High wellbeing in highly hypnotizable persons

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Introduction

"Wellbeing" indicates how individuals experience and evaluate their lives. The experience of wellbeing is defined as "hedonic well-being" and refers to the frequency and intensity of pleasant/positive emotional experiences, while the evaluation of the meaningfulness, sense of purpose and general satisfaction with life is defined as "eudaimonic well-being" (Steptoe, Deaton, & Stone, 2015). Both aspects are influenced by several life events and situations including physical, emotional, relational, economic conditions, so that the subjective wellbeing results from interactions between objective conditions and the individual reactions to them (McDowell, 2010). The bio-psycho-social model of wellbeing proposes, in fact, that both social and biological factors influence physical health and that the relationship between them is mediated by psychological characteristics (Karunamuni, Imayama, & Goonetilleke, 2020).

The multidimensional nature of psychological wellbeing may have induced inconsistent findings of gender differences. Among healthy adults, in fact, higher values of the Psychological General Wellbeing Index (PGWBI) have been reported in males than in females (Taylor et al., 2017), and job stress has a greater negative effect on mental wellbeing in females than in males (Mensah, 2021), whereas the psychological wellbeing related to expectations in romantic relations has been found higher in females than in males (Cheema & Malik, 2021). In contrast, no significant differences in wellbeing have been observed between females and males among caregivers after the first SARS-CoV-2 Pandemic (Douglas et al., 2021).

Low wellbeing is often associated with several diseases (Misurya, Misuraya, & Dutta, 2020; Hossain, et al., 2020; Maggio et al., 2020; D'Cunha et al., 2019), although high psychological wellbeing has been found in a few fibromyalgic patients with long duration, high intensity and large extension of chronic muskulo-skeletal pain (Huber, Suman, Biasi, & Carli, 2008). High wellbeing is associated with psychological and physiological advantages ranging from better cardiovascular prognosis (Boehm & Kubzansky, 2012; Kubzansky et al., 2018) to more efficient immune system

(Lasselin, Alvarez-Salas, & Grigoleit, 2016), healthy aging (Steptoe, Deaton, & Stone, 2015) and better overall mental health (Yüksel & Bahadir-Yilmaz, 2019).

Inhibition/Approach System and Wellbeing

Emotions contribute to wellbeing (Steptoe, Deaton, & Stone, 2015) in that a strong tendency to approach appetitive stimuli – that is pleasant events/conditions characterized by motivational salience - produces positive affect, whereas the tendency to inhibitory behaviours leading to withdrawal from unpleasant conditions is often associated with negative affect (Bradburn, 1969; Singh & Mishra 2011; Merchán-Clavellino, Alameda-Bailén, Zavas Garcia, & Guil, 2019). These opposite emotional traits – behavioral approach and withdrawal - are conceptualized by the Reinforcement Sensitivity Theory (RST) which states that emotions are intense experiences associated with withdrawing from unpleasant conditions (Behavioral Inhibition System, BIS) (Gray, 1970; 1981; 1987a) or with approaching pleasant situations (Behavioral Approach System, BAS). BIS is conceptualized as an attentional system sensitive to cues of punishment, non reward and novelty. It is related to the activity of the septo-hippocampal monoaminergic system, is associated with negative affect and anxiety (Gray, 1987b; Corr, 2004; De Pascalis, Cozzuto, Caprara, & Alessandri, 2013), is activated by goal conflicts, monitors possible unfavourable events and promotes withdrawal from them (Konorski, 1967; Lang, Bradley, & Cuthbert, 1992). BAS is activated by appetitive stimuli - that is pleasant events/conditions characterized by motivational salience - and mediates the emotion of anticipatory pleasure, is associated with dopaminergic activities in the dorsal (caudate and putamen) and ventral striatum (nucleus accumbens), promotes optimistic feelings and induces behaviours aimed to obtain desired goals and to experience positive emotions. High BAS scores, however, may be found in people with reduced inhibitory control and increased response impulsivity (Corr, 2004; Corr & Cooper, 2016). The third system described by the RST mediates fear and is activated by threatening stimuli that can be avoided without directly facing them (Fight–Flight–Freeze System, FFFS).

The BIS and BAS can either be activated independently from each other (Pickering, 1997) or contribute to psychological functioning in different ways. For example, BAS activation co-operates with high BIS in worsening the psychological functioning in individuals with chronic muskuloskeletal pain (Serrano-Ibáñez et al., 2018).

A positive relationship between the BAS Reward Reactivity (Gray, 1970; 1981; 1987a) and psychological well-being has been reported (Tabitiz, Pedersen, & Larson, 2015). Since the Reward Reactivity has a pre-eminent role in the resilience from maladaptive psychological functioning it seems to be the best trait responsible for high wellbeing in both healthy individuals and patients

Hypnotizability and the Inhibition/Approach System

Hypnotizability is a psychophysiological trait that has been measured by various scales and is characterized by several correlates in the cardiovascular, sensorimotor, and cognitive-emotional domains (Santarcangelo & Scattina, 2019; Kirenskaya, Novototsky-Vlasov, Chistyakov, & Zvonikov, 2011; Facco, Testoni, Ronconi, Casiglia, Zanette, & Spiegel, 2017). With respect to low hypnotizable individuals (lows), high hypnotizables (highs) exhibit characteristics predicting better cardiovascular function and outcomes of neuro-rehabilitation training. In the cardiovascular domain, in fact, highs display higher parasympathetic tone during relaxation (Santarcangelo et al., 2012), and their post occlusion artery flow mediated dilation (FMD) is not reduced by mental stress (Jambrik, Santarcangelo, Ghelarducci, Picano, & Sebastiani, 2004) and minimally impaired by nociceptive stimulation (Jambrik et al., 2005). Both high parasympathetic control of heart rate and better FMD are reliable prognostic factor for cardiovascular heath (Königstein et al., 2021; Thayer, Yamamoto, & Brosschot, 2010). In the sensorimotor/cognitive field, highs show stronger functional equivalence between imagery and perception (Ibanez-Marcelo, Campioni, Phinyomark, Petri, & Santarcangelo, 2019) and greater excitability of the motor cortex (Spina, Chisari, & Santarcangelo, 2020) than lows, which predicts better outcomes of imagery training for neurorehabilitation (Mizuguchi & Kanosue, 2017). In the emotional domain, highs display greater emotional contagion (Cardeña, Terhune, Lööf, & Buratti, 2009), emotional intensity during imagery, vividness of pain imagery, empathy (Kirenskaya, Novototsky-Vlasov, Chistyakov, & Zvonikov, 2011; Facco, Testoni, Ronconi, Casiglia, Zanette, & Spiegel, 2017; Picerni et al., 2019), and response impulsivity (Zhang et al., 2017). Moreover, highs display BAS scores higher than lows and medium hypnotizable participants (mediums), and BIS scores similar to lows, with both highs'and lows' values lower than mediums' (Diolaiuti, Huber, Ciaramella, Santarcangelo, & Sebastiani 2019). Gender differences have also been observed in the emotional characteristics of individuals with different hypnotizability level. Among highs, in fact, only females report greater complaints for somatic symtoms (Younger et al., 2009). In addition, the unselfish/self-sacrificing personality style is the best preditor of high hypnotizability only among males, while low males are more assertive than low females (Burkhard et al., 2014). Compared to highs, low males are more assertive, while compared to low females they are less loyal/dependent and display less secure attachment.

Aim of the study

The Psychological General Wellbeing has not been studied as a function of hypnotizability. Based on the relevance of BIS and BAS Reward Reactivity levels to wellbeing (Bradburn, 1969; Singh & Mishra 2011; Merchán-Clavellino, Alameda-Bailén, Zayas García, & Guil, 2019) and on the hypnotizability-related differences in BIS/BAS characteristics (Diolaiuti et al., 2019), the present study was aimed at assessing whether hypnotizability level is positively associated with psychological general wellbeing and whether the association is moderated by BIS and BAS Reward Reactivity. Since gender influences wellbeing (Taylor et al., 2017) and a few emotional hypnotizability-related characteristics (Younger et al., 2009; Burkhard et al.,2014), as a secondary aim we studied the relationship of gender with the Psychological General Wellbeing in highs, mediums and lows.

We hypothesize that high hypnotizability is associated with high wellbeing and that their association can be moderated by BIS/BAS emotional traits.

Methods

Subjects

Two hundred eighty-four healthy volunteers recruited among the students of the University of Pisa agreed to participate in the study and to undergo hypnotic assessment through the Italian version of the Stanford hypnotic Susceptibility Scale, form A (SHSS, A) (Weitzenhoffer & Hilgard, 1959), after signing an informed consent form approved by the Bioethics Committee of the University of Pisa (n.4/2019). SHSS, A is a behavioural scale for hypnotic assessment consisting of 12 items exploring motor inhibition, dissociation, and hallucination abilities. Each item can be passed (score = 1) or not passed (score = 0) so that the total score ranges from 0 to 12. Lows display scores $\leq$ 4, highs exhibit scores $\geq$ 8, and mediums obtain scores between 5 and 7, representing 70% of the general population (De Pascalis, Bellusci, & Russo, 2000). Consecutive persons with low (lows, N=53, 35 females, age (mean+sd): 24.01$\pm$4.1), medium (mediums, N=41, 18 females, age 23.6$\pm$3.6) and high hypnotizability scores (highs, N=31, 15 females, age: 23.8$\pm$3.05 were enrolled in the study. They completed a questionnaire for the assessment of the general psychological wellbeing (Psychological General Wellbeing Index, PGWBI) (Dupuy et al., 1984) and a questionnaire for the assessment of BIS/BAS related emotional characteristics (Reinforced Sensitivity Theory of Personality Questionnaire, RST-PQ) (Corr & Matthews, 2009). Data were anonymized and stored for successive analyses.

Measures

The Italian version of the Psychological General Wellbeing Index (PGWBI) (Grossi et al., 2006) was used. PGWBI (Dupuy, 1984) measures psychological and physical wellbeing and consists of 22 items exploring anxiety, depression, positivity and wellbeing, self-control, health and vitality that were experienced in the latest 4 weeks. Each item is scored on a scale from 0 (min) to 5 (max).

In line with the bio-psyco-social model of wellbeing, the PGWBI total score (Dupuy, 1984; Naughton & Wiklund, 1993; Chassany Dimenäs, Dubois, Wu, & Dupuy 2004) was used for analysis.

The Italian version (De Pascalis & Scacchia, 2019) of the Reinforced Sensitivity Theory of Personality Questionnaire (RST-PQ) (Corr & Cooper, 2016) was used. It explores BIS/BAS traits (Gray, 1990) in three areas: BAS (consisting of Reward Interest, Reward Reactivity, Goal Drive Persistence, and Impulsivity), Fight-Flight-Freeze System (FFFS) quantifying the behavioural responses to fear, and BIS (monitoring conflicts and possible unpleasantness and resolving goal conflicts between systems). There are 84 items scored on a scale from 0 to 4.

Statistical analysis

After data distribution normality assessment, as a preliminary analysis Pearson (r, for gaussian distributions) or Spearman (ρ, for non-gaussian distributions) correlation coefficient was computed between Hypnotizability, and BIS/Reward Reactivity scores (significance level set at p=.025 after Bonferroni correction). In addition, the correlation coefficients between PWGBI and BIB/BAS Reward Reactivity were computed.

A-priori power test for ANOVA ($\alpha = 0.05$, $\eta^2 = .35$, pwr = .80) indicated a minimum required sample size of 80 participants. A Univariate ANOVA was applied to PGWBI with Hypnotizability and Gender as *between* subjects factors. Post hoc Bonferroni corrected analysis was used to compare hypnotizability groups between each other. ASignificance was set at p=.05.

Results

The PGWBI (Cronbach α = .798), BIS (Cronbach α = .736) and BAS Reward Reactivity (Cronbach α = .919) mean values (SD) in highs, mediums and lows as well as in females and males are shown in Table 1. Table A (Supplementary Electronic Material) reports the mean values and SD of all RST scales. SHSS was not linearly correlated with BIS (ρ = .158, p = .076) and Reward Reactivity (ρ =.139, p = .125).

Table 1. Questionnaires scores

questionnaire				females		males	
		Mean	sd	Mean	sd	Mean	sd
PGWBI	lows	123.29	10.76	122.82	11.61	124.17	9.26
	mediums	125.80	10.10	122.94	10.10	128.04	9.76
	highs	130.42	13.48	128.47	12.58	132.25	14.43
RST							
Reward Reactivity	lows	28.25	0.73	28.00	6.29	28.72	4.79
	mediums	29.02	0.83	28.06	6.03	29.78	4.17
	highs	29.32	0.95	28.73	4.54	29.88	4.72
BIS	lows	54.98	14.72	55.26	15.34	54.44	13.81
	mediums	57.90	13.02	60.00	11.28	56.26	14.27
	highs	61.32	13.55	64.93	12.85	57.94	13.70

A significant positive linear correlation (Fig. 2) was observed between PGWBI and BIS ($r = .270$, $p = .003$), but not between PGWBI and Reward Reactivity ($r = .123$, $p = .172$).

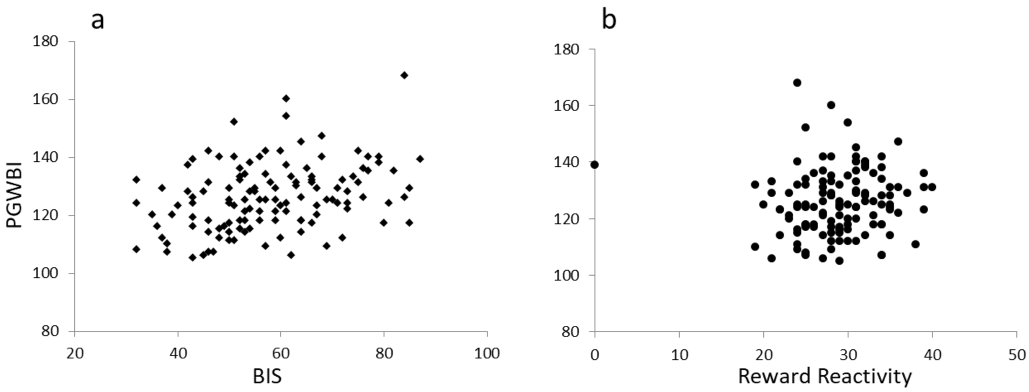

Fig. 1

Univariate ANOVA (Fig. 1a) revealed hypnotizability-related differences in PGWBI ($F(2,123) = 3.495$, $p = .034$, $\eta^2 = .056$, pwr =.643) with highs' scores higher than lows' ($p = .020$) and no significant difference between mediums and highs ($p = .266$) or lows ($p = .874$).

The Gender effect on PGWBI (Fig. 1b) was not significant ($F(1, 124) = 2.614$, $p = .106$, $\eta^2 = .022$, pwr = .361). No significant interaction was observed between hypnotizability and gender.

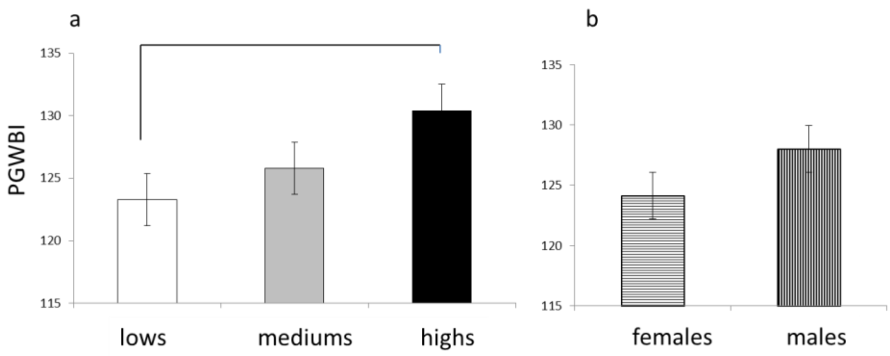

Fig. 2

Discussion

The findings support the hypothesis that highs display higher psychological wellbeing than lows, The highs' higher psychological general wellbeing indicates greater satisfaction with many aspects of life and could allow a better management of physical and psycho-social challenges. Highs display several psychophysiological characteristics which could sustain their high wellbeing. At least five factors should be considered. One is the highs' greater proneness to change their psychophysiological state with respect to lows, as occurs, for instance, for the passage from wakefulness to sleep (Dittborn & O'Connell, 1967) or to hypnosis (Elkins, Barabasz, Council, & Spiegel, 2015). Moreover, when both highs and lows report subjective relaxation, only in highs this is associated with a shift of the autonomic balance toward a pre-eminently parasympathetic control of heart rate (De Benedittis, Cigada, Bianchi, Signorini, & Cerutti, 1994; Santarcangelo et al., 2012), which is known to predict a better cardiovascular prognosis (Schwartz & De Ferrari, 2011) and cognitive functioning (Forte, Favieri, & Casagrande, 2019). The second potentially relevant factor is the highs' ability to maintain focused the attention on selected internal or external objects (Raz, 2005), which reduces the likelihood that external and internal information would alter their experience of pleasant states. The strong connection between the cortical executive network and the Salience and Default Mode circuits (Hoeft et al., 2012; Landry, Lifshitz, & Raz, 2017) could represent the physiological basis of this ability as the interaction between these circuits regulates the direction of attention and can reduce the salience of irrelevant stimuli. The third factor is that highs can experience specific, pleasant sensori-cognitive experiences efficaciously through their strong functional equivalence between imagery and perception (Ibanez-Marcelo et al., 2019). The fourth potentially explanatory factor is the highs' cortical dopaminergic tone, which predisposes to positive affect (Schultz, 2016) and is generally considered higher than lows', although the physiological mechanism responsible for it, that is the reduced dopamine catabolism by the Cathecol-O-Methil-Transferase, is not unanimously reported (Szekely et al., 2010; Rominger et al., 2014; Bryant, Hung, Dobson-Stone, & Schofield, 2013; Presciuttini et al., 2014). Finally, high wellbeing could be at least partially sustained by the highs' greater interoceptive sensitivity leading them to consider their body as a safe place (Diolaiuti et al., 2019), as indicated by their high scores of the *trusting* scale of the questionnaire for the Multidimensional Assessment of Interoceptive Awareness (Mehling, 2012). Finally, it is noticeable that the pre-eminent left frontal activation observed in highs (Gruzelier, 2006; Naish, 2010) mediates approach, thus possibly favouring BAS-related behaviors, while activation of right frontal cortical areas, which is lower in highs, is associated with lower BIS scores and lower tendency to withdrawal (Harmon-Jones & Gable, 2018). In other words, the highs' higher PWGI index could be sustained by their left directed cortical asymmetry, which is associated with traits i.e. optimism (Hecht, 2013), that can support wellbeing also independently from hypnotizability.

No significant gender difference in PGWBI was observed in the studied sample, which accords with part of the available evidence. Nonetheless, gender differences in wellbeing, possibly due to the gender specific morphometry of the brain areas involved in the BIS/BAS activity (Assari, 2020; Li et al., 2014), have been reported (Taylor et al., 2017; Beaton, Kaack, & Corr, 2015; Mensah, 2021, Cheema & Malik, 2021; Douglas et al., 2021)

Association of PWGBI and BIS/BAS

The findings of previous clinical studies (Misurya, Misuraya, & Dutta, 2020; Hossain, et al., 2020; Maggio et al., 2020; D'Cunha et al., 2019) showing a positive association between BIS activity and psychological wellbeing may seem in contrast to our hypothesis and findings, as high hypnotizability is characterized by low BIS (Diolaiuti et al., 2019) and high wellbeing (present study). The inconsistency may be accounted for by possibly different coping styles of patients and healthy participants. In the former, in fact, high proneness to avoid unpleasant experiences and could promote wellbeing by inducing them to enact pleasant rather than unpleasant behaviours. Moreover, in healthy subjects the activity of circuits sustaining pre-existing wellbeing could promote further wellbeing, as stressful events presented while maintaining high levels of wellbeing activate networks where dopamine and acetylcholine promote wellbeing, which, in turn, promotes norepinephrine and inhibits cortisol release (Toole et al., 2018). Moreover, BIS and BAS could cooperate rather than oppose to each other (Serrano-Ibáñez et al., 2018), and the multidimensional nature of the general psychological wellbeingcould account for a complex relation between BIS/BAS and wellbeing.

Limitations and conclusions

The association of high hypnotizability and high psychological wellbeing is a novel finding. Nonetheless, the low effect size of a few comparisons, makes the replication of the study in larger sample size mandatory. Also, other traits possibly relevant to the relation between hypnotisability and wellbeing - coping styles (Gruzelier, 2002), imagery abilities (Ibanez-Marcelo, Campioni, Phinyomark, Petri, & Santarcangelo, 2019), interoceptive accuracy (Rosati et al., in press) and sensitivity (Diolaiuti et al., 2019)- should be studied. Finally, further research should assess whether the hypnotizability and wellbeing positive effects on health are independent from each other, as high scores of both traits predict better cardiovascular and immune functions (Lasselin, Alvarez-Salas, & Grigoleit, 2016; Gruzelier, 2002).

References

1. Assari, S. (2020). Gender Differences in the Association between Cortical Thickness and Children’s Behavioral Inhibition. *Journal of Psychology & Behavior Research, 2(2)*, 49. doi: 10.22158/jpbr.v2n2p49
2. Balconi, M. & Vanutelli, E.M. (2016). Emotions and BIS/BAS components affect brain activity (ERPs and fNIRS) in observing intra-species and inter-species interactions. Brain Imaging & Behavior;10(3):750-60 doi: 10.1007/s11682-015-9443-z.
3. Beaton, A. A., Kaack, I. H., & Corr, P. J. (2015). Handedness and behavioural inhibition system/behavioural activation system (BIS/BAS) scores: A replication and extension of Wright, Hardie, and Wilson (2009). Laterality: Asymmetries of Body, *Brain and Cognition, 20(5)*, 585-603. doi.org/10.1080/1357650X.2015.1016530
4. Boehm, J. K., & Kubzansky, L. D. (2012). The heart's content: The association between positive psychological well-being and cardiovascular health. *Psychological Bulletin, 138*(4), 655–691. doi.org/10.1037/a0027448
5. Bradburn, N. M. (1969). The structure of psychological well-being. Chicago:Aldine.
6. Bryant, R. A., Hung, L., Dobson-Stone, C., & Schofield, P. R. (2013). The association between the oxytocin receptor gene (OXTR) and Hypnotizability. *Psychoneuroendocrinology*, 38(10), 1979-1984. doi.org/10.1016/j.psyneuen.2013.03.002
7. Burkhard, P. B, Prade, T., Vogel, S.E., Mohl, J.C., Geiger, E., & Piesbergen, C. (2014). Hypnotizability, personality style, and attachment: an exploratory study, part 2-results with particular focus on sex. *American Journal of Clinical Hypnosis*, 57(1), 41-56. doi: 10.1080/00029157.2014.910746.
8. Cardeña, E., Terhune, D.B., Lööf, A., & Buratti, S. (2009). Hypnotic experience is related to emotional contagion. *International Journal of Clinical and Experimental Hypnosis*, 57(1), 33-46. doi: 10.1080/00207140802463500.

9. Chassany, O., Dimenäs, E., Dubois, D., Wu, A., & Dupuy, H. (2004). The psychological general well-being index (pgwbi) user manual. Lyon, France: *Mapi Research Institute*.

10. Cheema, S.T., & Malik, J.A. (2021) Expectations in Romantic Relations and Psychological Well-Being of Adolescents in Pakistan: Moderating Role of Parental Support. Psychologica Belgica, 61(1), 79-87. doi: 10.5334/pb.556.

11. Corr, P. J. (2004). Reinforcement sensitivity theory and personality. *Neuroscience & Biobehavioral Reviews*. 28(3), 317-332. doi.org/10.1016/j.neubiorev.2004.01.005

12. Corr, P. J., & Cooper, A. J. (2016). The Reinforcement Sensitivity Theory of Personality Questionnaire (RST-PQ): Development and validation. *Psychological Assessment, 28(11)*, 1427. doi.org/10.1037/pas0000273

13. D'Cunha, N. M., Isbel, S. T., Frost, J., Fearon, A., McKune, A. J., Naumovski, N., & Kellett, J. (2020). Effects of a virtual group cycling experience on people living with dementia: A mixed method pilot study. *Dementia (London, England)*, 1471301220951328. Advance online publication. doi.org/10.1177/1471301220951328

14. De Benedittis, G., Cigada, M., Bianchi, A., Signorini, M.G., & Cerutti, S. (1994). Autonomic changes during hypnosis: A heart rate variability power spectrum analysis as a marker of sympathovagal balance. *International Journal of Clinical and Experimental Hypnosis,* 42, 140 – 152. doi: 10.1080/00207149408409347.

15. De Pascalis, V., Bellusci, A., & Russo, P. M. (2000). Italian norms for the Stanford hypnotic susceptibility scale, form C. *International Journal of Clinical and Experimental Hypnosis*, *48(3)*, 315-323. doi:10.1080/00207140008415249

16. De Pascalis, V., Cozzuto,G., Caprara, G.V., &Alessandri, G. (2013).Relations among EEG-alpha asymmetry, BIS/BAS, and dispositional optimism Biol Psychol94(1):198-209. doi: 10.1016/j.biopsycho.2013.05.016.

17. De Pascalis, V., & Scacchia, P. (2019). The influence of reward sensitivity, heart rate dynamics and EEG-delta activity on placebo analgesia. *Behavioural Brain Research* , 359 , 320–332.

18. Diolaiuti, F., Huber, A., Ciaramella, A., Santarcangelo, E. L., & Sebastiani, L. (2019). Hypnotisability-related interoceptive awareness and inhibitory/activating emotional traits. *Archives Italiennes de Biologie, 157(4)*, 111-119. doi:10.12871/00039829202042

19. Dittborn, J.M., & O'Connell, D.N. (1967). Behavioral sleep, physiological sleep, and hypnotizability. *International Journal of Clinical and Experimental Hypnosis*, 15, 181-188, 1967

20. Douglas, D.R., Choi, D., Marcus, H.J., Muirhead, W., Reddy, U., Stewart T., & Luoma, A.M.V. (2021). Wellbeing of Frontline Health Care Workers After the First SARS-CoV-2 Pandemic Surge at a Neuroscience Centre: A Cross-sectional Survey. Journal of Neurosurgery and Anesthesiology,doi: 10.1097/ANA.0000000000000767.

21. Dupuy, H. J. (1984). The psychological general well-being (PGWB) index. *Assessment of Quality of Life in Clinical Trials of CardiovascularTherapies*, 170-183.

22. Elkins, G. R., Barabasz, A. F., Council, J. R., & Spiegel, D. (2015). Advancing research and practice: The revised APA Division 30 definition of hypnosis. *American Journal of Clinical Hypnosis*, 57(4), 378-385. doi.org/10.1080/00029157.2015.1011465

23. Facco, E., Testoni, I., Ronconi, L., Casiglia, E., Zanette, G., & Spiegel, D. (2017). Psychological features of hypnotizability: a first step towards its empirical definition. *International Journal of Clinical and Experimental Hypnosis*, *65(1),* 98-119. doi.org/10.1080/00207144.2017.1246881

24. Forte, G., Favieri, F., & Casagrande, M. (2019). Heart Rate Variability and Cognitive Function: A Systematic Review. *Frontiers in Neuroscience*, 13, 710. doi.org/10.3389/fnins.2019.00710

25. Gray, J. A. (1970). The psychophysiological basis of introversion-extraversion. *Behaviour Research and Therapy,* 8(3), 249-266. doi.org/10.1016/0005-7967(70)90069-0

26. Gray, J. A. (1981). A critique of Eysenck's theory of personality. In A model for personality (pp. 246-276). *Springer*, *Berlin*, Heidelberg. doi.org/10.1007/978-3-642-67783-0_8

27. Gray, J. A. (1987) a. Perspectives on anxiety and impulsivity: A commentary. *Journal of Research in Personality*, 21(4), 493–509. doi.org/10.1016/0092-6566(87)90036-5.

28. Gray, J. A. (1987) b. The psychology of fear and stress. Cambridge, England: *Cambridge University Press*.

29. Gray, J. A. (1990). Brain systems that mediate both emotion and cognition. *Cognition & Emotion*, 4(3), 269-288.

30. Gruzelier, J.H. (2002). A Review of the Impact of Hypnosis, Relaxation,Guided Imagery and Individual Differences on Aspects ofImmunity and Health. Stress, 5 (2), 147–163.

31. Gruzelier, J.H. (2006). Frontal functions, connectivity and neural efficiency underpinning hypnosis and hypnotic susceptibility.Contemporary Hypnosis 23(1), 15–32.doi: 10.1002/ch.35

32. Harmon-Jones, E., & Gable, P.A. (2018). On the role of asymmetric frontal cortical activity in approach and withdrawal motivation: An updated review of the evidence. *Psychophysiology*, 55(1). doi: 10.1111/psyp.12879.

33. Hecht, D. (2013). The neural basis of optimism and pessimism. *Experimental Neurobiology*, 22(3), 173-99. doi: 10.5607/en.2013.22.3.173.

34. Hoeft, F., Gabrieli, J. D., Whitfield-Gabrieli, S., Haas, B. W., Bammer, R., Menon, V., & Spiegel, D. (2012). Functional brain basis of hypnotizability. *Archives of General Psychiatry*, 69(10), 1064-1072. doi:10.1001/archgenpsychiatry.2011.2190

35. Hossain, M. M., Tasnim, S., Sultana, A., Faizah, F., Mazumder, H., Zou, L., McKyer, E., Ahmed, H. U., & Ma, P. (2020). Epidemiology of mental health problems in COVID-19: a review. *F1000Research, 9*, 636. doi.org/10.12688/f1000research.24457.1
36. Huber, A., Suman, A. L., Biasi, G., & Carli, G. (2008). Predictors of psychological distress and well-being in women with chronic musculoskeletal pain: two sides of the same coin?. *Journal of Psychosomatic Research*, 64(2), 169–175. doi.org/10.1016/j.jpsychores.2007.09.005
37. Ibáñez-Marcelo, E., Campioni, L., Phinyomark, A., Petri, G., & Santarcangelo, E. L. (2019). Topology highlights mesoscopic functional equivalence between imagery and perception: The case of hypnotizability. *NeuroImage*, 200, 437-49.doi.org/10.1016/j.neuroimage.2019.06.044
38. Jambrik, Z., Santarcangelo, E. L., Ghelarducci, B., Picano, E., & Sebastiani, L. (2004). Does hypnotizability modulate the stress-related endothelial dysfunction?. *Brain Research Bulletin*, 63(3), 213-216. doi.org/10.1016/j.brainresbull.2004.01.011.
39. Jambrik, Z., Santarcangelo, E. L., Rudisch, T., Varga, A., Forster, T., & Carli, G. (2005). Modulation of pain-induced endothelial dysfunction by hypnotisability. *Pain*, 116(3), 181-186. doi.org/10.1016/j.pain.2005.03.041.
40. Karunamuni, N., Imayama, I., & Goonetilleke, D. (2020). Pathways to well-being: Untangling the causal relationships among biopsychosocial variables. *Social Science & Medicine*, *112846*. doi: 10.1016/j.socscimed.2020.112846.
41. Kirenskaya, A. V., Novototsky-Vlasov, V. Y., Chistyakov, A. N., & Zvonikov, V. M. (2011). The relationship between hypnotizability, internal imagery, and efficiency of neurolinguistic programming. *International Journal of Clinical and Experimental Hypnosis*, 59(2), 225-241. doi.org/10.1080/00207144.2011.546223
42. Königstein, K., Wagner, J., Frei, M., Knaier, R., Klenk, C., Carrard, J., Schwarz, A., Hinrichs, T., & Schmidt-Trucksäss, A. (2021). Endothelial function of healthy adults from 20

to 91 years of age: prediction of cardiovascular risk by vasoactive range. *Journal of Hypertension*, doi: 10.1097/HJH.0000000000002798

43. Konorski, J. (1967). Some new ideas concerning the physiological mechanisms of perception. *Acta Biol Exp (Warsz)*, 27, 147-161.
44. Kubzansky, L. D., Huffman, J. C., Boehm, J. K., Hernandez, R., Kim, E. S., Koga, H. K., Feig, E.H., Lloyd-Jones, D.M., Seligman, M.E.P., & Labarthe, D. R. (2018). Reprint of: Positive Psychological Well-Being and Cardiovascular Disease: JACC Health Promotion Series. *Journal of the American College of Cardiology*, 72(23 Part B), 3012-3026. doi: 10.1016/j.jacc.2018.07.042.
45. Landry, M., Lifshitz, M., & Raz, A. (2017). Brain correlates of hypnosis: A systematic review and meta-analytic exploration. *Neuroscience & Biobehavioral Reviews*, 81, 75-98. doi.org/10.1016/j.neubiorev.2017.02.020
46. Lang, P. J., Bradley, M. M., and Cuthbert, B. N. (1992). A motivational analysis of emotion: reflex cortex connections. *Psychological Science 3*, 44–49. doi: 10.1111/j.1467-9280.1992.tb00255.x
47. Lasselin, J., Alvarez-Salas, E., & Grigoleit, J. S. (2016). Well-being and immune response: a multi-system perspective. *Current Opinion in Pharmacology*, *29*, 34-41. doi: 10.1016/j.coph.2016.05.003
48. Li, Y., Qiao, L., Sun, J., Wei, D., Li, W., Qiu, J., Zhang, Q., & Shi, H. (2014). Gender-specific neuroanatomical basis of behavioral inhibition/approach systems (BIS/BAS) in a large sample of young adults: a voxel-based morphometric investigation. *Behavioural Brain Research*, 274, 400-408. doi.org/10.1016/j.bbr.2014.08.041
49. Maggio, M. G., Cuzzola, M. F., Latella, D., Impellizzeri, F., Todaro, A., Rao, G., Manuli, A., & Calabrò, R. S. (2020). How personality traits affect functional outcomes in patients with multiple sclerosis: A scoping review on a poorly understood topic. *Multiple Sclerosis and Related Disorders*, 46, 102560. doi.org/10.1016/j.msard.2020.102560

50. McDowell, I. (2010). Measures of self-perceived well-being. *Journal f Psychosomatic Research*, 69(1), 69-79. doi: 10.1016/j.jpsychores.2009.07.002
51. Mehling, W.E., Acree, M., Stewart, A., Silas, J., & Jones, A. (2018). The Multidimensional Assessment of Interoceptive Awareness, Version 2 (MAIA-2). *PLoS One*,13(12):e0208034. doi: 10.1371/journal.pone.0208034.
52. Mensah, A. (2021). Job Stress and Mental Well-Being among Working Men and Women in Europe: The Mediating Role of Social Support. I*nternational Journal of Environmental Research and Public Health, ;18(*5):2494. doi: 10.3390/ijerph18052494.
53. Merchán-Clavellino, A., Alameda-Bailén, J. R., Zayas García, A., & Guil, R. (2019). Mediating effect of trait emotional intelligence between the behavioral activation system (BAS)/behavioral inhibition system (BIS) and positive and negative affect. *Frontiers in Psychology,* 10, 424. doi.org/10.3389/fpsyg.2019.00424
54. Mizuguchi, N. & Kanosue, K. (2017). Changes in brain activity during action observation and motor imagery: Their relationship with motor learning. *Progress in Brain Research*, 234, 189-204. doi.org/10.1016/bs.pbr.2017.08.008
55. Misurya, I., Misurya, P., & Dutta, A. (2020). The Effect of Self-Compassion on Psychosocial and Clinical Outcomes *in Patients With Medical Conditions: A Systematic Review. Cureus, 12(10),* e10998.PMCID: PMC7669250. PMID:33209554.
56. Naish, P.L. (2010). Hypnosis and hemispheric asymmetry. Consciousness & Cognition,19(1), 230-4. doi: 10.1016/j.concog.2009.10.003.
57. Naughton, M. J., & Wiklund, I. (1993). A critical review of dimension-specific measures of health-related quality of life in cross-cultural research. *Quality of Life Research*, 2(6), 397-432. doi.org/10.1007/BF00422216
58. Picerni, E., Santarcangelo, E.L., Laricchiuta, D., Cutuli, D., Petrosini, L., Spalletta, G., & Piras, F. (2019). Cerebellar Structural Variations in Subjects with Different Hypnotizability. *Cerebellum*. 18(1),109-118. doi: 10.1007/s12311-018-0965-y.

59. Pickering, A. D. (1997). The conceptual nervous system and personality: From Pavlov to neural networks. *European Psychologist*, 2(2), 139-163. doi.org/10.1027/1016-9040.2.2.139

60. Presciuttini, S., Gialluisi, A., Barbuti, S., Curcio, M., Scatena, F., Carli, G., & Santarcangelo, E. L. (2014). Hypnotizability and catechol-o-methyltransferase (COMT) polymorphysms in Italians. *Frontiers in Human Neuroscience, 7,* 929. doi.org/10.3389/fnhum.2013.00929

61. Raz, A. (2005). Attention and hypnosis: neural substrates and genetic associations of two converging processes. *International Journal of Clinical and Experimental Hypnosis*, *53(3)*, 237-258. doi:10.1080/00207140590961295

62. Rominger, C., Weiss, E. M., Nagl, S., Niederstätter, H., Parson, W., & Papousek, I. (2014). Carriers of the COMT Met/Met allele have higher degrees of hypnotizability, provided that they have good attentional control: A case of gene–trait interaction. *International Journal of Clinical and Experimental Hypnosis,* 62(4), 455-482. doi.org/10.1080/00207144.2014.931177.

63. Rosati, A., Belcari, I., Sebastiani, L., Santarcangelo, E.L. (2021). Interoceptive accuracy as a function of hypnotizabiliy. *International Journal of Clinical and Experimental Hypnosis,* in press.

64. Santarcangelo, E. L., & Scattina, E. (2019). Responding to sensorimotor suggestions: From endothelial nitric oxide to the functional equivalence between imagery and perception. *International Journal of Clinical and Experimental Hypnosis,* 67(4), 394-407. doi.org/10.1080/00207144.2019.1649539

65. Santarcangelo, E. L., Paoletti, G., Balocchi, R., Carli, G., Morizzo, C., Palombo, C., & Varanini, M. (2012). Hypnotizability modulates the cardiovascular correlates of subjective relaxation. *International Journal of Clinical and Experimental Hypnosis*, 60(4), 383-396. doi.org/10.1080/00207144.2012.700609

66. Schultz W. (1993). Quality of life in cross-cultural research. Quality Life Res, 2, 397– 432

67. Schultz W. (2016). Reward functions of the basal ganglia. *Journal of Neural Transmission (Vienna).* 123(7), 679-693. doi: 10.1007/s00702-016-1510-0.

68. Schwartz, P. J., & De Ferrari, G. M. (2011). Sympathetic–parasympathetic interaction in health and disease: abnormalities and relevance in heart failure. *Heart Failure Reviews*, 16(2), 101-107. doi: 10.1007/s10741-010-9179-1

69. Serrano-Ibáñez, E. R., Ramírez-Maestre, C., López-Martínez, A. E., Esteve, R., Ruiz-Párraga, G. T., & Jensen, M. P. (2018). Behavioral inhibition and activation systems, and emotional regulation in individuals with chronic musculoskeletal pain. *Frontiers in Psychiatry*, 9, 394. doi.org/10.3389/fpsyt.2018.00394

70. Singh, S., & Mishra, R. C. (2011). Emotion regulation strategies and their implications for well-being. *Social Science International*, 27(2*)*, 179-198.

71. Spina, V., Chisari, C., & Santarcangelo, E. L. (2020). High Motor Cortex Excitability in Highly Hypnotizable Individuals: A Favourable Factor for Neuroplasticity? *Neuroscience,* 430, 125-130. doi.org/10.1016/j.neuroscience.2020.01.042

72. Steptoe, A., Deaton, A., & Stone, A. A. (2015). Subjective wellbeing, health, and ageing. *The Lancet,* 385(9968*)*, 640-648. doi: 10.1016/S0140-6736(13)61489-

73. Szekely, A., Kovacs-Nagy, R., Bányai, E. I., Gosi-Greguss, A. C., Varga, K., Halmai, Z., Ronai, Z., & Sasvari-Szekely, M. (2010). Association between hypnotizability and the catechol-O-methyltransferase (COMT) polymorphism. *The International Journal of Clinical and Experimental Hypnosis,* 58(3*)*, 301–315. doi.org/10.1080/00207141003760827

74. Taylor, A. W., Kelly, G., Dal Grande, E., Kelly, D., Marin, T., Hey, N., Burke, K.J., & Licinio, J. (2017). Population levels of wellbeing and the association with social capital. *BMCPsychology,* 5(1), 23. doi: 10.1186/s40359-017-0193-0

75. Thayer, J.F, Yamamoto, S.S., & Brosschot, J.F.T. (2010). The relationship of autonomic imbalance, heart rate variability and cardiovascular disease risk factors. *Internationa Journal of Cardiol*ogy, 141,122–31.10.1016/j.ijcard.2009.09.543

76. Taubitz, L. E., Pedersen, W. S., & Larson, C. L. (2015). BAS Reward Responsiveness: A unique predictor of positive psychological functioning. *Personality and Individual Differences*, 80, 107-112. doi.org/10.1016/j.paid.2015.02.029

77. Toole, J. T., Rice, M. A., Cargill, J., Craddock, T. J., Nierenberg, B., Klimas, N. G., Fletcher, M.A., Morris, M., Zysman, J., & Broderick, G. (2018). Increasing Resilience to Traumatic Stress: Understanding the Protective Role of Well-Being. In Psychoneuroimmunology (pp. 87-100). *Humana Press, New York*, NY. doi: 10.1007/978-1-4939-7828-1_6.

78. Weitzenhoffer, A.M., & Hilgard, E.R. (1959). Scala Stanford di Suscettibilità Ipnotica, forme A e B. *Organizzazioni Speciali,* Firenze.

79. Younger, J.W., Rossetti, G..C, Borckardt, J.J., Smith, .AR., Tasso, A.F., & Nash, M.R. (2007). Hypnotizability and somatic complaints: a gender-specific phenomenon. *The International Journal of Clinical and Experimental Hypnosis,* , 55(1):, -13. doi: 10.1080/00207140600995745.

80. Yüksel, A., & Bahadir-Yilmaz, E. (2019). Relationship between depression, anxiety, cognitive distortions, and psychological well-being among nursing students. *Perspectives in Psychiatric care,* 55(4), 690-696. doi: 10.1111/ppc.12404.

81. Zhang, B., Wang, J., Zhu, Q., Ma, G., Shen, C., Fan, H., & Wang, W. 82017). Hypnotic susceptibility and affective states in bipolar I and II disorders. *BMC Psychiatry*,17(1), 362. doi: 10.1186/s12888-017-1529-2.

Figure legend

Figure 1. PWGBI distribution as a function of BIS (a) and Reward Reactivity (b).

Figure 2. Psychological General Wellbeing Index (PWGBI). Mean, SEM. a) highs, mediums, lows; b) females and males. The line indicates a significant difference between highs and lows.

Figure 1

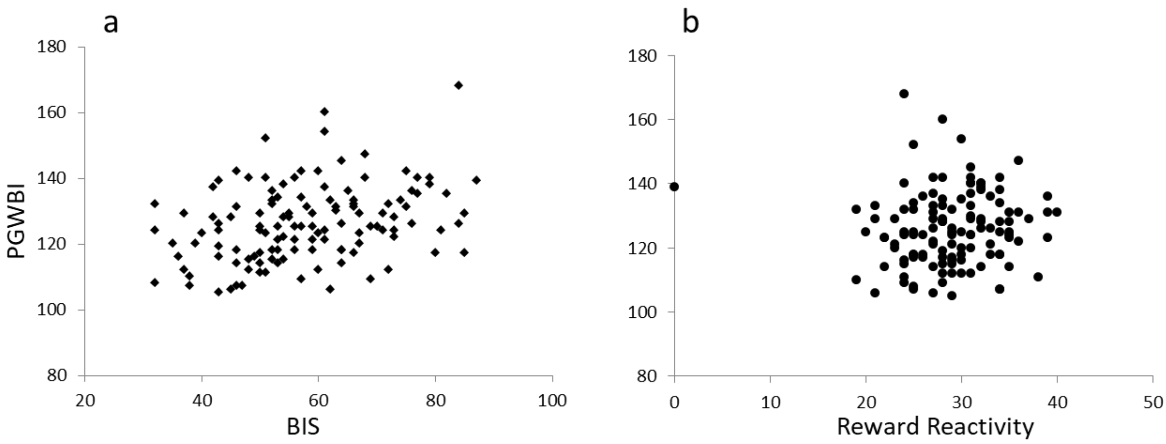
a
b
180
160
140
120
100
80
PGWBI
20
40
60
80
100
BIS
0
10
20
30
40
50
Reward Reactivity

Figure 2

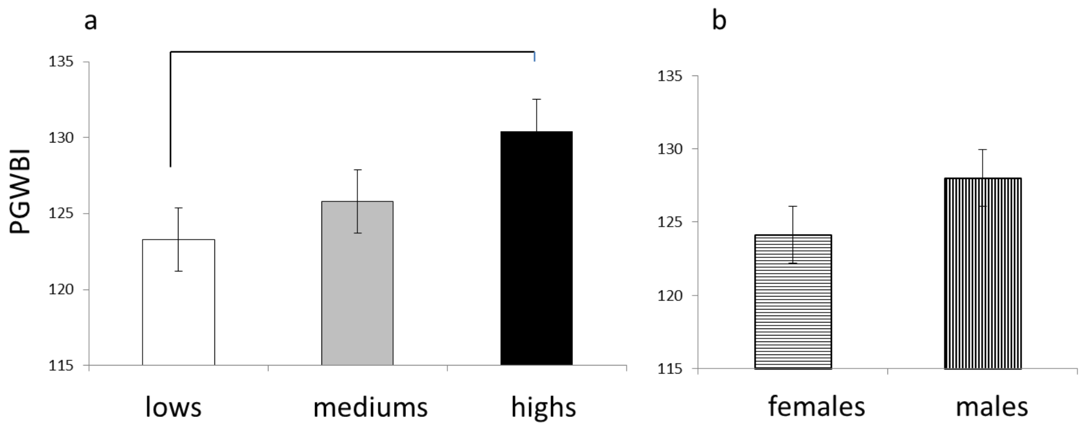
a
b
PGWBI
135
130
125
120
115
lows
mediums
highs
females
males

Table 1. Questionnaires scores

questionnaire				females		males	
		Mean	sd	Mean	sd	Mean	sd
PGWBI	lows	123.29	10.76	122.82	11.61	124.17	9.26
	mediums	125.80	10.10	122.94	10.10	128.04	9.76
	highs	130.42	13.48	128.47	12.58	132.25	14.43
RST							
RewardReactivity	lows	28.25	0.73	28.00	6.29	28.72	4.79
	mediums	29.02	0.83	28.06	6.03	29.78	4.17
	highs	29.32	0.95	28.73	4.54	29.88	4.72
BIS	lows	54.98	14.72	55.26	15.34	54.44	13.81
	mediums	57.90	13.02	60.00	11.28	56.26	14.27
	highs	61.32	13.55	64.93	12.85	57.94	13.70

Table A. RST-PQ scores

questionnaire	gender			females		males	
	hypn	Mean	sd	Mean	sd	Mean	sd
BAS							
GoalDrivePersistance	lows	1.98	0.62	19.23	4.98	20.78	4.41
	mediums	2.1	0.7	21.61	4.68	20.43	4.26
	highs	2.03	0.81	19.93	4.27	22.06	3.47
Reward Interest	lows	19.4	0.61	18.31	5.29	21.50	4.62
	mediums	19.24	0.7	18.56	3.99	19.78	3.81
	highs	20.39	0.8	19.40	3.56	21.31	3.44
Reward Reactivity	lows	28.25	0.73	28.00	6.29	28.72	4.79
	mediums	29.02	0.83	28.06	6.03	29.78	4.17
	highs	29.32	0.95	28.73	4.54	29.88	4.72
Impulsivity	lows	18.11	0.59	18.11	5.12	18.67	2.50
	mediums	17.66	0.67	18.61	3.97	16.91	3.55
	highs	18.42	0.77	18.20	4.41	18.63	5.15
BIS	lows	54.98	14.72	55.26	15.34	54.44	13.81
	mediums	57.90	13.02	60.00	11.28	56.26	14.27
	highs	61.32	13.55	64.93	12.85	57.94	13.70
FFFS	lows	21.93	0.85	23.63	6.57	18.61	4.78
	mediums	22.63	0.96	25.11	4.39	20.70	5.13
	highs	24.52	1.1	27.80	7.02	21.44	4.83

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