

Balancing autonomic nervous system activity through hypnosis clinical implications for pain therapy

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Abstract

Hypnosis, a clinically valuable therapeutic modality, is increasingly recognized for its efficacy in treating a spectrum of psychological and somatic disorders, including pain. Its influence extends beyond central nervous system processes to encompass the autonomic nervous system (ANS), thereby affecting peripheral physiological responses. Objective psychophysiological measures, including heart rate (HR), heart rate variability (HRV), electrodermal activity (EDA), and the Analgesia Nociceptive Index (ANI), provide quantifiable evidence of ANS modulation. Studies consistently demonstrate that hypnosis promotes a shift towards parasympathetic dominance, characterized by reduced sympathetic activity and enhanced parasympathetic tone, particularly during relaxation protocols. This effect is subject to individual differences in hypnotizability and the specific task conditions. While acknowledging methodological considerations, this mini review highlights the promising role of targeted ANS modulation through hypnosis in optimizing therapeutic interventions for pain disorders associated with ANS dysregulation.

Keywords: Hypnosis, Autonomic nervous system, HRV, EDA, ANI, Pain therapy

Introduction

Hypnotherapy appears to be particularly effective in treating disorders associated with autonomic nervous system (ANS) impairment, such as chronic pain [1,2]. However, the effects of hypnosis on the ANS remain a topic of debate. Understanding these effects could shed light on the mechanisms underlying hypnotherapy's medical benefits. Additionally, examining ANS changes during hypnosis may clarify whether hypnosis primarily exerts its physiological effects through the relaxation response.

Functional Indices of Autonomic Nervous System Activity

Psychophysiological research commonly employs several measures to assess ANS activity, including heart rate variability (HRV), electrodermal activity (EDA) and the Analgesia Nociception Index (ANI), derived from HRV and reflecting relative parasympathetic tone, which has recently emerged as a valuable tool in clinical pain management [3].

Heart Rate Variability (HRV)

HRV refers to rhythmic fluctuations in the intervals between successive R-R waves on an electrocardiogram (ECG). This variability is modulated by the dynamic interplay between the sympathetic and parasympathetic branches of the ANS and provides insight into the current state of autonomic balance. Frequency-domain analysis decomposes the HRV waveform into its constituent

rhythms, generating a power spectrum of the tachogram (a series of time differences between consecutive R waves). This spectrum is typically divided into two primary frequency bands: high frequency (HF, 0.15–0.4 Hz), often associated with parasympathetic activity, and low frequency (LF, 0.04–0.15 Hz), often associated with sympathetic activity [4]. The ratio of LF to HF power (LF/HF ratio) is often used as an indicator of sympatho-vagal balance [5].

Higher HRV is generally associated with better health, resilience, well-being, longevity, and stronger social connections. Conversely, lower HRV is linked to increased morbidity and is observed in both medical and psychological disorders [6]. HRV is increasingly recognized as a valuable marker of physiological and psychological health. For example, HRV is sensitive to emotional arousal; HF activity is often observed to decrease under conditions of acute time pressure, emotional strain, heightened anxiety and pain [1].

It's crucial to acknowledge that HRV is susceptible to artifacts and errors. Therefore, while HF variability can provide some insight into vagal control, it is an indirect and potentially imprecise measure, and its interpretation should be approached carefully [1].

Electrodermal Activity (EDA)

EDA reflects continuous fluctuations in the skin's electrical properties, primarily driven by changes in the activity of eccrine sweat glands. These glands are innervated by the sympathetic nervous system [7], and their activation leads to increased skin conductance, which serves as a marker of psychological and physiological arousal. Increased sympathetic activity, often elicited by emotional stimuli, stimulates sweat gland activity, resulting in increased skin conductance. Thus, EDA provides a reliable measure of both emotional and sympathetic responses [8].

EDA measurements can be influenced by external factors like temperature and humidity, leading to variability in results. Furthermore, different measurement locations can yield different responses, reflecting the complex interplay between regional brain activity and sweat gland innervation [9].

Analgesia Nociception Index (ANI)

ANI is a relatively new tool that provides an objective measure of intraoperative nociception by analyzing HRV. ANI is expressed on a scale from 0 to 100, with higher scores indicating greater parasympathetic activation. Studies have demonstrated the validity of ANI in reflecting nociception during surgery and in other clinical settings [3,10].

Hypnosis and the ANS: Exploring the Mechanisms of Hypnotherapy

Hypnosis has demonstrated efficacy in managing various medical conditions linked to ANS dysfunction, notably pain [11]. However, the precise mechanisms by which hypnosis influences the ANS remain unclear, hindering a deeper understanding of hypnotherapy's therapeutic effects.

While numerous studies suggest that hypnosis promotes parasympathetic nervous system (PNS) activity [5,12,13], indicative of a relaxation response [14], these findings are not entirely consistent [1]. Similarly, research on the impact of hypnosis on SNS activity yields mixed results. Some studies report decreased SNS activity [5,12,15,16], while others find no significant changes [17,18].

A recent review by Fernandez *et al.* [19] offers valuable insights. Their comprehensive analysis of 49 studies (1,315 participants) explored the effects of hypnosis on psychophysiological indicators of ANS activity related to stress and relaxation, such as HRV and EDA. Critically, they investigated the roles of hypnotic susceptibility and specific hypnotic suggestions or tasks. The review consistently demonstrated that hypnosis led to reductions in SNS activity and/or increased PNS tone, primarily in healthy volunteers (only four studies involved patients).

Although these findings strongly support the notion that hypnosis modulates ANS activity, methodological limitations requiring attention have been identified [19]. These include reliance on older studies with manual data analysis, small sample sizes, and a lack of correction for multiple comparisons. These limitations highlight the need for more robust and standardized research to fully elucidate the mechanisms underlying hypnotic modulation of the ANS.

Hypnotizability and ANS Modulation: A Complex Relationship

The relationship between hypnotizability and ANS activity is complex and not fully understood. During prolonged relaxation, both highly and less hypnotizable individuals typically show reduced heart rate (HR), but highly hypnotizable individuals exhibit a stronger parasympathetic and weaker sympathetic contribution to HRV [20].

Conversely, some studies have reported higher skin conductance (SC) levels in highly hypnotizable individuals, suggesting increased sympathetic tone [21]. This seemingly paradoxical finding might be explained by greater attentional engagement in the relaxation task among highly hypnotizable individuals, while less hypnotizable individuals may disengage from external stimuli [1].

While some studies reported distinct ANS states or reactivity in highly hypnotizable individuals, the majority found no consistent differences [19]. Intriguingly, DeBenedittis *et al.* [5] found that hypnotizability influenced psychophysiological responses *during* hypnosis, with highly hypnotizable individuals showing a trend toward greater increases in vagal efferent activity.

The relationship between hypnotizability and EDA, particularly during and after hypnotic induction, is also inconsistent. While some studies suggest a correlation, others have found no clear differences [22]. In summary, the evidence for distinct autonomic states or reactivity in highly hypnotizable individuals is mixed, with most studies finding no consistent differences. This suggests that hypnotizability modulates autonomic responses in a subtle and nuanced manner, with both shared and distinct patterns emerging across different autonomic measures and experimental conditions [1]. These inconsistencies likely stem from methodological variations across studies.

Hypnosis and ANS Modulation in Healthy Volunteers: Focus on Experimental Pain

Hypnosis has shown promise in modulating the ANS response to experimental pain in healthy volunteers. The cold-pressor task, typically eliciting increases in HR, EDA, and systolic blood pressure (SBP), has been used to study this effect. Studies have shown that hypnotic analgesic suggestions can effectively reduce HR during this

task, although other physiological parameters like EDA and SBP may remain unchanged [23]. In highly hypnotizable individuals, these suggestions have also been shown to lower skin conductance responses (SCR) to electrical pain stimuli [24]. These findings suggest that hypno-analgesia can mitigate the stress response associated with pain, although the range of physiological measures employed in these studies is often limited.

More recently, Terzulli *et al.* [25] investigated the effects of Virtual Reality Hypnosis (VRH) on heat pain thresholds in 60 healthy adult volunteers, while simultaneously monitoring various physiological and autonomic functions. Their results demonstrated a clear reduction in sympathetic tone during VRH, evidenced by a decrease in nonspecific skin conductance peak responses and an increase in the ANI. This study provides further support for the ability of hypnosis to modulate ANS activity in the context of experimental pain.

The Interplay between Chronic Pain and the ANS

Whilst various regions of the central nervous system (CNS) are known to play a role in both pain and the ANS, currently there is a lack of knowledge concerning how pain-autonomic interactions may be reflected in clinical pain populations. Sympathetic reactivity is blunted during typical and complex walking tasks in persons with chronic pain reflecting autonomic dysregulation [26]. Patients with chronic pain conditions such as fibromyalgia often show reduced HF power in addition to increased LF and LF/HF, suggesting increased sympathetic activity as compared with healthy controls [27].

The effects of neuromodulation on the ANS in the context of chronic pain remain poorly understood. A systematic review by Billet *et al.* [28] on the effects of neuromodulation for chronic pain on the ANS revealed inconsistent results towards contribution of SCS, DBS, and peripheral nerve stimulation on ANS parameters.

Hypnosis and ANS Modulation in Clinical Pain Patients

A few studies have compared ANS responses during interventional procedures in patients receiving hypnosis versus those undergoing medicated sedation. For example, Baglini *et al.* [29] examined physiological parameters during coronary angioplasty and found that while the drug sedation group showed an increased low frequency (LF) and LF/HF ratio (indicators of heightened sympathetic activity), the hypnosis group did not exhibit these signs of sympathetic activation.

Similarly, Boselli *et al.* [30] evaluated the ANI, a measure of parasympathetic tone, in patients undergoing axillary brachial plexus blocks. The hypnosis group demonstrated significantly higher ANI scores than the standard premedication group, suggesting that hypnosis promotes parasympathetic activity and may contribute to pain relief.

The benefits of hypnosis extend to chronic conditions as well. A limited number of studies addressed the relationships between hypnosis and ANS in clinical pain patients. Palsson *et al.* [31] conducted a longitudinal study on patients with irritable bowel syndrome (IBS) and found that hypnosis led to significant symptom improvement and reduced stress reactivity, as measured by EDA, although HR and blood pressure (BP) remained unchanged.

Excoffier *et al.* [32] investigated ANS responses to sutures

during pediatric emergencies under hypnosis. They observed a decrease in the LF/HF ratio during sutures in the hypnosis group compared to the control group, coupled with increases in HF and ANI (parasympathetic indicators) specifically during hypnosis. This highlights the potential of hypnosis for regulating ANS function and alleviating pain in stressful pediatric situations.

These studies suggest that hypnosis holds promise as a therapeutic tool for modulating the ANS and managing a range of pain conditions, and even some chronic disorders. Further research is needed to fully understand the underlying mechanisms of these effects and optimize the use of hypnosis in diverse clinical settings.

Discussion

Neuroscience research has traditionally emphasized the central mechanisms of hypnosis. However, a growing body of evidence highlights its peripheral effects on the ANS. Studies consistently demonstrate that hypnosis can modulate ANS activity, typically manifesting as reduced sympathetic activity and increased parasympathetic tone [1,19]. This effect is particularly prominent during relaxation protocols and can extend to mitigating specific stressors, notably pain. While some studies suggest promising analgesic effects of hypnosis in both experimental pain and chronic pain patients, findings remain inconsistent and require further replication.

A significant methodological challenge lies in the analysis of HRV, a key ANS marker. HRV analysis, though valuable, is prone to artifacts and errors, and the lack of standardized methodological guidelines across studies impedes the comparability of findings. This inconsistency hinders the identification of robust mechanisms underlying hypnosis's influence on the ANS. Future research must prioritize the establishment of clear, standardized methodological protocols to enhance the reliability and reproducibility of results.

Furthermore, current research predominantly focuses on highly hypnotizable individuals, limiting the generalizability of findings. To address this, future investigations should broaden participant pools to include individuals with medium hypnotizability, thereby providing a more comprehensive understanding of hypnosis's effects on ANS function across the population spectrum [1].

The prevalent use of small sample sizes also poses a critical limitation, compromising statistical power and the reliability of findings. To strengthen the evidence base, future studies should prioritize larger sample sizes, ensuring greater statistical robustness and enabling more definitive conclusions regarding hypnosis's impact on the ANS.

There is also a notable deficit of research examining the effects of hypnotic modulation on the ANS in patient populations, particularly those experiencing chronic pain. Future studies should address this gap by directly comparing ANS measures before and after hypnotic interventions across diverse chronic pain conditions.

Finally, a deeper understanding of the interplay between hypnotic modulation of the ANS and pain holds significant potential. It could clarify how chronic pain alters ANS function and, conversely, how ANS-focused hypnotherapy can enhance therapeutic outcomes for diverse chronic pain conditions. Further research is therefore needed to confirm these assumptions.

Conclusion

Although existing research provides valuable contributions, a more rigorous methodological approach is needed to fully understand hypnosis's impact on ANS function and its clinical applications in ANS-mediated pain disorders. Specifically, future studies should: standardize HRV analysis, employ robust theoretical frameworks, ensure diverse participant representation, utilize adequate sample sizes, optimize experimental designs for efficiency, include a variety of chronic pain disorders, and investigate the interplay between the CNS and ANS. By addressing these critical areas, we can strengthen the scientific basis of hypnosis and enhance its clinical utility, transforming it into a more reliable and evidence-based therapeutic modality.

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