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An Evolutionary Approach to Hypnotizability

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Abstract

We propose here an evolutionary interpretation of the presence of highly hypnotizable persons (highs) among the general population. Current experimental evidence suggests the presence of stronger functional equivalence between imagery and perception, non-opioid cognitive control of pain, favourable cardiovascular asset and greater interoceptive sensitivity in highs. We hypothesize that these characteristics were greatly relevant to our ancestors' survival, and that they may have facilitated the natural selection of individuals who are now named " highs" due to one of their side effects – the proneness to accept suggestions – as part of the reported physiological features. Unfortunately, our theoretical hypothesis cannot be currently experimentally proven. We believe, however, that looking at hypnotizability in a naturalistic, evolutionary perspective may emphasize the importance of its physiological correlates in daily life and in the prediction of the outcome of medical treatments.

An evolutionary approach to hypnotizability

Fifteen years ago we published a review suggesting that, in the context of experimental hypnosis, the dispositional trait of hypnotizability could be considered an adaptive one (Santarcangelo & Sebastiani, 2004). This hypothesis was motivated by two considerations. On the one hand, highly hypnotizable individuals (highs) can easily change their mental and bodily state. On the other hand, they exhibit vascular functions with characteristics which have been associated with a better cardiovascular prognosis. In particular, highs appear to modulate their heart activity during relaxation through specific cognitive strategies (Santarcangelo et al., 2012), to disentangle the autonomic activation from the subjective experience (Sebastiani, D'Alessandro, Menicucci, Ghelarducci, & Santarcangelo, 2007) and to escape from the cardiac correlates of unpleasant imagery exhibited by the general population (Sebastiani, Simoni, Gemignani, Ghelarducci & Santarcangelo, 2003). Additionally, in contrast to low hypnotizables (lows) and to the general population, the brachial artery flow mediated dilation (FMD) in highs is not or scarcely impaired by mental stress (Jambrik ,Santarcangelo, Ghelarducci, Picano, & Sebastiani, 2004; Jambrik , Sebastiani, Picano, Ghelarducci, & Santarcangelo, 2005) and nociceptive stimulation (Jambrik et al., 2005), respectively. This is relevant because FMD - the increase in the blood vessels diameter following 5 minutes occlusion - is considered to be a favourable prognostic factor for cardiovascular health.

The findings reported in our original review were limited to the cardiovascular domain. However, during the last 15 years, we have obtained further evidence that hypnotizability can be considered as an adaptive trait in the cardiovascular as well as in other physiological domains. For instance, the cardiac advantage of highs consists not only of their better FMD (Jambrik ,Santarcangelo, Ghelarducci, Picano, & Sebastiani, 2004; Jambrik , Sebastiani, Picano, Ghelarducci, & Santarcangelo, 2005; Jambrik et al., 2005), but also of their pre-eminent parasympathetic control of heart rate, which can be observed during long-lasting relaxation (Santarcangelo et al., 2012).

Here we put forward again the proposal to consider an adaptive role of hypnotizability from an evolutionary perspective. We aim to theoretically answer the question: why did a consistent fraction of highs in the population (15%) survive to natural selection? It seems unlikely that it may have happened just due to their proneness to accept suggestions.

The power of imagery

Among the cognitive characteristics which have been associated with high hypnotizability, the most intriguing in our opinion is the peculiar ability of mental imagery and, in particular, the strong functional equivalence (FE) between imagery and perception (Ibanez-Marcelo, Campioni, Phinyomark, Petri, & Santarcangelo, 2019; Santarcangelo & Scattina, 2019).

FE usually regards sensory and motor mental images and it is customarily defined on the basis of the superimposition of brain activations occurring during the two activities. Recently, advanced analyses of various imagery modalities have better defined the equivalence between actual and imagined perception by assessing the properties of the corresponding brain functional states based on the networks of regional coactivations rather than their activations alone (Petri et al., 2014; Lee, Chung, Kang, Kim, & Lee, 2011). Such analyses have shown that the two brain functional states are more similar between each other in highs than in lows (Ibanez-Marcelo, Campioni, Phinyomark, Petri, & Santarcangelo, 2019), which indicates that mental imagery is more powerful and can better simulate actual sensorimotor conditions in highs than in lows. Indeed, the excitability of the highs' motor cortex is greater than lows' in basal conditions and shows a further increase during motor imagery (Spina, Chisari, & Santarcangelo, 2020). Since imagery training is an effective rehabilitation treatment of brain injuries (Zimmermann-Schlatter, Schuster, Puhan, Siekierka, & Steurer, 2008; García Carrasco, & Aboitiz Cantalapiedra, 2013; Ang & Guan, 2015), in the challenging and dangerous environment where our ancestors lived, spontaneous and absorptive engagement in the mental images (Green & Lynn, 2011) of lost perceptive/motor abilities might have reduced the cognitive and behavioral effects of the brain injuries, thus favouring the highs' recovery and survival.

Finally, the above cited EEG study showed that highs display a distributed mode of information processing (Ibanez-Marcelo, Campioni, Phinyomark, Petri, & Santarcangelo, 2019; Ibáñez-Marcelo , Campioni, Manzoni, Santarcangelo, & Petri, 2019), which characterizes the individuals with greater cortical excitability (Bassett & Sporns, 2017). Since greater excitability facilitates brain plasticity (Keller et al., 2018; Ni et al., 2018; Minzenberg & Leuchter, 2019), this style of information processing may have contributed to make highs less vulnerable than other individuals to the cognitive and behavioral effects of injuries and favoured their survival.

Pain: to perceive or not to perceive

The most popular characteristic of highs is their ability to control pain through cognitive strategies (Brugnoli, 2016; Jensen et al., 2016; Wortzel & Spiegel, 2017; Santarcangelo & Consoli, 2019). While suggestions for analgesia can be accepted also by several healthy subjects and chronic pain patients through different cognitive strategies, i.e. hypnotizability-related strategies, placebo enacted mechanisms, distraction (Santarcangelo & Consoli, 2019), it has been shown that highs respond consistently better than lows/mediums to explicit suggestions for analgesia and to conditioned analgesia. In this way, they are able to counteract pain through both top-down and bottom-up antinociceptive mechanisms (Fidanza. Varanini, Ciaramella, Carli, & Santarcangelo, 2017).

The ability to control pain should have been a great advantage in the dangerous environment where our ancestors lived. In this respect, the facts are:

a) suggestions of analgesia are not associated with release of endogenous opiates;

b) the A118G rs1799971 polymorphism of μ1 opioid receptors, which is more frequently found in highs (Presciuttini et al., 2018), is associated with lower sensitivity to opiates (see Santarcangelo & Consoli, 2019), thus highs cannot rely on an efficient opioid control of pain;

c) placebo responses are powerful mechanisms for pain control mostly based on the release of endogenous opioids (Frisaldi, Piedimonte & Benedetti, 2015; Darnall & Colloca, 2018).

We hypothesize that part of our ancestors with an inefficient opioid system may have developed alternative cognitive strategies to control pain and compensate for this inefficiency making them less prone to develop placebo responses. In fact, good placebo responders have an efficient endogenous opioid system (Petrovic, Kalso, Petersson, & Ingvar., 2002), whereas scarce placebo responses have been observed in the people exhibiting the highs' most frequent polymorphism (Peciña & Zubieta, 2014; Trescot, & Faynboym, 2014). For example, these subjects require larger dosage of opiates to control post-operative and cancer pain (see Santarcangelo & Consoli, 2019) The ancestors who developed an alternative mechanism to control pain survived because, reducing pain perception, they may have been able to cope with maladaptive behavior, depressive symptoms and social exclusion.

Feeling the body

Highs seem to have a better relation with their body with respect to lows and mediums (Diolaiuti, Huber, Ciaramella, Santarcangelo, & Sebastiani, 2019). They exhibit greater proneness to be aware of bodily sensations, concentrate on and interpret them as aspects of emotional states, to cope with distress by attention to body sensations, and to consider the body as a safe place. Moreover, highs exhibit a lower tendency to withdraw from possibly unpleasant situation with respect to mediums.

Hypnotizability-related interoceptive sensitivity could be sustained by differences in the brain regions involved in interoception such as the insula, which processes interoceptive signals and integrate them in conscious experience (Critchley & Garfinkel, 2019; Critchley & Harrison, 2013; Strigo & Craig, 2013) through connections with the cingulate and prefrontal cortex and with subcortical nuclei (Kűhn, Mueller, Lohmann, & Schuetz-Bosbach, 2016). Also, differences in cerebellar lobules (Picerni et al., 2019) could be involved, as the cerebellum participates in autonomic monitoring and controls emotional behavior through its wide connections to cortical and subcortical regions (Koziol et al., 2014; Cavdar, Özgur, Kuvvet, & Bay, 2018; Moreno-Ruis, 2018).

All in all, these observations suggest that the ancestors with the cortical characteristics of present day highs may have been able to evaluate their physical condition and choose to enact behaviours appropriate to their psychophysical conditions after injuries or illnesses, further contributing to their survival.

It's not all gold what glitters

The absence, or great reduction of the brachial artery FMD to mental stress (Jambrik, Santarcangelo, Ghelarducci, Picano, & Sebastiani, 2004; Jambrik, Sebastiani, Picano, Ghelarducci, & Santarcangelo, 2005) and nociceptive stimuli (Jambrik et al., 2005) indicates a conserved endothelial nitric oxide (NO) supply to the blood, which is a favourable prognostic factor for the cardiovascular system. Experiments aimed at assessing whether similar uncontrolled NO release occurs in cerebral vessels of highs have not been performed yet. In the general population, however, the brachial artery FMD has been found to be correlated with the brain functional hyperemia (Tarumi et al., 2015), which is in turn also largely dependent on NO (Liu, De Visa, & Lu, 2019). Thus, if a similar NO release occurred in the highs' brachial artery and brain vessels, a large release of endothelial NO could be toxic for brain tissue (Contestabile, 2012). This could - at least partially - account for the smaller grey matter volume observed in several highs' brain regions (Landry, Lifshitz & Raz 2017; Picerni et al., 2019).

Thus, the possible consequences of a positive cardiovascular configuration are not necessarily positive for the brain, as indicated by behavioral studies showing that the highs' postural and visuomotor control systems are much looser than ones of the lows (Santarcangelo & Scattina, 2016). Further, this could be related to the less accurate control by the cerebellum, which exhibits a reduced grey matter volume in highs (Picerni et al., 2019), and exerts a paradoxical control on pain after transcranial anodal stimulation (Bocci et al., 2017).

In an evolutionary perspective, the highs' cardiovascular advantage may have buffered the detrimental effects of the low accuracy of their postural and visuomotor control, both very important functions when our ancestors gained the upper stance, had to chase and struggle.

Conclusion

Theoretically, highs may have survived to natural selection owing to their cardiovascular advantage, greater cortical excitability reducing their vulnerability to the consequences of brain injuries, ability to control pain in the absence of an efficient opioid mechanism, and greater interoceptive sensitivity (Figure 1).

Unfortunately, our hypothesis cannot be experimentally tested. However, it places the trait of hypnotizability in a reference frame more complex than a merely psychological one. It also suggests that from an evolutionary perspective the proneness to accept suggestions could be just a side effect of other physiological features, which were instead directly relevant to survival during human evolution. It emphasizes the importance of hypnotizability-related physiological correlates in everyday life, and indicates the relevance of hypnotic assessment as a predictor of treatments outcome in clinical fields, from cardiology to neurology.

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Figure legend

Figure. 1. Summary of the evolutionary hypothesis of hypnotizability.