Neuroscience Letters 557 (2013) 184–187

Contents lists available at ScienceDirect

Neuroscience Letters

journal homepage: www.elsevier.com/locate/neulet

Plenary article

Pain-inducing imagery as a function of hypnotisability and of the activity of Gray's Behavioral Inhibition/Activation Systems

Enrica L. Santarcangelo[a,*], Maurizio Varanini[b], Giulia Paoletti[a], Eleonora Castellani[a], Carlo Palombo[c], Giancarlo Carli[d]

[a] Department of Translational Research and New Technologies in Medicine and Surgery, University of Pisa, Italy
[b] Institute of Clinical Physiology, National Council of Research, Pisa, Italy
[c] Department of Surgery, University of Pisa, Italy
[d] Department of Medicine, Surgery and Neuroscience, University of Siena, Italy

ARTICLE INFO

Keywords:
Pain
Imagery
Hypnotisability
BIS BAS
Heart rate
Skin conductance

ABSTRACT

The aim of the study was to test the efficacy of pain imagery as a function of hypnotisability and of the activity of Behavioral Inhibition/Activation Systems. Questionnaires of imagery abilities (Betts) for the visual, cutaneous and organic modalities, absorption in cognitive tasks (TAS), proneness to inhibit stressful/painful experience/seek out positive experiences (BIS BAS), trait anxiety (STAI-Y2) and psychological well-being (PWB) were administered to 21 subjects with high hypnotisability (*highs*) and 21 subjects with low hypnotisability (*lows*). Self-reports of pain intensity and of neutral tactile perception were collected during imagery of nociceptive (Pain) and neutral tactile stimulation (NT). ECG and skin conductance were recorded. *Highs* exhibited greater imagery abilities, absorption, Behavioral Inhibition System Activity and psychological well-being with respect to *lows*. They reported lower scores of pain intensity than of tactile perception, while in *lows* Pain and NT scores did not differ. However, controlling for BAS, but not for BIS, revealed differences in the efficacy of pain imagery between *highs* and *lows*. Heart rate decreased in both tasks and groups; heart rate variability and skin conductance did not change significantly during imageries. Our findings suggest that the Behavioral Inhibition/Activation Systems interact with imagery abilities reducing the efficacy of pain imagery and prompt investigation of possible similar interactions in the modulation of physically induced experimental pain and of chronic pain in the general population.

1. Introduction

Hypnotisability is a cognitive multidimensional trait measured by scales and associated with proneness to accept suggestions in and out of hypnosis [14]. The ability to imagine is one of its main factors and is characterized by several properties – vividness, absorption, fantasy proneness embodiment depth – variably involved in subjects and tasks [9,13,16,18,19,22].

The High Risk Model of Threat Perception (HRMTP) states that the greater prevalence of subjects with high hypnotisability (*highs*) among patients suffering from chronic pain depends on the *highs*' peculiar imagery abilities which promote the shift from acute to chronic pain by allowing them to re-experience pain vividly, repeatedly, and associated with congruent autonomic activation [4,15,25,26]. Indeed, in highly hypnotisable chronic pain patients, pain intensity can be decreased and increased by both hypnotic and non-hypnotic suggestions [6] and in healthy *highs* pain imagery induces pain perception under hypnosis [7].

In contrast, the results obtained in healthy *highs* out of hypnosis are not univocal and challenge the HRMTP theory. For instance, during imagery of leg injury *highs* perceived medium-to-high pain intensity and exhibited postural adjustments similar to those induced by the corresponding real leg lesions [19], whereas during imagery/memory of previously experienced pressor pain they reported quite low pain intensity [17]. Discrepancies could be accounted for by various factors such as the higher imaginative content of the script for the imagery of leg pain, and/or by the difficulty to recall pressor pain on the thorax – which is a very unfamiliar experience – as well as by the fact that the *highs* who had previously experienced pressor pain may have not performed the imagery task at their best because, consciously or unconsciously, they tried to avoid pain. This may occur, in particular, in the presence of high responsiveness to impending potentially stressful/painful situations, a trait related to the activity of the Behavioral Inhibition

* Corresponding author. Tel.: +39 050 2213465; fax: +39 050 2213527.
E-mail address: enricals@dfb.unipi.it (E.L. Santarcangelo).

0304-3940/$ – see front matter © 2013 Elsevier Ireland Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.neulet.2013.06.049

System (BIS), which is based in septo-hippocampus networks receiving information from the prefrontal cortex and projecting to the *locus coeruleus* and to the nuclei of the median *raphe* [10–13].

According to Gray [10–12], the BIS is sensitive to signals of punishment/non-reward and is involved in the negative feelings induced by these cues, although the subjects with high BIS sensitivity may learn how to avoid provoking situations, which results in less negative subjective experiences [8]. In contrast, the Behavioral Activation System, based in the septal area and the lateral hypothalamus, is associated with high levels of dopamine and is sensitive to potential rewards, thus to motivation to seek out positive experiences [11,12].

In the present study we investigated the subjective experience and the autonomic correlates of pain imagery as a function of hypnotisability and of the responsiveness to impending pain and the motivation to positive experiences compared to the subjective and physiological correlates of a neutral tactile imagery.

2. Methods

2.1. Subjects

The experimental protocol was approved by the Ethics Committee of the University of Pisa. After signing an informed consent following the rules of the Declaration of Helsinki, 42 healthy subjects (age, mean ± SD: 20.1 ± 1.4 yrs) divided in high (*highs*, $n = 21$, score ≥ 9/12, 9 females) and low hypnotisables (*lows*, $n = 21$, score ≤ 3/12, 8 females) through the Italian version of the Stanford Hypnotic Susceptibility Scale, form C [5] volunteered in the study. They received questionnaires (to complete at home) concerning trait anxiety (STAI-Y2, State-Trait Anxiety Scale), the ability of absorption in cognitive tasks (TAS, Tellegen Absorption Scale), the ability of imagery in the visual, cutaneous and organic sensory modalities (Betts Questionnaire), the strategies of the response to impending reward and punishment/seeking positive experiences (BIS/BAS_{tot} Scales), and psychological well-being (PWB). One month later they underwent cold pressor test (CPT) to condition their response to the impending imagery-induced pain experience by triggering the activity of the Behavioral Inhibition System [10–12]. No conditioning tactile stimulation was administered to prevent any influence on the subjects' ability to imagine non-nociceptive sensations. Thirty subjects out of 40 participants completed questionnaires.

2.2. Experimental procedure

The experimental sessions were carried out between 2.00 and 4.00 p.m., at least 4 h after the latest light meal and 6 h after the latest caffeine containing beverages, in a semi-darkened, sound-attenuated and temperature-controlled room (20–25 °C). Females were tested during the second week after their last menses. Electrocardiogram (ECG) was recorded after eye closure (sitting position) during resting conditions (basal: b_{Pain}, b_{NT}) lasting 5 min each, preceding imagery tasks (pain-inducing imagery of CPT (Pain); imagery of neutral tactile stimulation of the hand (NT), randomly administered and lasting 2 min each).

The script for Pain imagery guided subjects to imagine to perceive "*the sensation of having the left hand immersed in icy water... with more and more intense pain... it propagates to the wrist... very cold... unpleasant... The script for NT described "having the left hand being caressed... softly touched by smooth fabrics... pure silk... soft velvet... what a delicate sensation...*". The two scripts were balanced for number of names/adjectives/verbs and pauses. The subjects had to score the intensity of the perceived pain and of the tactile sensation (range: 0–10).

2.3. Data acquisition and analysis

Skin conductance (SC) was recorded continuously via 8 mm Ag/AgCl electrodes placed on the thenar eminence of the right hand. SC signals (sampling frequency 500 Hz) were digitized using the PSYLAB SC5 24 bit coupler (Contact Precision Instruments). The series of its mean values was computed by averaging consecutive 20 s intervals after discarding the 5% of the lowest and highest values (trimmed averaging). Values are expressed in microSiemens (μS). For ECG recording 3M Red Dot Ag/AgCl disposable electrodes were placed according to the standard DI lead. ECG was amplified by a LACE-Elettronica System amplifier (Pisa, Italy), QRS complexes were detected and artifacts/abnormal beats were discarded. The distances between consecutive R waves of the ECG (RR distance = 1/heart rate, ms), the RR-series Standard Deviation (SD) and *Root Mean Square Successive Differences* (RMSSD) were computed.

2.4. Statistical analysis

Hypnotisability and gender were *between* subjects factors. TAS and STAI scores and the PWB index were analyzed through univariate ANOVAs, BIS BAS, Betts scales (visual, cutaneous, org) and self-reports (pain intensity, tactile intensity) through multivariate ANOVAs. Moreover, ANCOVA was applied to self-reports controlling for the scores of each questionnaire, separately (in the reduced number of subjects who completed questionnaires).

RR, SD, RMSSD and SC were analyzed through repeated measures ANOVA with Imagery (Pain, NT) and Condition (basal, task) as *within* subjects factors. ANCOVA was applied to the changes in the autonomic variables (Δ_{Pain} = (pain imagery − basal) values; Δ_{NT} = (tactile imagery − basal) values) with self-reports and questionnaires scores as covariates. The Greenhouse–Geisser ε correction was applied when appropriate. Significance was set at $p < 0.05$.

3. Results

3.1. Questionnaires

Highs exhibited significantly lower scores (thus, greater abilities) than *lows* at visual, cutaneous and organic imagery (Table 1), higher scores of absorption, activity of the Behavioral Inhibition System and Well-Being. STAI and BAS_{tot} scores were similar in the two groups (Table 1). No significant gender difference/interaction was found.

3.2. Intensity of perception

A significant imagery × hypnotisability interaction ($F(1,35) = 17.581$, $p < 0.0001$) revealed that there was no significant difference in pain perception between *highs* and *low* (Fig. 1A), while the *lows*' intensity of tactile perception was significantly lower that the *highs*' one ($F(1,37) = 35.867$, $p < 0.001$). Indeed, *highs*' reported lower pain than tactile intensity of perception ($F(1,20) = 5.017$, $p < 0.0001$), while *lows* gave the same scores to both imageries (Fig. 1A).

In the reduced number of subjects who completed questionnaires, multivariate analysis of self reports performed controlling for BIS and $BETTS_{org}$ did not reveal significant differences between *highs* and *lows* in Pain, and confirmed the differences in NT ($df = 28$); BIS, $F = 15.496$, $p \leq 0.001$; $Betts_{org}$ ($F = 7.366$, $p \leq 0.012$). Controlling for TAS confirmed, in trend, a difference between *highs* and *lows* only for NT ($F = 4.210$, $p = 0.060$). In contrast, controlling for $Betts_{visual}$ and BAS_{tot} revealed significantly higher scores of imagery in *highs* for both Pain ($Betts_{visual}$, $F = 6.938$, $p \leq 0.015$; BAS_{tot}, $F = 4.019$, $p = \mathbf{0.052}$) and NT ($Betts_{visual}$, $F = 5.723$, $p \leq 0.025$; BAS_{tot},