Brief hypnosis relaxation suggestions are beneficial to subjective psychological states but have no effect on cardiac vagal activity and breathing frequency

Abstract

The aim of this study was to investigate the effects of a brief hypnosis including relaxation suggestions on physiological markers of relaxation, cardiac vagal activity and breathing frequency. Forty participants were tested in a within-subject design. Participants listened to a recorded hypnosis and to a non-hypnotic recording. No differences were found regarding cardiac vagal activity. Participants breathed significantly faster during the audio conditions (hypnosis and non-hypnotic recording) in comparison to resting measures. After hypnosis subjective arousal was significantly lower and emotional valence was significantly more positive than after the non-hypnotic recording condition. The relaxing effects of hypnosis including relaxation suggestions appear to be located at the subjective level but not at the peripheral physiological level.

Keywords: Hear rate variability, parasympathetic nervous system; respiratory sinus arrhythmia; respiratory rate; vagal tone

Introduction

As humans we face many stressors in everyday life that can cause subjective stress and physiological activation, for example visiting the dentist (Facco & Zanette, 2017; Facco, Zanette, & Casiglia, 2014) or taking an exam (Naito et al., 2003). A holistic method that has become increasingly popular to promote relaxation in these situations is hypnosis (Facco & Zanette, 2017; Facco et al., 2014). The *American Psychological Association* defined hypnosis as „*a state of consciousness involving focused attention and reduced peripheral awareness characterized by an enhanced capacity for response to suggestion*" (Elkins, Barabasz, Council, & Spiegel, 2015, p. 6). Hypnosis generally finds broad application in clinical settings, such as providing analgesia, sedation, or reducing anxiety (Iserson, 2014; Jensen & Patterson, 2014; Montgomery, DuHamel, & Redd, 2000). Hypnosis is deemed to be effective to help people relax, however the peripheral physiological mechanisms underlying this relaxation effect are yet to be fully understood. Therefore, the aim of this study was to investigate the effects of hypnosis on two peripheral physiological parameters linked to relaxation, cardiac vagal activity and breathing frequency.

Hypnosis states are usually induced via listening to a hypnotist, who aims to induce a relaxing state through using different techniques such as eye closing, a specific voice tone, and relaxing suggestions (Weitzenhoffer & Hilgard, 1962). The hypnotic state results from interpersonal relations between the hypnotist and the client through verbal and nonverbal communication (Haley, 2015). Several induction methods exist, and in this study where our goal was to induce relaxation, we used one derived from the Waterloo-Stanford group scale of hypnotic susceptibility (Bowers, 1998), which contains relaxing suggestions. One drawback of hypnosis research regarding reproducibility is that hypnosis is almost always provided by a hypnotherapist (for exceptions see Kekecs, Szekely, & Varga, 2016; VandeVusse, Hanson, Berner, & White Winters, 2010). Even if most measures of hypnotic susceptibility (e.g., Stanford, Form C; Weitzenhoffer & Hilgard, 1962) contain a written standardized hypnotic induction and test suggestions, the effects of experimenter voice characteristics and non-verbal behaviour while providing the standardized hypnotic induction can still vary from participant to participant, consequently constituting a potential methodological bias and influencing the results of the study (Goodwin & Goodwin, 2017). Our study aims to address this issue and offers a standardized recorded hypnosis script including relaxing suggestions.

Hypnosis can be used as a tool to induce relaxation (Gruzelier, 2002). At the subjective level, results are contrasted, given some inductions increased subjective relaxation (Sheiner, Lifshitz, & Raz, 2016) but could not be replicated (Lifshitz, Sheiner, Olson, Theriault, & Raz, 2017), which may indicate that the findings are sample dependent. The relaxation mechanisms of hypnosis based on central nervous system measures have received extensive attention (e.g., Jiang, White, Greicius, Waelde, & Spiegel, 2016; Rainville, Hofbauer, Bushnell, Duncan, & Price, 2002). For example, several brain structures appear to be involved in the production of hypnotic states such as the thalamus, the ponto-mesencephalic brainstem, and the anterior cingulate cortex (Rainville et al., 2002). Furthermore, hypnosis seems to change the neural activity in brain regions linked to the typical sensations of hypnosis, such as focused attention or lack of self-consciousness, so that the activity of the dorsal anterior cingulate cortex and the connectivity between the executive control network and the default mode network decrease (Jiang et al., 2016). However, regarding peripheral physiology, the underlying mechanisms are still rather unclear. This is why we focus in this study on two peripheral physiological variables linked to relaxation, cardiac vagal activity and breathing frequency.

Cardiac vagal activity, the activity of the vagus nerve regulating cardiac functioning (Laborde, Mosley, & Thayer, 2017), can be inferred via heart rate variability (HRV) measurement. HRV represents the change in the time interval in successive heartbeats (Laborde et al., 2017; Malik, 1996). Traditional indicators of cardiac vagal activity are for example the root mean square of the successive differences (RMSSD) and high-frequency HRV (HF-HRV). The vagus nerve is the main nerve of the parasympathetic nervous system, which is responsible for energy conservation mechanisms (Roberts, 2010; Ruffoli et al., 2011). The neurovisceral integration model postulates that cardiac vagal activity is an indicator of the effectiveness of self-regulation mechanisms

(Thayer, Hansen, Saus-Rose, & Johnsen, 2009). It can be assumed that a relaxation state is linked to effective self-regulation, therefore cardiac vagal activity could be used as an indicator of relaxation states (Terathongkum & Pickler, 2004).

The current state-of-play regarding the effects of hypnosis on cardiac vagal activity is somehow unclear, given many studies focused on indicators that are not related to clear physiological mechanisms. For example, several studies considered the low frequency/high frequency (LF/HF) ratio as an indicator of stress or of the sympatho-vagal balance, while no clear physiological underpinnings can be related to this ratio (Billman, 2013; Laborde et al., 2017; Malik, 1996). Some studies found significant increases in LF/HF in control conditions and decreased LF/HF during hypnosis (Aubert, Verheyden, Beckers, Tack, & Vandenberghe, 2009; DeBenedittis, Cigada, Bianchi, Signorini, & Cerutti, 1994), whereas others found higher LF/HF during hypnosis (Gemignani et al., 2000). Regarding HF-HRV, a marker of cardiac vagal activity, findings are mixed. Studies found an increase in HF-HRV after hypnosis compared to baseline (Aubert et al., 2009; Chen, Yang, Ge, Luo, & Lv, 2017; VandeVusse et al., 2010), no change in comparison to baseline (Hippel, Hole, & Kaschka, 2001; Yuksel, Ozcan, & Dane, 2013), and no differences in HF-HRV between hypnosis and control group (Kekecs et al., 2016). Whether changes in HRV during hypnosis can be linked to hypnotisability of participants is also unclear, some studies having found relationships (DeBenedittis et al., 1994; Diamond, Davis, & Howe, 2008) while others not (Ray et al., 2000). Therefore, the claim that HRV is a valid method to measure hypnotic depth, which depicts the momentary capability of the subject to respond to hypnotic suggestions (Diamond et al., 2008), is so far not fully supported by the literature. The main issues with the studies related to hypnosis and HRV are located at the theoretical and methodological level. At the theoretical level, the current literature does not refer to theory linked to HRV, which does not help to understand this relationship, given we need theories to be able to make predictions. At the methodological level, we can highlight the diversity of HRV indicators reported, the use of HRV indicators that do not have clear underlying physiological systems, the absence of a control group in several studies, and the lack of standardization regarding the delivery of hypnosis. Regarding this last aspect, to the best of our knowledge in only two studies (Kekecs et al., 2016; VandeVusse et al., 2010) hypnosis was not delivered by an instructor, meaning that standardization of the delivery via audio recording to control for voice and non-verbal characteristics of the experimenter was not achieved in the others. The highlighted issues will be addressed in the current study.

Breathing frequency may also be related to relaxation (e.g., Lehrer, 2013). The autonomic nervous system can be influenced by breathing frequency, as breathing impacts HRV through a phenomenon called respiratory sinus arrhythmia (Bernardi et al., 1989). Usually healthy adults breathe at a rate of between 12 and 20 cycles per minute (Sherwood, 2006), and one of the mechanisms of breathing techniques to induce relaxation is usually to reduce breathing rates (Lehrer, 2013). Therefore, breathing frequency is also assessed in this study.

The effect of hypnosis on breathing frequency is still to be clarified, given most of the studies don’t investigate it. It is suggested that hypnosis decreases breathing frequency (Paul, 1969). Situations of stress usually induce an increase in breathing frequency (Grossman, 1983), therefore based on the relaxing effects of slow breathing (Lehrer, 2013), we may hypothesized that as hypnosis is set to induce relaxation (Gruzelier, 2002) it will be associated to reduced breathing frequency.

To sum up, we identified the following research gaps in the literature regarding hypnosis and HRV: studies conducted were atheoretical, they reported a diversity of HRV indicators that are not always clearly linked to underlying physiological systems, they did not use systematically a control group, they did not take systematically into account the subjective experience of the participants, and breathing frequency was not assessed. Therefore, we decided to address those issues when investigating the effects of hypnosis on cardiac vagal activity and breathing frequency in this study. As hypnosis is expected to favor a relaxation state (Gruzelier, 2002), based on the neurovisceral integration model (Thayer et al., 2009) and the links between slow breathing and relaxation (Lehrer, 2013) we hypothesize a higher cardiac vagal activity as well as a decreased breathing frequency during hypnosis compared to the control condition, a non-hypnotic recording. Regarding subjective ratings of relaxation, given the contradictory findings from the literature we make no directional hypothesis, but we will explore the effects of hypnosis on subjective ratings of stress, arousal, and emotional valence in comparison to the non-hypnotic recording.

Method

Participants

40 participants (26 male, 14 female), ranging from 18 to 29 years in age (*M* = 22,7 years old, Age *Range = 18-29*) were recruited for the study. Eighteen participants had already experienced hypnosis. Before conducting the experiment, all participants were asked to fill out a demographic questionnaire based on the one presented in Laborde et al. (2017) to assess psychological and physical characteristics to exclude factors that may impact HRV. None of them reported exclusion criteria (e.g., cardiovascular diseases, mental disorders, taking medication). The ethics committee of the local university approved the study.

Material

An ECG-device (Faros 180, Mega Electronics, Kuopio, Finland) was used during the experiment to assess HRV, with a sampling rate of 500 Hz. We used two disposable ECG pre-gelled electrodes (Ambu L-00-S/25, Ambu GmbH, Bad Nauheim, Germany). The negative electrode was placed in the right infraclavicular fossa (just below the right clavicle) while the positive electrode was placed on the left side of the chest, below the pectoral muscle in the left anterior axillary line. From ECG recordings we extracted the HRV variables via the use of Kubios© (University of Eastern Finland, Kuopio, Finland). The full ECG recording was inspected visually, and artefacts were corrected manually (Laborde et al., 2017). We calculated time domain parameters and used the root mean square of the successive differences (RMSSD) as an indicator of cardiac vagal activity (Laborde et al., 2017). Breathing frequency was calculated via the ECG derived respiration parameter calculated with Kubios (Tarvainen, Niskanen, Lipponen, Ranta-Aho, & Karjalainen, 2014).

The recorded hypnosis was deemed to have relaxing effects (Edmonston, 1977) and was based on a script developed to help people cope with stressful situations (Simon, 2012). The full-recorded script is available in the Appendix. The non-hypnotic recording was based on a documentary about the Maldives islands[1]. A music playing device (JBL Pulse; Los Angeles, USA) was used to play the recorded hypnosis and audio documentary.

The subjective levels of stress, arousal and emotional valence were determined via self-report items. For subjective stress, we used a visual analogue scale (Scott & Huskisson, 1976), which is a line of a length of 10cm, anchored from 0 “not stressed” to 10 “absolutely stressed”. This visual analogue scale as been found to be as reliable and as valid as longer questionnaires to quickly assess perceived stress (Lesage & Berjot, 2011; Lesage, Berjot, & Deschamps, 2012; Williams, Morlock, & Feltner, 2010). The self-assessment Manikin scales (Bradley & Lang, 1994) range for subjective arousal from 1 “extremely relaxed” to 9 “extremely aroused” and for subjective emotional valence from 1 “extremely negative” to 9 “extremely positive”. The reliability and validity of the self-assessment Manikin scale has received extensive support (Betella & Verschure, 2016; Bynion & Feldner, 2018).

Procedure

Participants for this study were acquired via flyers on the university campus, via the cover story that we were interested in testing the physiological effects of visualization following audio instructions. The experiment lasted approximately 50 minutes. Participants realized the two conditions on the same day (see Figure 1 for a graphical display of the procedure), given within-subject designs are preferred for HRV experiments (Laborde et al., 2017; Quintana & Heathers, 2014). The order of the hypnosis and the non-hypnotic recording conditions was counterbalanced. Our design was planned to consider the three Rs (i.e. resting, reactivity, recovery) with a pre-event, event, and post-event measurement phase to better understand HRV functioning as recommended

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[1] GEOaudio Extra: Maldiven. Online unter: http://www.geo.de/GEOaudio/audios/2015-12-17/GEOaudio500_Extra_Malediven.mp3. Accessed on April 28th, 2016.

by Laborde et al. (2017). During every condition, the participants sat in a chair, knees bended in 90°, feet in a parallel position, and hands were positioned on the participant's thighs. Eyes were closed during the entire experiment, and light in the laboratory was not dimmed or turned off at any point during the experiment. During resting measures participants sat silently on a chair with no further instructions. The hypnosis was conducted by playing a sound file recorded by the experimenter. In the non-hypnotic recording condition, participants had to listen to an audio documentary of the same length as the hypnosis. Both audio files were played on a volume of 60dB from a mobile audio device. Participants were placed one meter away from the audio device. Questionnaires for assessing subjective relaxation were filled out after the first resting measure and after the hypnosis/non-hypnotic recording condition. The experiment was conducted individually with each participant.

Insert Figure 1 near here

Data-analysis

Following recommendations regarding HRV measurement time (Laborde et al., 2017; Malik, 1996), the resting measures lasted 5 minutes, and we took the last 5min for the hypnosis and non-hypnotic recording conditions, given we expected the effects on cardiac vagal activity to be more stable at the end of the conditions. We used RMSSD as a marker for cardiac vagal activity[2] (Laborde et al., 2017; Malik, 1996). For the questionnaire data, we subtracted baseline from post-event to index the change happening during both conditions. Data were checked for normality and outliers. Outliers were corrected by using the winsorizing technique (Ghosh & Vogt, 2012). Results of the Shapiro-Wilk test showed that the data was still not normally distributed. For the questionnaire data, we used a non-parametric test, the Wilcoxon test, given we wanted to compare

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[2] The analyses were also conducted with other markers of cardiac vagal activity, HF absolute power with Fast Fourier transform and autoregressive modeling, with which similar patterns of results were obtained.

the two conditions (hypnosis vs. non-hypnotic recording condition) within the same sample. For the HRV and breathing frequency data we wanted to analyse three data points across two conditions, therefore, a natural logarithm transformation has been performed (Laborde et al., 2017) followed by repeated-measures ANOVAs. Two repeated measures ANOVA were ran to investigate the main and interaction effects of audio condition (hypnosis vs. non-hypnotic recording) and time (i.e., before the audio listening, during the audio listening, and after the audio listening) on respectively RMSSD and breathing frequency.

Results

Subjective experience

Descriptive statistics can be found in Table 1. We performed three Wilcoxon-tests using as dependent variable the change between before and after the audio listening (hypnosis vs. non-hypnotic recording), for subjective stress, subjective arousal, and subjective emotional valence. Given we performed three tests, we adjusted consequently our α level with Bonferroni correction to .016 (.05/3). No significant difference was found for subjective stress, Z = 2.186, p = .029. Subjective arousal was found to decrease significantly more in the hypnosis condition in comparison to the non-hypnotic recording condition, Z = 2.468, p = .014. Subjective emotional valence was found to increase significantly more after the hypnosis condition in comparison to the non-hypnotic recording condition, Z = 4.013, p < .001.

Insert Table 1 near here

Cardiac vagal activity – RMSSD

Descriptive statistics can be found in Table 2. A repeated measures ANOVA with Greenhouse-Geisser correction was run, with as independent variables condition and time, and as dependent variable the natural logarithm of RMSSD. No significant main effect of condition was found, F(1, 39) = 1.653, p = .206, η^2 = .04. No significant main effect of time was found, F(2, 78) = 2.123, p = .127, η^2 =.05. No significant time x interaction effect was found, F(2, 78) = 0.347, p = .708, η^2 = .01.

Taking gender, test order, and previous experience with hypnosis as covariates did not change the results.

Insert Table 2 near here

Breathing frequency

A repeated measures ANOVA with Greenhouse-Geisser correction was run, with as independent variables condition and time, and as dependent variable the natural logarithm of breathing frequency. No significant main effect of condition was found, $F(1, 39) = 2.459$, $p = .206$, $\eta^2 = .06$. A significant main effect of time was found, $F(2, 78) = 7.230$, $p = .002$, $\eta^2 = .16$. Further post-hoc tests with Bonferroni correction indicated a significant difference between the audio condition (either hypnosis or non-hypnotic recording condition) and both resting measures, the one coming before the audio condition ($p = .001$, $d = 0.41$) and the one coming after the audio condition ($p = .026$, $d = .74$). No differences were found between the two resting measures. No significant time x interaction effect was found, $F(2, 78) = 1.102$, $p = .332$, $\eta^2 = .03$. Taking gender, test order, and previous experience with hypnosis as covariates did not change the results.

Discussion

The aim of this study was to investigate the effects of hypnosis on peripheral physiological markers of relaxation, cardiac vagal activity and breathing frequency, and its effects on subjective markers of relaxation. We found no effect on cardiac vagal activity, and an increase of breathing frequency during both audio conditions in comparison to the resting measures. In addition, we found in the hypnosis condition a lower subjective arousal and a higher positive valence, when compared to the non-hypnotic recording condition. This study also provided a methodological advancement via the audio recording, a method that has been rarely used (for exceptions, see Kekecs et al., 2016; VandeVusse et al., 2010). The audio recording enables to control for confounding variables linked to participant-to-participant variations in the voice and non-verbal behaviour of the experimenter while delivering the hypnosis induction, contributing to reduce this methodological bias (Goodwin & Goodwin, 2017), Moreover, our analyses were based on clear markers of cardiac vagal activity and we used a control group with a non-hypnotic recording in order to understand the effects of hypnosis further.

Contrary to our hypothesis, we found no significant differences in cardiac vagal activity between the conditions or measurement points. This is in line with previous studies that did not find effects of hypnosis on cardiac vagal activity (Hippel et al., 2001; Kekecs et al., 2016). Regarding methodological considerations, it should be noticed that Hippel et al. (2001) had no control group, however the design of Kekecs et al. (2016) was more similar to our given they had a control group and used an audio recording for the hypnosis induction, which would confirm that hypnosis has no effect on reflected on the measured variables of peripheral physiology. Regarding the studies that did find increases in cardiac vagal activity during hypnosis (Aubert et al., 2009; Chen et al., 2017; VandeVusse et al., 2010), we should note that none of those studies used a control group, and that in all cases the effects sizes were to be interpreted as small. In addition, methodological differences can be reported with regard to hypnosis duration. In VandeVusse et al. (2010), the hypnosis duration was longer (30 min vs. 11min in our study). In Chen et al. (2017) the hypnosis duration was not mentioned, and an hypnotist realized the hypnotic induction. In Aubert et al. (2009), in addition to the fact an hypnotist realized the induction, and that this induction lasted longer than our (from 20 to 30 minutes approximately), baseline was taken eyes open while the hypnosis was realized eyes closed, which alone could account for changes in cardiac vagal activity. This is why the baseline condition should be always resembling as much as possible in its characteristics to the experimental condition in order to make direct comparisons (Laborde et al., 2017).

Findings regarding breathing frequency show no significant differences between hypnosis and the non-hypnotic recording condition, however breathing frequency was significantly higher during the audio listening (either hypnosis or non-hypnotic recording) in comparison to before or after the audio listening. Our hypothesis that breathing frequency as a marker of relaxation would decrease during hypnosis (Lehrer, 2013; Paul, 1969) was therefore not confirmed. The fact that the breathing frequency is increased while either listening to the hypnosis or the non-hypnotic recording may be related to cognitive load. Literature shows indeed that the breathing frequency may be increased while individuals experience cognitive loads (Bernardi et al., 2000; Vlemincx, Taelman, De Peuter, Van Diest, & Van den Bergh, 2011; Wallentin et al., 2011).

Hypnosis, in comparison to the non-hypnotic recording condition, induced a decrease in subjective arousal and a more positive emotional valence. A tendency (*p* = .029) was also found for the hypnosis condition being less stressful than the non-hypnotic recording. It can be concluded that hypnosis created a subjective relaxing state for the participants, in line with previous research (Edmonston, 1977; Sheiner et al., 2016). We may speculate that the statements used in the hypnosis condition helped to prime participants with relaxed feelings, such as in Sheiner et al. (2016). The different findings obtained in our study regarding objective and subjective markers are in line with previous studies where hypnosis suggestion induced a differential response at the subjective and physiological level (Lifshitz et al., 2017; Sheiner et al., 2016). This suggests that objective and subjective parameters should be systematically acquired in parallel, given they represent different facets of the emotional experience of the individual (Scherer, 2005). Further, it is relevant mentioning that the subjective measures of emotional valence and emotional arousal were not supposed to mirror specifically the objective physiological indicators assessed, given both cardiac vagal activity and breathing frequency reflect the adaptation of the organism to a large range of psychophysiological phenomena (Flenady, Dwyer, & Applegarth, 2017; Laborde et al., 2017).

The main limitation of our study is that the hypnotisability of the participants has not been assessed prior to the experiment. The hypnotic state may be influenced by hypnotisability, the individual differences regarding the acceptance of hypnosis by the individual and the effects it has on them (Elkins et al., 2015). Using the Stanford Hypnotic Susceptibility Scale (Weitzenhoffer & Hilgard, 1962) has been taken into consideration, however we chose not to include it to our protocol, given its relationship with cardiac vagal activity is unclear (Diamond et al., 2008; Ray et al., 2000), and given time limitations, because completing this scale requires at least 45 min (Weitzenhoffer & Hilgard, 1962). In addition, our hypnosis recording was much briefer than the induction of the Waterloo-Standford procedure (Bowers, 1998), and might not have been sufficiently potent to provoke changes on CVA and breathing frequency. Consequently future research should investigate more powerful ways of producing relaxation, combining for example the full induction from the Waterloo-Stanford procedure, followed by suggestions for progressive muscle relaxation or guided imagery delivered in hypnosis (Tsitsi, Charalambous, Papastavrou, & Raftopoulos, 2017). Further, our non-hypnotic recording condition was about the Maldive Islands, which can by itself trigger relaxation. If one could criticize this choice, another look at it makes it actually a perfectly suitable control condition, given it was as close as possible to the experimental condition, inducing potentially relaxation, but only differing regarding the instructions specific to hypnosis suggestions.

Conclusion

The aim of this study was to investigate the effects of hypnosis on peripheral physiological markers of relaxation, cardiac vagal activity and breathing frequency, as well as on subjective markers of relaxation. Using a brief recorded hypnosis induction we found no effect on cardiac vagal activity in comparison to a non-hypnotic recording, but an increase of breathing frequency was found while listening to both hypnosis and non-hypnotic recordings. Subjective markers showed a higher relaxation state after the hypnosis induction. Nowadays many videos or audio recording on hypnosis are available on the internet, however the question of their effectiveness remains unanswered. The delivery of the induction by an hypnotist that may take into consideration the reactions of the person may foster hypnosis effectiveness, and would match the fact that the effects of hypnosis may be highly dependent on the relationship between the hypnotist and the client (Haley, 2015). Therefore, further research should consider investigating the same hypnosis script delivered by a hypnotist and by an audio device, and their effects on peripheral physiology.

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