or sensory components of pain have been shown to affect different brain areas (Rainville et al., 1999). However, no recent studies have been carried out on the EEG activity associated with specific, spontaneous (i.e., non-suggested) hypnotic experiences. The only relevant reference in the hypnosis literature is by Sherman (1971), but his EEG set-up was primitive and he did not provide specific information on his analyses. The objective of this study was to compare the phenomenology and EEG activity of high, medium, and low hypnotizable individuals under a "neutral," deep hypnotic condition, and in response to hypnotic and non-hypnotic tasks.

METHODS

Design

This project follows a general mixed within/between factor design, with hypnotizability (high, medium, or low) as a between factor, and condition of task (e.g., willed or hypnotically suggested arm levitation) as a within factor.

Participants

Through media and internet announcements, members of Lund University and the surrounding communities were invited to participate. The research had been approved earlier by the Swedish Federal Human Subjects Agency (Etikprövningsnämden). Those participants who completed all phases of the experiment were paid 90 SEK (about 12 Euros).

Procedure

Participants were administered an approved "informed consent form" and then a group hypnotizability screening instrument (Harvard Group Scale of Hypnotic Susceptibility), and the Inventory Scale of Hypnotic Depth (ISHD). From this group, those with high (HGSHS scores from 9-12), medium (5-7), and low (0-3) hypnotizability were contacted, and those interested in continuing to participate were further evaluated with an individual measure, the Stanford Hypnotic Susceptibility Scale: Form C (SHSS:C), and the Brief Symptom Inventory (BSI). Those who continued to score as either high, medium, or low hypnotizables, did not manifest obvious pathology, and wanted to continue were further evaluated in two EEG sessions.

In the first session, after learning the self-report scale of hypnotic depth, participants: 1) completed the Phenomenology of Consciousness Inventory in reference to their expectancies of deep hypnosis, and 2) had their cortical activity evaluated during an eyes-closed, 3 minute baseline period and a request to voluntarily lift their left arm and hold it there for a minute. Subsequently they were given an arm levitation hypnotic induction and asked to keep their arm up for a minute, after which they heard a 1-10-count to deepen their hypnotic state, were asked to remain in that state for 2 minutes, were asked about their experience for the previous 2 minutes, and were then dehypnotized with a count from 10-0. They were then asked to voluntarily lift their arm again and hold it up for 1 minute.

In the second session, as their EEG activity was being measured, participants underwent a two-minute, eye-closed baseline period, were asked to fill out the PCI for their experience for the past two minutes, and were then administered a 1-30 count induction with the only suggestion that they would continue to go into a deeper state of hypnosis throughout the session. Then, every 5 minutes for about 45 minutes, they were asked to provide a depth report ("state"?) and describe their experience ("what were you experiencing?") in the period before the promts. All reports were digitally recorded and later transcribed. After about 8 prompts (fewer in the case of those who reported discomfort with the EEG electrocap), participants were dehypnotized with a 10-0 count, completed the PCI for their "deepest" state during the session and were asked about their general impression for the session.

Instruments

The *Harvard Group Scale of Hypnotic Susceptibility* (HGSHS; Shor & Orne, 1962) is widely used as a screening measure of hypnotic ability and has a scoring range of 0-12.

The *Stanford Hypnotic Susceptibility Scale, Form C* (SHSS:C; Weitzenhoffer & Hilgard, 1962), has a scoring range of 0 to 12 and is typically considered the "gold standard" of hypnotic susceptibility measurement.

The self-report scale of hypnotic depth used in this study was derived from the *North Carolina Scale* (Tart, 1970), in which the participant is told that a number that indicates his/her hypnotic depth will appear "automatically" in the mind whenever the experimenter says "state." As compared to the original North Carolina Scale, no phenomena are provided as examples of what might constitute hypnosis (Cardeña, 2005). The scale used was: 0 = wide-awake, 1-10 = feeling slightly different than normal, 11-20 = light hypnosis, 21-30 = medium hypnosis, 31-40 = deep hypnosis, 41-... = very deep hypnosis.

The *Inventory Scale of Hypnotic Depth* (ISHD; Field, 1965) is a valid instruments that includes 38 items of subjective experiences empirically associated with hypnosis: a) absorption and internal and external unawareness, b) feelings of automaticity and compulsion, and c) discontinuity from normal experience.

The *Brief Symptom Inventory* (BSI; Derogatis, 1975) is a 53 items abbreviation of the SCL-90 to evaluate general psychiatric symptomatology, with very good validity and reliability.

The *Phenomenology of Consciousness Inventory* (PCI; Pekala 1991) is a 53-item valid and reliable questionnaires scored on a 0-7 Likert-type scale with various dimensions that evaluate retrospective account of subjective experience. It has been used for the assessment of many different types of alterations of consciousness (Pekala & Cardeña, 2000).

EEG data were collected using a 64-channel system channels (with linked mastoids as reference) at a rate of 256 Hz and a bandpass filter of .5-100 Hz. Data acquisition and pre-processing analysis was done with a Neuroscan 4.3 system; advanced final analyses (e.g., Low Resolution Electromagnetic Tomography) were done with the programs developed by the KEY Institute.

Analyses

For psychological variables, quantitative and qualitative content analyses were carried out to establish categories of experience. ANOVAs, t-tests, and regression analyses were conducted with interval data; chi squares with categorical data. The significance level for analyses with psychological measures was set at .05, two-tailed. Brown-Forsythe tests were used for heterogeneity of variance; Greenhouse-Geisser corrections for not meeting sphericity.

All EEG data were examined for muscle, movement, sweat, and technical artifacts. Artifact-free data epochs of 2 seconds each were identified and selected for further processing. Four types of power spectra were computed using FFT for each participant and each recording condition:
1) spectrum of original or 'raw' power averaged ('mean') across the spectra of all channels,
2) spectrum of relative* or 'normalized' power, averaged ('mean') across the spectra of all channels,
3) spectrum of original or 'raw' power of the Global Field Power=GFP** curve.
4) spectrum of relative* or 'normalized' Global Field Power=GFP**.

* for the computation of relative or 'normalized' power values, the sum of power in all 86 frequency bins (steps of 0.5 Hz) from 1.5 Hz to 44 Hz was set to 1.

** the single curve of Global Field Power (GFP) for each data epoch was computed for each time point as the standard deviation of the momentary potential values at all electrodes.

Spectral power was integrated across frequency bins into 3 or 8 frequency bands as follows:

Three EEG frequency bands: 1) 'low' (delta & theta, 1.5-8.0 Hz), 2) 'middle' (alpha-1 & alpha-2, 8.5-12.0 Hz), and 3) 'high' (beta-1 & beta-2 & beta-3 & gamma, 13.5-44 Hz). Eight EEG frequency bands: 1) delta (1.5 - 6.0 Hz), 2) theta (6.5-8.0 Hz), 3) alpha1 (8.5-10.0 Hz), 4) alpha2 (10.5 - 12.0 Hz), 5) beta1 (12.5 – 18.0 Hz), 6) beta2 (18.5 – 21.0 Hz), 7) beta3 (21.5 – 30 Hz), and 8) gamma (35 - 44 Hz).

LORETA functional imaging (Pascual-Marqui 2002; Pascual-Marqui et al. 1994) was employed for the intracortical localization of the sources of brain electric activity. The total solution space of the employed sLORETA functional imaging software (downloadable at <http://www.unizh.ch/keyinst/index/download.html>) is 6239 voxels in the cortical areas. LORETA computed current density for each voxel in the solution space. Voxel-wise statistics for the assessment of differences between conditions and participant groups was done using the sLORETA software package. LORETA functional images were computed separately for the same 3 and 8 frequency bands as for the power spectral analyses: The following option was chosen for the computations with sLORETA: ‘time frame normalized’ = normalized global strength for each frequency band for each participant. This option leads to the detection of ‘landscape’ differences (detection of differences of the spatial distribution of intracortical brain electric activity) while overall strength of this activity is disregarded. For the assessment of general topographic tendencies in comparisons of the detailed voxel-wise LORETA results between conditions and participant groups, and for ease of visualization of these dominant LORETA results, the intracerebral 3-dimensional localizations of the gravity centers of the voxels' current density values were computed for each frequency band.

RESULTS

Sample

After various group tests, 186 participants completed the HGSHS. Of these participants 62 were male (33.5%) and 123 (66.4) female. Complete data for the variables gender, age and HGSHS was available for 183 participants. The mean age of the participants was 29.16 (range = 18-66, *SD* = 11.00). For participation in EEG sessions 1 and 2, 40 participants completed individual hypnotizability testing and both EEG sessions (28 women, 12 men; 14 highs, 14 lows, 12 mediums). Because not all participants had complete datasets or analyzable EEGs, most psychological analyses were done on 14 lows, 12 mediums and 12 highs. Although noticeably most men were in the low group (n=8), there was no statistical effect for gender ($p > .05$) but there was a significant effect for age ($F(2, 34) = 5.32$, p ,$\leq .01$). Because highs ($M = 33.46$, $SD = 10.96$*) were* significantly older than mediums ($M = 25.50$, SD = 4.12; $p \leq .01$) and lows ($M = 25.07$, SD = 25.07; $p < .05$), age was entered as a covariate in most analyses. For EEG analyses, appropriate data were available for 33 participants in session 1 and 27 participants in session 2.

Self-reports of hypnotic depth

For session one, self-reports of hypnotic depths were procured after a three-minute baseline, after lifting the arm voluntarily, after the hypnotic arm levitation induction, after the deepening instruction, after a two-minutes period of "remaining in a hypnotic state," after a de-hypnosis procedure, and after lifting the arm voluntarily. Although sex and age did not have a significant effect on ratings (all main and interaction effects *ns*), age was used as a covariate in a 3 (levels of hypnotizability) x 7 (conditions) ANCOVA. Main effects were found for condition (i.e., time of rating in session: baseline, report 1, 2, etc.) and hypnotizability (high, medium, or low). For condition: ($F(6, 192) = 4.26$, $p \leq .01$, $\eta^2 = .12$), with a significant cubic trend ($F(1, 32) = 9.75$, $p = .004$, $\eta^2 = .23$). For hypnotizability: ($F(2, 32) = 5.21$, $p \leq .01$, $\eta^2 = .25$); the interaction between condition X hypnotizability was also significant ($F(12, 192) = 5.14$, $p < .001$, interaction = .24), with quadratic ($F(2, 32) = 6.37$, p = .005, $\eta^2 = .29$) and cubic ($F(2, 32) = 4.98$, p = .013, $\eta^2 = .24$) effects. Bonferroni tests showed that lows differed from highs at $p<.005$. Whereas the first two ratings (before hypnosis) had no impact on participants, hypnosis did have a pronounced effect on highs, a parallel but smaller effect on mediums, and almost no effect on lows (whose average did not raise above "feeling slightly different than normal.")

For session 2, it should be mentioned that there was no depth rating at the end of the session because the de-induction process continued until every person mentioned being around 0-3 in depth. In the depth reports for the second session there is a similar pattern to the first session. Although sex and age did not have a significant effect on ratings (all main and interaction effects *ns*), age was used as a covariate. After the Greenhouse-Geisser correction, there was only a trend for significance for condition ($F(7, 224) = 2.48$, $p = .078$, $\eta^2 = .072$.) There was a main effect for hypnotizability ($F(2, 32) = 8.31$, $p < .001$, $\eta^2 = .34$), and the interaction of condition X hypnotizability was also significant: ($F(14, 224) = 5.34$, $p < .001$, $\eta^2 = .25$), with significant linear ($F(2, 33) = 8.64$, $p < .001$, $\eta^2 = .34$) and quadratic ($F(2, 32) = 4.52$, $p < .05$, $\eta^2 = .22$) effects. Bonferroni showed that low hypnotizables differed from mediums and highs ($p \leq .01$, and $p < .005$). For mediums and especially highs, depth ratings increase for the first three hypnotic reports and then went into a plateau, whereas there was only a minor effect for the lows throughout the session.

Verbal reports of hypnotic phenomenology for session 2

For the second session, after a baseline period, there was a hypnotic induction (just counting to 30 with a suggestion to go deeper) followed by probes for hypnotic depth and experience at the end of the induction and then every five minutes for about 6 more probes for each participant. There were a total of 355 usable reports. An emergent coding approach was used following a grounded theory approach (e.g., Glaser, 1992). Two raters, one of them masked as to the participants' level of hypnotizability, independently evaluated the phenomenological reports. After reading the transcriptions, they arrived at a very similar set of categories and after eliminating some for redundancies arrived to the following list: 1) imagery/fantasy/dreaming (imagery), 2) normal attention/cognition (normal cognition), 3) vestibular body alterations/hallucinations (body), 4) environmental perceptual alterations/hallucinations (environmental), 5) enhanced cognition/exceptional-experience/positive affect (positive), 6) negative affect/discomfort (negative), 7) lethargy/relaxation/sleepiness (relaxation), 8) forgetting, and 9) loss of mental control/sudden thought (loss of control). Some of these categories are compounds (e.g., enhanced cognition/exceptional experience/positive affect) because those phenomena tended to be distinguishable conceptually but still cluster together in participants' reports. For these dimensions, the two raters also independently assessed how indicative were the dimensions for each report, where 1 = not at all, 2 = a little, 3 = somewhat, and 4 = strongly so. They also evaluated which was the main dimension for each report. A comparison of their ratings on which dimension was the primary one showed a 75% concordance. Because agreement percentage does not consider chance agreements, Cohen's (1960) κ statistic was computed. The reliability of the ratings was strong ($\kappa = .69$, $p < .001$), where $\kappa > .6$ reflects substantial agreement. Average scores were then computed from the set of report scores from individual sessions per phenomenological dimension. Six of the 9 variables violated the assumption of homogeneity of variance between hypnotizability groups, so group differences for these variables were assessed with non-parametric statistics (Kruskal-Wallis tests for main effects and Mann Whitney tests for contrasts).

The first analyses were on the average ratings for the reports. Main effects of group were found for three of the phenomenological dimensions: imagery, exceptional, and normal; each was found to account for more than 30% of the variance in hypnotizability. Mann-Whitney tests revealed that high hypnotizables experienced more imagery across the different epochs than low but not medium hypnotizables. Low hypnotizables displayed significantly greater normal cognition than medium and high hypnotizables, but the latter two did not differ. Finally, high hypnotizables experienced more positive affect and exceptional experiences than both low and medium hypnotizables, who did not differ from each other. It is worthy mentioning that the groups did not differ in reported relaxation, so the results cannot be explained as a confound of that variable.

Analyses just for the primary dimension were generally consistent with the findings above, In this case, 50% of low hypnotizable reports were primarily composed of normal cognition, and approximately 40% of medium and high hypnotizable epochs were primarily comprised of body and imagery dimensions, respectively. Main effects of group were found for imagery, normal cognition, body, and positive. The reports of high hypnotizables were more often seen as primarily reflecting exceptional experience than those of the other two hypnotizability groups High hypnotizables were more likely to experience imagery as a primary epoch dimension than low hypnotizables, but not medium hypnotizables. The reports of low hypnotizables were more likely than the other two groups to have normal as the primary phenomenological dimension, and there was a very suggestive (p=.06 with a Tukey test, p.05 with a t test) result that the reports of mediums were more often of body alterations than those of highs.

The Phenomenology of Consciousness Inventory for Session 2

A mixed 3 (low, medium, or high hypnotizability) x 2 (baseline vs. deepest hypnotic state) ANCOVA (controlling for age) using the PCI dimensions and sub-dimensions as dependent variables supports and extends the phenomenological analyses. Level of hypnotizability was associated with having an altered experience, alterations in body image, time sense, perception, enhanced meaning, changes in positive affect, joy, love, changes in self-awareness, experiencing an altered state, and changes in memory. The time of testing (baseline versus deepest state) was associated with altered experience, alterations in body image, time sense, perception, enhanced meaning, changes in positive affect, joy, negative affect, anger, fear, imagery in general and amount and vividness of imagery, changes in self-awareness, arousal, rationality, and voluntary control. Given the hypotheses of this study, interaction effects are of particular importance. They were found for having an altered experience, changes in body image and perception, enhanced meaning, changes in love, sadness, and imagery, and experiencing an altered state.

Comparing groups as a function of hypnotizability at baseline show that lows differed from the other two groups only in reporting less memory than highs. Mediums differed from highs at baseline in altered experience, body image, time, perceptual alterations, joy, self-awareness. A different pattern is found for the self-rated deepest hypnotic state. Lows differed from both mediums and highs in altered experience, body image, perception, and being in an altered state. They differed only from highs in time, enhanced meaning, positive affect, love, self-awareness, and voluntary control. Moderates differed only from highs in time alterations, positive affect, and love.

The PCI results show that although there are a few baseline phenomenological differences across levels of hypnotizability, they become more pronounced during hypnosis, thus supporting a state by trait position on hypnosis. Furthermore, in concordance with the phenomenological ratings, a deep hypnotic state is associated with experiencing an altered state and various other alterations of consciousness. It is also worth mentioning that comparisons across levels of hypnotizability in both conditions suggest that the relationship between lows, mediums, and highs is not just linear as the depth reports would suggest.

EEG frequency band spectral power in high and low hypnotizable volunteers: session 1

EEG frequency band power computed in four types of analyses across all available recording channels was tested for differences between high and low hypnotizables in the four experimental conditions of baseline, combined arm1+2 (willful arm raising), HypArm (hypnotic arm levitation), and hypnosis proper. No power difference was observed between high and low hypnotizable volunteers during hypnosis, whereas during the other conditions, various indications for differences between the two groups were detected. The results found are quite consistent across the four types of power spectra and three of the experimental conditions, excepting the hypnosis condition. Table 1 concentrates on the differences between high and low hypnotizable volunteers. The data in Table 1 show that larger power in highs than lows occurred consistently in the EEG frequencies above 12.5 Hz in both relative (normalized) power spectra during baseline, willful arm lifting and hypnotic arm elevation (not during hypnosis). Also evident is that 12 of the 13 differences of interest in the delta, theta, alpha-1 and alpha-2 frequency bands showed less power for highs than lows. In particular, less power for highs than lows was seen during baseline in alpha-1 and during HypArm in alpha-2. These differences between groups disappeared in the hypnosis condition. This suggests that hypnosis installs a brain functional state that is no different in highs and lows in terms of EEG frequency band-wise global power spectra.

EEG frequency band power comparing high versus low hypnotizable participants during hypnosis in Session 2

During the hypnosis 1 condition of session 2, there were no differences of power values between the 9 highs and the 11 lows in any of the 8 frequency bands in any of the four types of spectra computations at two tail $p<0.10$. This confirmed the previous reported observation in session 1 that EEG band power differences between highs and lows that had been observed during the conditions of baseline, willful arm lifting and hypnotic arm levitation disappeared in the hypnosis condition.

Correlations between EEG frequency band power and subjective depth of hypnosis in high and low hypnotizable volunteers: Session 1

The ratings of experienced depth of hypnosis during the 'hypnosis' condition were correlated with power spectral results of the multichannel EEG data that were recorded during this condition. The results showed that for the entire cohort, the experience of deeper hypnosis was associated with decreased power in the delta, theta and alpha-1 frequency range, and with increased power in the beta and gamma frequency ranges. However, there was a tendency to opposite behavior for highs and lows, making the general observation for the entire group somewhat irrelevant.

differences Hi minus Lo								Session 1	N=10,11
HZ band #	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	
	mean raw								
base		***-7.73***							
arm12		***-5.28***							
Hypar				***-17***					
hypno									
	mean norm								
base			***-0.09***					0.01	
arm12						0.01	0.02	0.01	
Hypar	0.062			***-0.08***		0.01			
hypno									
	GFP raw								
base	***-1.19***		***-1.3***						
arm12									
Hypar	***-0.93***	***-0.23***		***-0.46***					
hypno									
	GFP norm								
base			***-0.06***		0.02	0.01	0.03	0.01	
arm12					0.02	0.01	0.03		
Hypar				***-0.02***	0.02	0.01	0.03		
hypno									

Table 1. Differences of EEG frequency band spectral power between highs and lows, for the four types of spectra, for the eight frequency bands and for the four recording conditions (baseline, arm1+2, HypArm, and hypnosis), for comparisons where the corresponding t-test yielded $p<0.2$. Underlined and italics are difference values where highs showed less power than lows; regular font are difference values where highs showed more power than lows.

When comparing the results between highs and lows, it is noteworthy that 9 of the 12 correlations in the analysis for three frequency bands, and 22 of the 32 correlations in the eight-band analyses showed correlations of opposite sign for highs and lows. Although this mean tendency appears interesting, only two of these pairs of opposing correlation coefficients differed at $p=0.1$. On the other hand, such opposing signs of the correlations were not observed in the analysis of the data of the hypnosis condition S1 of session 2 where deeper hypnosis was associated with higher power in high frequencies as in session 1, but without differences between highs and lows.

Correlations between EEG frequency band power and subjective depth of hypnosis in highs and lows: Session 2

A correlational analysis showed that deeper subjective depth of hypnosis was associated with increased power in EEG beta-2, beta-3 and gamma frequencies. These obvious tendencies for all 27 participants were quite similar in the sub-groups of high and low hypnotizables, although less significant as to be expected because of the smaller Ns. Further, the closer examination of the coefficients showed that negative correlations occurred for slower EEG frequencies, i.e. for the alpha-1, theta and delta frequencies, but none of these correlations reached the level of $p<0.1$.

These results confirm the observation in the hypnosis condition of session 1 where likewise, deeper hypnosis correlated with higher power in fast frequencies. On the other hand, these session 2 data did not confirm the observation of session 1 where opposing signs of the correlations were seen for highs and lows (although there was limited statistical underpinning for this observation in session 1, the trend seemed obvious).

Correlation of spectral power values with the contents of the volunteers' oral reports of their experiences in session 2

In session 2, participants reported their experiences with brief oral comments that were other-rated for various characteristics. The EEG power spectral analysis results were correlated with the experience reports on the scales A and B (A= imagery/fantasy/dreaming, B = normal attention/cognition; see table below). Table 2 shows the results for the 27 volunteers. With increasing rating values on scale A, the various analyses indicated increase of relative EEG power in delta (1.5-6 Hz), decrease of relative power in alpha-1 (8.5-10 Hz), and increase of relative power in beta-3 (21-30 Hz) and gamma (35-44 Hz). On the other hand, the rating values on scale B showed very little effect relative to the EEG frequency band power measurements.

Sess2 cond S-1		band1	band2	band3	band4	band5	band6	band7	band8	0	N=27
Linked		**Pearson correlations log power with other rating scale A**									
raw mean	A	.01	-.24	-.31	-.22	-.10	-.23	-.12	.10		
norm mean	A	***.34***	-.13	***-.39***	-.14	.18	-.01	.17	***.31***		
raw GFP	A	-.26	-.31	***-.38***	-.28	-.29	-.25	-.10	.06		
norm GFP	A	.22	-.16	***-.45***	-.13	-.09	.11	***.37***	***.40***		
		Pearson correlations log power with other rating scale B									
raw mean	B	.06	.06	.04	-.15	.02	.07	.12	.02		
norm mean	B	.00	.04	.04	***-.30***	-.03	.06	.09	-.03		
raw GFP	B	.08	.17	.16	.03	.13	.14	.09	-.04		
norm GFP	B	-.10	.27	.22	-.09	.10	.08	-.05	-.15		
								.3233	= r for p=0.1 N=27		
								.3808	= r for p=0.05 N=27		

Table 2. Pearson Correlation r-values between EEG frequency band power (4 types of values) and other-rating scores on scales A (imagery/fantasy/dreaming) and B (normal attention/cognition) during the hypnosis 1 condition of session 2 for 27 volunteers (9 highs, 7 mediums, 11 Lows). Significant differences are underlined.

However, when these correlations were computed separately for high and low hypnotizables, very different results emerged, For scale A, for high hypnotizables, none of the correlations reached $p<0.10$, but 12 of the 32 correlations for low hypnotizables were negative at $p<0.10$ (8 of them at $p<0.05$), indicative that higher rating scores were associated with lower EEG power in the frequency bands between 6.5 and 30 Hz, i.e,. from the theta to the beta-3 band. In one of the 4 power analysis types (normalized relative GFP power), delta band power correlated positively with scale A scores at $p=0.007$. For scale B, only three correlations reached $p<0.1$, all three concerning high hypnotizables who showed decreased beta-3 and gamma band power with higher ratings for normal attention / cognition.

When statistically comparing the obtained correlations of ratings-to-EEG-power between high and low hypnotizables, differences between the two groups were clearly observed. The significance of the differences between corresponding correlation coefficients of the two subject groups was determined, and if $p<0.2$. Patently, the statistics substantiated the description of the obtained correlations in the top four panels. Highs and Lows tended to have different correlations, Highs showing higher coefficients than Lows for faster EEG frequencies in scale A correlations (lower correlation for delta frequencies), and Highs showing lower coefficients than Low's for faster EEG frequencies in scale B correlations. The difference in correlations when comparing the groups was clear in that of the 21 correlations at $p<0.2$, 18 were of opposite sign, that is, they were positive in highs, negative correlations in lows, and vice versa.

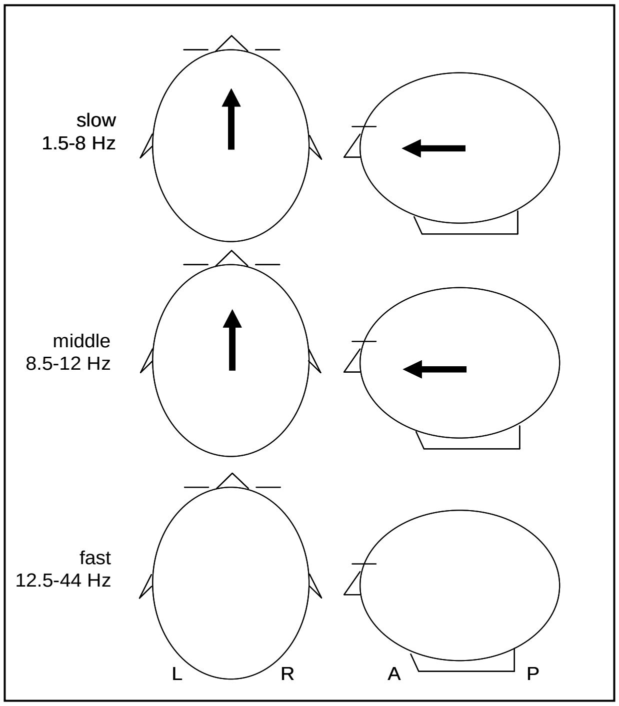

Fig. 1. Direction of differences of the locations of sLORETA current density gravity centers between the 11 low hypnotizables (origin) versus the 10 high hypnotizables (arrowhead) for the sources of the three major EEG frequency bands (slow, middle and fast frequencies). Data were recorded during the 'resting' condition of session 1. - Solid arrows = direction of change of the gravity center location at $p<0.10$.

Intracortical localization of brain electric activity in high and low hypnotizables using LORETA functional tomography

EEG data during the resting condition of Session 1 were compared between highs and lows using frequency-band wise LORETA functional tomography. The overall main tendency of the differences in localizations of EEG frequency band-wise activity between the highs and lows are illustrated in Fig. 1, which shows the results of source gravity center assessment of the LORETA images: Measured in the three major EEG frequency bands, high hypnotizables compared to lows showed a generally more anterior localization of the sources of EEG slow and middle frequency sources at $p<0.10$.

The assessment in Fig. 1 reflects the general tendency of the LORETA functional images that represent the differences of the detailed, voxel-wise computed cortical current density between the two groups as shown in Fig. 2. In Fig. 2, the anterior brain area predominance of the red-colored voxels that represent larger current density in high hypnotizables (at $p<0.05$) is obvious in the slow and middle frequency band.

Table 3 shows that the LORETA gravity center of low hypnotizables moved to more *anterior* from rest to hypnosis ($p=0.100$), but that of high hypnotizables moved slightly to more *posterior* ($p=0.18$), with the difference of this difference reaching $p=0.066$. For the middle frequency band, the gravity centers of both groups moved more anterior without a statistical significance between groups. This difference cannot, conclusively elucidate the brain electric differences between waking and hypnosis because the two experimental conditions of resting and hypnosis were successive in session 1 and there was no resting condition following the hypnosis condition so that effects of passing time cannot be checked.

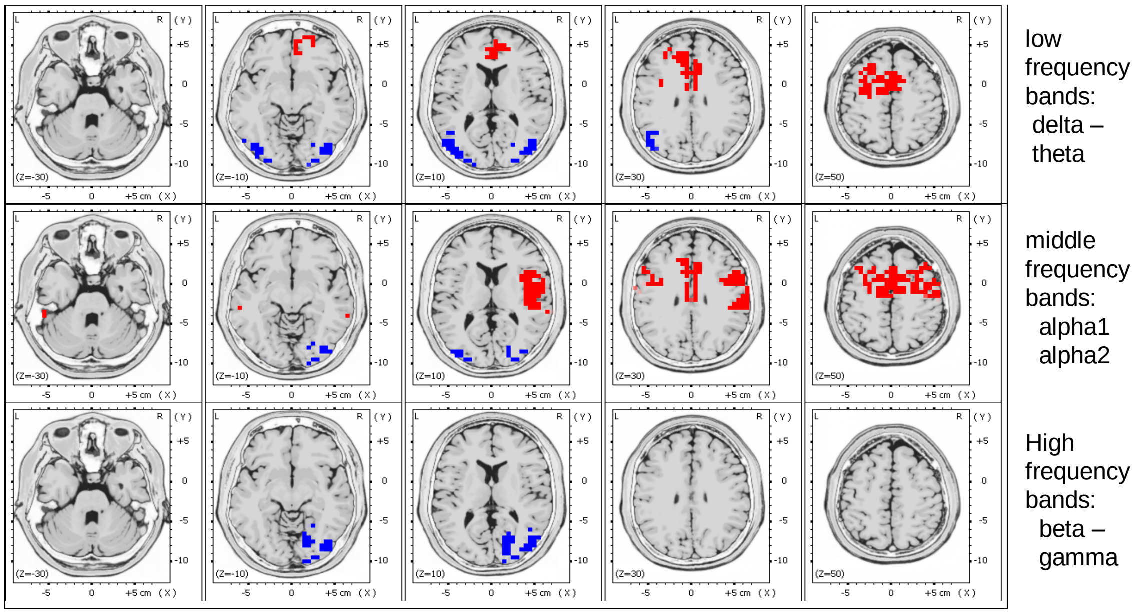

Fig. 2. Difference of EEG intracortical current density (sLORETA) between highs and lows during resting. Illustrated are axial slices through sLORETA images (total solution space is 6239 voxels in the cortical areas) at (left to right) z-levels (inferior to superior axis) of -30, -10, +10, +30, +50 mm. Shaded coded are voxels where unpaired t-test p-values (not corrected for multiple testing) reached $p<=0.05$.

In fact, the differences between normal arm raising and hypnotic arm levitation go in the opposite direction: in the hypnotic arm levitation condition compared to normal arm raising, the results of all 33 volunteers showed a posteriorization of the LORETA gravity center for slow frequencies. For comparison with the results of highs and lows, Table 4 shows the results obtained with all 33 participants; the anteriorization of the LORETA gravity centers during hypnosis yielded $p=0.004$ for the middle frequency band sources, whereas the anteriorization of the slow frequency band gravity centers was not significant.

Table 5 presents the complete gravity center localization results for all 33 volunteers (which include the results of Table 4). Evidently, slow and fast frequency gravity centers were significantly more to the left in the hypnosis than in the rest condition. This is reminiscent of the left-shift of the LORETA gravity centers of slow and fast frequencies in the comparison between willful arm raising and hypnotic arm levitation. On the other hand, the anterior-posterior tendencies of location changes in Table 5 are opposite to those observed in the non-hypnotic and hypnotic arm conditions.

The left-shift in the two hypnotic conditions is intriguing, conceivably indicating a predominance of left-hemispheric processing, of attentional control activity in hypnosis. But, as already noted above, the comparison of the results between rest and hypnosis is limited because there are no rest condition data after hypnosis to check for time effects.

Hz Band:	**Slow**	**Middle**
<u>*Low Hypnotizables N=11*</u>		
mean in Hypnosis	-20.28	-37.98
mean in Rest	-22.23	-39.31
Difference Hypnosis minus Rest		
	1.95	1.33
t-test p	**0.100**	**0.085**
Hypnosis was more	anterior	anterior
<u>*High Hypnotizables N=10*</u>		
mean in Hypnosis	-18.67	-32.61
mean in Rest	-18.21	-33.56
Difference Hypnosis minus Rest		
	-0.46	0.94
t-Test p =	**0.18**	**0.113**
Hypnosis was more	<u>*posterior*</u>	anterior
<u>*High versus Low Hypnotizables*</u>		
Differences of differences:		
Highs (Hypnosis minus Rest)		
minus / versus		
Lows (Hypnosis minus Rest)		
mean	-2.41	-0.39
t-Test p =	**0.066**	**0.73**

Table 3. Mean LORETA gravity center localizations of lows and highs on the posterior-to-anterior brain axis for slow and middle EEG frequency bands, in 'resting' and 'hypnosis' of session 1.

Hz Band:	**Slow**	**Middle**
<u>*All volunteers N=33*</u>		
mean in Hypnosis	-20.07	-35.36
mean in Rest	-20.70	-36.59
Difference Hypnosis minus Rest		
	0.64	1.22
t-test p	**0.20**	**0.004**
Hypnosis was more	anterior	anterior

Table 4. Mean LORETA gravity center localizations on the posterior-to-anterior brain axis for slow and middle EEG frequency bands, in 'resting' and 'hypnosis' of session 1.

All 33 subjects	Slow Frequency Band			Middle Frequency Band			Fast Frequency Band		
	L to R	P to A	I to S	L to R	P to A	I to S	L to R	P to A	I to S
mean location: Hypnosis	0.38	-20.07	17.65	0.91	-35.36	18.85	-0.45	-20.23	14.78
mean location: Rest	0.80	-20.70	17.30	0.95	-36.59	19.40	0.70	-19.83	14.39
Diff. location: hypnosis minus rest	-0.42	0.64	0.35	-0.04	1.22	-0.55	-1.15	-0.40	0.38
t-test hypnosis vs rest p=	0.04	0.20	0.14	0.77	0.004	0.01	0.02	0.67	0.23
Change from rest to hypnosis was to	Left	Ant.	Sup.	Left	Ant.	Inf.	Left	Post.	Sup.

Table 5. Mean LORETA gravity center localizations on the three brain axis, for the three EEG frequency bands in 'resting' and 'hypnosis' of session 1. Significant or suggestive differences are underlined.

DISCUSSION

Analyses using both quantitative and qualitative measures, in the context of a minimal suggestion ("neutral" suggestion) design shows conclusively that according to their previously assessed level of hypnotizability, individuals experience hypnosis in very different ways. Especially contrasting the two more extreme groups (highs and lows), it is clear that the former experienced an increasingly deeper level of hypnosis during the session, whereas the latter had almost no change. When looking specifically at what phenomena may explain this self-rating of depth, it seems clear that whereas "lows" mostly continue experiencing "normal" mentation, "highs" have noticeable alterations, especially of experiences of positive affect and exceptional phenomena. The "medium" hypnotizable seemed to mostly experience somatic changes, in concordance with previous work suggestion that a low to medium" hypnotic state" is characterized by body image alterations (Cardeña, 2005). Although the EEG results cannot be easily summarized, they show that brain processes differ across levels of hypnotizability and task In general, power in higher frequencies seem to be positively correlated with hypnotizability, and the hypnotic procedure seems to have opposite effects (e.g., different valence in correlations) for highs than for lows. The results, which suggest concordance of sensitive phenomenological and EEG measures recommend a neurophenomenology of specific consciousness alterations, rather than using imprecise terms such as "hypnotized." At this point, we hypothesize that the greater unitive experience of highs in "deep" hypnosis is more likely to be conducive to psi phenomena, which also support a more interconnected (entangled?) description of reality.

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