Abstract: This study investigated 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-subjects design. Participants listened to a recorded hypnosis session and to a nonhypnotic recording. No differences were found regarding cardiac vagal activity. Participants breathed significantly faster during the audio conditions (hypnosis and nonhypnotic recording) in comparison to resting measures. After hypnosis, subjective arousal was significantly lower and emotional valence was significantly more positive than after the nonhypnotic recording condition. The relaxing effects of hypnosis that includes relaxation suggestions appear to be located at the subjective level but not at the peripheral physiological level.

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,
Hypnosis generally finds broad application in clinical settings, such as providing analgesia or sedation, or reducing anxiety (Iserson, 2014; Jensen & Patterson, 2014; Montgomery, DuHamel, & Redd, 2000). Hypnosis is deemed to be effective in helping 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.

Hypnotic states are usually induced via listening to a hypnotist, who aims to induce a relaxing state 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, in which 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 vocal characteristics and nonverbal behavior 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 aimed 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 unclear. This is why in this study we focused 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 knowledge base surrounding the effects of hypnosis on cardiac vagal activity is somehow unclear, given that many studies have 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, although 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, & Vandenberghhe, 2009; De Benedittis, 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 have 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 the hypnotizability of participants is also unclear; some studies having found relationships (De Benedittis et al., 1994; Diamond, Davis, & Howe, 2008) and others have 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 a theory linked to HRV, which does not help our understanding of this relationship, given that 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 there have been only two studies (Kekecs et al., 2016; VandeVusse et al., 2010) in which hypnosis was not delivered by an instructor, meaning that standardization of the delivery via audio recording to control for voice and nonverbal 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 that most of the studies have not investigated 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 hypothesize that as hypnosis is set to induce relaxation (Gruzelier, 2002) it will be associated with 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 systematically use a control group, they did not systematically take 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 hypothesized higher cardiac vagal activity as well as decreased breathing frequency during hypnosis compared to the control condition, a nonhypnotic recording.
Regarding subjective ratings of relaxation, given the contradictory findings from the literature, we made no directional hypothesis, but we explored the effects of hypnosis on subjective ratings of stress, arousal, and emotional valence in comparison to the nonhypnotic recording.

**METHOD**

**Participants**

Forty participants (26 male, 14 female), ranging in age from 18 to 29 years ($M = 22.7$ 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 might 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.

**Materials**

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 pregelled 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) and 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$^\text{©}$ (University of Eastern Finland, Kuopio, Finland). The full ECG recording was inspected visually, and artifacts were corrected manually (Laborde et al., 2017). We calculated time domain parameters and used the root mean square of the successive differences (RMSSDs) 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 nonhypnotic recording was based on a documentary about the Maldivian Islands. A music-playing device (JBL Pulse, Los Angeles, California, 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 10 cm, 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 have 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 completed the two conditions on the same day (see Figure 1 for a graphic display of the procedure), given that within-subjects designs are preferred for HRV experiments (Laborde et al., 2017; Quintana & Heathers, 2014). The order of the hypnosis and the nonhypnotic recording conditions was counterbalanced. Our design was planned to consider the three Rs (i.e., resting, reactivity, and recovery) with a preevent, event and postevent measurement phase to better understand cardiac vagal activity functioning, as recommended by Laborde et al. (2017, 2018). During every condition, the participants sat in a chair, knees bent at 90°, feet in a parallel position, and hands positioned on the thighs. Eyes were closed during the entire experiment, and light in the laboratory was not dimmed or turned off at any point. During resting measures, participants sat silently on a chair with no further instructions. The hypnosis

![Figure 1. Study protocol. For the hypnosis and the non-hypnotic recording events, the last 5 min were taken for the cardiac vagal activity analyses.](image-url)
was conducted by playing a sound file recorded by the experimenter. In the nonhypnotic 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/nonhypnotic recording condition. The experiment was conducted individually with each participant.

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 5 minutes for the hypnosis and nonhypnotic recording conditions, given that 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 (Laborde et al., 2017; Malik, 1996). For the questionnaire data, we subtracted baseline from postevent 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-Wilks test showed that the data were still not normally distributed. For the questionnaire data, we used a nonparametric test, the Wilcoxon test, given that we wanted to compare the two conditions (hypnosis vs. nonhypnotic recording condition) within the same sample. For the HRV and breathing frequency data, we wanted to analyze three data points across two conditions; therefore, a natural logarithm transformation was performed (Laborde et al., 2017) followed by repeated measures ANOVAs. Two repeated measures ANOVAs were run to investigate the main and interaction effects of audio condition (hypnosis vs. nonhypnotic recording) and time (i.e., before, during, and after the audio listening) on RMSSD and breathing frequency, respectively.

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. nonhypnotic recording), for subjective stress, subjective arousal, and subjective emotional valence. Given that we performed three tests, we consequently adjusted our \( \alpha \) 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
Subjective emotional valence was found to increase significantly more after the hypnosis condition in comparison to the nonhypnotic recording condition, $Z = 4.013, p < .001$.

**Cardiac Vagal Activity—RMSSD**

Descriptive statistics can be found in Table 2. A repeated measures ANOVA with Geisser-Greenhouse correction was run, with independent variables of condition and time, and dependent variable of the natural logarithm of RMSSD. No significant main effect of condition was found, $F(1, 39) = 1.653, p = .206, \eta^2 = .04$. No significant main effect of time was found, $F(2, 78) = 2.123, p = .127, \eta^2 = .05$. No significant time x interaction effect was found, $F(2, 78) = .347, p = .708, \eta^2 = .01$. Taking gender, test order, and previous experience with hypnosis as covariates did not change the results.

**Breathing Frequency**

A repeated measures ANOVA with Geisser-Greenhouse correction was run, with independent variables of condition and time, and dependent variable of 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 nonhypnotic recording condition) and both resting measures, the one coming before the audio condition ($p = .001, d = .41$) 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,
Table 2
Descriptive Statistics RMSSD and Breathing Frequency

|                  | Neutral hypnosis |            | Control condition |            |
|------------------|------------------|------------|-------------------|------------|
|                  | Before | During | After | Before | During | After | Before | During | After |
| RMSSD            | M      | SD     | M     | SD     | M      | SD    | M      | SD     | M      | SD    |
|                  | 57.81  | 36.07  | 52.31 | 27.17  | 54.50  | 25.66 | 54.56  | 26.94  | 55.65  | 29.11 |
| Breathing frequency | 12.89  | 2.39   | 13.40 | 2.58   | 13.17  | 2.33  | 13.97  | 2.33   | 13.21  | 2.17  |

Note: RMSSD: Root mean square of the successive differences.
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 nonhypnotic recording condition.

This study also provided a methodological advancement via the audio recording, a method that has rarely been used (for exceptions, see Kekecs et al., 2016; VandeVusse et al., 2010). The audio recording enables control of confounding variables linked to participant-to-participant variations in the voice and nonverbal behavior of the experimenter while delivering the hypnosis induction, contributing to reducing 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 nonhypnotic 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 for hypnosis on cardiac vagal activity (Hippel et al., 2001; Kekecs et al., 2016). Regarding methodological considerations, it should be noted that Hippel et al. (2001) had no control group; however, the design of Kekecs et al. (2016) was more similar to ours given that they had a control group and used an audio recording for the hypnosis induction, which would confirm that hypnosis has no effect 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 effect 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 minutes vs. 11 minutes in our study). In Chen et al. (2017), the hypnosis duration was not mentioned, and a hypnotist administered the hypnotic induction. In Aubert et al. (2009), in addition to the fact that a hypnotist administered the induction and that this induction lasted longer than ours (from 20 to 30 minutes approximately), baseline was taken eyes open while the hypnosis was administered eyes closed, which alone could account for
changes in cardiac vagal activity. This is why the baseline condition should always resemble as much as possible 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 nonhypnotic recording condition; however, breathing frequency was significantly higher during the audio listening (either hypnosis or nonhypnotic 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 increased while listening to either the hypnosis or the nonhypnotic recording may be related to cognitive load. Literature indeed shows that 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 nonhypnotic 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 to be perceived as less stressful than the nonhypnotic 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, in which 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 that they represent different facets of the emotional experience of the individual (Scherer, 2005). Furthermore, it is important to note that the subjective measures of emotional valence and emotional arousal were not supposed to mirror the objective physiological indicators assessed, given that 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 hypnotizability of the participants was not assessed prior to the experiment. The hypnotic state may be influenced by hypnotizability—the individual differences regarding the acceptance of hypnosis by the individual and the effect it has on that individual (Elkins et al., 2015). We considered using the Stanford Hypnotic Susceptibility Scale (Weitzenhoffer & Hilgard, 1962); however, we chose not to include it in our protocol, given that its
relationship with cardiac vagal activity is unclear (Diamond et al., 2008; Ray et al., 2000) and because of time limitations—completing this scale requires at least 45 minutes (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 cardiac vagal activity 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). Furthermore, our nonhypnotic 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 that it was as close as possible to the experimental condition, potentially inducing 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 nonhypnotic recording, but an increase of breathing frequency was found while listening to both hypnosis and nonhypnotic recordings. Subjective markers showed a higher relaxation state after the hypnosis induction. Today, many videos and audio recordings on hypnosis are available on the internet, but the question of their effectiveness remains unanswered. The delivery of the induction by a 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 the effects on peripheral physiology.

ACKNOWLEDGMENTS

We would like to thank the members of the research group of Dr. Markus Raab, Institute of Psychology, Department of Performance Psychology, Cologne, Germany, for their critical and helpful comments.
No potential conflict of interest was reported by the authors.

REFERENCES

Aubert, A. E., Verheyden, B., Beckers, F., Tack, J., & Vandenberghe, J. (2009). Cardiac autonomic regulation under hypnosis assessed by heart rate variability: Spectral analysis and fractal complexity. *Neuropsychobiology*, 60(2), 104–112. doi:10.1159/000239686

Bernardi, L., Keller, F., Sanders, M., Reddy, P. S., Griffith, B., Meno, F., & Pinsky, M. R. (1989). Respiratory sinus arrhythmia in the denervated human heart. *Journal of Applied Physiology*, 67(4), 1447–1455. doi:10.1152/jappl.1989.67.4.1447

Bernardi, L., Wdowczyk-Szulc, J., Valenti, C., Castoldi, S., Passino, C., Spadacini, G., & Sleight, P. (2000). Effects of controlled breathing, mental activity and mental stress with or without verbalization on heart rate variability. *Journal of the American College of Cardiology*, 35(6), 1462–1469.

Betella, A., & Verschure, P. F. (2016). The affective slider: A digital self-assessment scale for the measurement of human emotions. *PLoS ONE*, 11(2), e0148037. doi:10.1371/journal.pone.0148037

Billman, G. E. (2013). The effect of heart rate on the heart rate variability response to autonomic interventions. *Frontiers in Physiology*, 4, 1–9. doi:10.3389/fphys.2013.00222

Bowers, K. S. (1998). Waterloo-stanford group scale of hypnotic susceptibility, Form C: Manual and response booklet. *International Journal of Clinical Experimental Hypnosis*, 46, 250–268. doi:10.1080/00207149808410006

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, 25(1), 49–59. doi:10.1016/0005-7916(94)90063-9

Bynion, T.-M., & Feldner, M. T. (2018). Self-Assessment Manikin. In V. Zeigler-Hill & T. K. Shackelford (Eds.), *Encyclopedia of personality and individual differences* (pp. 1–3). Basel, Switzerland: Springer International Publishing.

Chen, X., Yang, R., Ge, L., Luo, J., & Lv, R. (2017). Hypnosis in the treatment of major depression: An analysis of heart rate variability. *International Journal of Clinical Experimental Hypnosis*, 65(1), 52–63. doi:10.1080/00207144.2017.1246873

DeBeneditts, 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 sympatho-vagal balance. *International Journal of Clinical Experimental Hypnosis*, 42, 140–152. doi:10.1080/00207149408409347

Diamond, S. G., Davis, O. C., & Howe, R. D. (2008). Heart-rate variability as a quantitative measure of hypnotic depth. *International Journal of Clinical Experimental Hypnosis*, 56, 1–18. doi:10.1080/00207140701672961

Edmonston, W. E., Jr. (1977). Neutral hypnosis as relaxation. *American Journal of Clinical Hypnosis*, 20(1), 69–75. doi:10.1080/00207140701672961

Elkins, G. R., Barabasz, A. F., Council, J. R., & Spiegel, D. (2015). Advancing research and practice: The revised APA division 30 definition of hypnosis. *International Journal of Clinical Experimental Hypnosis*, 63, 1–9. doi:10.1080/00207144.2014.961870

Facco, E., & Zanette, G. (2017). The Odyssey of Dental Anxiety: From Prehistory to the Present. A Narrative Review. *Frontiers in Physiology*, 8, 1–15. doi:10.3389/fpsyg.2017.01155

Facco, E., Zanette, G., & Casiglia, E. (2014). The role of hypnotherapy in dentistry. *SAAD Digest*, 30, 3–6.

Flenady, T., Dwyer, T., & Applegarth, J. (2017). Accurate respiratory rates count: So should you! *Australasian Emergency Nursing Journal*, 20(1), 45–47. doi:10.1016/j.aenj.2016.12.003
Gemignani, A., Santarcangelo, E., Sebastiani, L., Marchese, C., Mammoliti, R., Simoni, A., & Gelarducci, B. (2000). Changes in autonomic and EEG patterns induced by hypnotic imagination of aversive stimuli in man. *Brain Research Bulletin, 53*(1), 105–111.

Ghosh, D., & Vogt, A. (2012). *Outliers: An evaluation of methodologies*. Paper presented at the Joint Statistical Meetings, San Diego, CA.

Goodwin, K. A., & Goodwin, K. (2017). Methodological control in experimental research. In K. A. Goodwin & C. J. Goodwin (Eds.), *Research in psychology: Methods and design* (pp. 159–188). Hoboken, NJ: Wiley.

Grossman, P. (1983). Respiration, stress, and cardiovascular function. *Psychophysiology, 20* (3), 284–300.

Gruzelier, J. H. (2002). A review of the impact of hypnosis, relaxation, guided imagery and individual differences on aspects of immunity and health. *Stress, 5*(2), 147–163. doi: 10.1080/10253890290027877

Haley, J. (2015). An interactional explanation of hypnosis. *International Journal of Clinical Experimental Hypnosis, 63*, 422–443. doi: 10.1080/00207144.2015.1062696

Hippel, C. V., Hole, G., & Kaschka, W. P. (2001). Autonomic profile under hypnosis as assessed by heart rate variability and spectral analysis. *Pharmacopsychiatry, 34*(3), 111–113.

Iserson, K. V. (2014). An hypnotic suggestion: Review of hypnosis for clinical emergency care. *Journal of Emergency Medicine, 46*(4), 588–596. doi: 10.1016/j.jemermed.2013.09.024

Jensen, M. P., & Patterson, D. R. (2014). Hypnotic approaches for chronic pain management: Clinical implications of recent research findings. *American Psychologist, 69*, 167–177. doi: 10.1037/a0035644

Jiang, H., White, M. P., Greicius, M. D., Waelde, L. C., & Spiegel, D. (2016). Brain activity and functional connectivity associated with hypnosis. *Cerebral Cortex, 27*(8), 4083–4093. doi: 10.1093/cercor/bhw220

Kekecs, Z., Szekely, A., & Varga, K. (2016). Alterations in electrodermal activity and cardiac parasympathetic tone during hypnosis. *Psychophysiology, 53*(2), 268–277. doi: 10.1111/psyp.12570

Lambert, S, Mosley, E, & Mertgen, A. (2018). Vagal tank theory: the three rs of cardiac vagal control functioning – resting, reactivity, and recovery. *Frontiers in Neuroscience, 12*. doi: 10.3389/fin.2018.00458

Lieber, P. M. (2013). How does heart rate variability biofeedback work? Resonance, the baroreflex, and other mechanisms. *Biofeedback, 41*(1), 26–31. doi: 10.5298/1081-5937-41.1.02

Lesage, F.-X., & Berjot, S. (2011). Validity of occupational stress assessment using a visual analogue scale. *Occupational Medicine, 61*(6), 434–436. doi: 10.1093/occmed/kqr037

Lesage, F.-X., Berjot, S., & Deschamps, F. (2012). Clinical stress assessment using a visual analogue scale. *Occupational Medicine, 62*, 600–605. doi: 10.1093/occmed/kqs140

Lifshitz, M., Sheiner, E. O., Olson, J. A., Theriault, R., & Raz, A. (2017). On suggestibility and Placebo: A follow-up study. *American Journal of Clinical Hypnosis, 59*(4), 385–392. doi: 10.1080/00029157.2016.1225252

Malik, M. (1996). Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *European Heart Journal, 17*, 354–381.

Montgomery, G. H., DuHamel, K. N., & Redd, W. H. (2000). A meta-analysis of hypnotically induced analgesia: How effective is hypnosis? *International Journal of Clinical Experimental Hypnosis, 48*, 138–153. doi: 10.1080/00207140008410045

Naito, A., Laidlaw, T. M., Henderson, D. C., Farahani, L., Dwivedi, P., & Gruzelier, J. H. (2003). The impact of self-hypnosis and Johrei on lymphocyte subpopulations at exam
time: A controlled study. *Brain Research Bulletin*, 62(3), 241–253. doi:10.1016/j.brainresbull.2003.09.014

Paul, G. L. (1969). Physiological effects of relaxation training and hypnotic suggestion. *Journal of Abnormal Psychology*, 74, 425–437.

Quintana, D. S., & Heathers, J. A. (2014). Considerations in the assessment of heart rate variability in biobehavioral research. *Frontiers in Physiology*, 5, 805. doi:10.3389/fpsyg.2014.00805

Rainville, P., Hofbauer, R. K., Bushnell, M. C., Duncan, G. H., & Price, D. D. (2002). Hypnosis modulates activity in brain structures involved in the regulation of consciousness. *Journal of Cognitive Neurosciences*, 14(6), 887–901. doi:10.1162/089892902760191117

Ray, W. J., Sabsevitz, D., De Pascalis, V., Quigley, K., Aikins, D., & Tubbs, M. (2000). Cardiovascular reactivity during hypnosis and hypnotic susceptibility: Three studies of heart rate variability. *International Journal of Clinical Experimental Hypnosis*, 48, 22–31.

Roberts, A. (2010). *The complete human body*. London, UK: Dorling Kindersley Limited.

Ruffoli, R., Giorgi, F. S., Pizzanelli, C., Murri, L., Paparelli, A., & Fornai, F. (2011). The chemical neuroanatomy of vagus nerve stimulation. *Journal of Chemical Neuroanatomy*, 42(4), 288–296. doi:10.1016/j.jchemneu.2010.12.002

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information*, 44, 695–729. doi:10.1177/0539018405058216

Scott, J., & Huskisson, E. C. (1976). Graphic representation of pain. *Pain*, 2(2), 175–184.

Sheiner, E. O., Lifshitz, M., & Raz, A. (2016). Placebo response correlates with hypnotic suggestibility. *Psychology of Consciousness: Theory, Research, and Practice*, 3(2), 146–153. doi:10.1037/cns0000074

Sherwood, L. (2006). *Fundamentals of physiology: A human perspective* (3rd ed.). Belmont, CA: Brooks/Cole.

Simon, I. M. (2012). *Zehn Hypnosen. Band 3: Burnout*. [Ten hypnosis inductions. Vol. 3: Burnout]. St. Wendel, Germany: Verlag Ingo Simon.

Tarvainen, M. P., Niskanen, J. P., Lipponen, J. A., Ranta-Aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV–Heart rate variability analysis software. *Computer Methods Programs Biomedical*, 113(1), 210–220. doi:10.1016/j.cmpb.2013.07.024

Terathongkum, S., & Pickler, R. H. (2004). Relationships among heart rate variability, hypertension, and relaxation techniques. *Journal of Vascular Nursing*, 22(3), 78–82. doi:10.1016/j.jvn.2004.06.003

Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine*, 37, 141–153. doi:10.1007/s12160-009-9101-z

Tsitsi, T., Charalambous, A., Papastavrou, E., & Raftopoulos, V. (2017). Effectiveness of a relaxation intervention (progressive muscle relaxation and guided imagery techniques) to reduce anxiety and improve mood of parents of hospitalized children with malignancies: A randomized controlled trial in Republic of Cyprus and Greece. *European Journal of Oncology Nursing*, 26, 9–18. doi:10.1016/j.ejon.2016.10.007

VandeVusse, L., Hanson, L., Berner, M. A., & White Winters, J. M. (2010). Impact of self-hypnosis in women on select physiologic and psychological parameters. *Journal of Obstetric, Gynecologic, and Neonatal Nursing*, 39(2), 159–168. doi:10.1111/j.1552-6909.2010.01103.x

Vlemincx, E., Taelman, J., De Peuter, S., Van Diest, I., & Van den Bergh, O. (2011). Sigh rate and respiratory variability during mental load and sustained attention. *Psychophysiology*, 48(1), 117–120. doi:10.1111/j.1469-8986.2010.01043.x
Wallentin, M., Nielsen, A. H., Vuust, P., Dohn, A., Roepstorff, A., & Lund, T. E. (2011). Amygdala and heart rate variability responses from listening to emotionally intense parts of a story. *NeuroImage, 58*(3), 963–973. doi:10.1016/j.neuroimage.2011.06.077

Weitzenhoffer, A. M., & Hilgard, E. R. (1962). *Stanford hypnotic susceptibility scale, Form C*. Palo Alto, CA: Consulting Psychologists Press.

Williams, V. S., Morlock, R. J., & Feltner, D. (2010). Psychometric evaluation of a visual analog scale for the assessment of anxiety. *Health and Quality of Life Outcomes, 8*, 57. doi:10.1186/1477-7525-8-57

Yuksel, R., Ozcan, O., & Dane, S. (2013). The effects of hypnosis on heart rate variability. *International Journal of Clinical Experimental Hypnosis, 61*(2), 162–171. doi:10.1080/00207144.2013.753826

**APPENDIX: NEUTRAL HYPNOSIS SCRIPT**

Please get yourself comfortable, close your eyes, and then we will begin. While you are sitting here, in the laboratory at the German Sports University, you may hear some noises in the background but try to ignore them, follow my voice, and start to relax deeper and deeper. You may start to notice that your body slowly feels a bit heavier. As you relax deeper, your arms and legs may also start to feel heavier. Move your attention to your breathing, perhaps you notice that your breathing becomes slower and deeper. This is also helping you to relax further. I will now start to count down from 10 to 0. When I reach 0, you will be ten times more relaxed than you are now. Imagine that, with every stage of the countdown, you take a step downwards a staircase, or you take the lift to a lower floor, or maybe you have your own image in your mind. I will now count down from 10 to 0, and by the time I reach 0, you will be ten times more relaxed than you are now. Ten, nine, eight, seven. Already you notice that you slowly become more and more relaxed. Seven, six, five, four. You relax deeper and deeper. Four, three, two, one, and zero. You are now ten times more relaxed than you were before. Perhaps you notice the feeling of relaxation right now, perhaps a bit later, that’s absolutely fine. I’d like to invite you now to use your imagination to visit a place where you feel absolutely comfortable. Maybe a place from your everyday life, maybe a fictitious place. Perhaps you think of a beach or a forest, maybe you have your very own imaginary place. If you are at your own place by now, take a moment to look around and see what you can see. Maybe you can also listen to what there is to hear at your place. And maybe your place has its own smell. Take in all of the senses and impressions of your place and feel absolutely relaxed. Feel absolutely relaxed. Feel absolutely relaxed. For the last time, take in all the impressions and senses of your place. I will now count from the number 1 to 5. When I reach number 5, you can open your eyes again, and you will be back in the here and now, you will feel free and easy. When I reach 5, you can open your eyes, you are back in the here and now. One, two, three, four, five. Open your eyes.

Die Effekte einer kurzen hypnotischen Entspannungsinduktion auf subjektive psychologische Zustände, kardiale vagale Aktivität und Atemfrequenz

**SYLVAIN LABORDE, SEBASTIAN HEUER, UND EMMA MOSLEY**
Abstract: Diese Studie untersuchte die Effekte einer kurzen Hypnose, die Entspannungssuggestionen beinhaltete, auf physiologische Marker wie Entspannung, kardiale vagale Aktivität und Atemfrequenz. 40 Teilnehmer wurden in einem within-subjects-Design getestet. Die Teilnehmer hörten eine aufgenommene Hypnosesitzung und eine nicht-hypnotische Aufnahme. Bezüglich der kardialen vagalen Aktivität wurden keine Unterschiede gefunden. Die Teilnehmer atmeten signifikant schneller während der Aufnahmen (hypnotische und nicht-hypnotische Aufnahmen) im Vergleich zum Ruhezustand. Nach Hypnose war die subjektive Aufregung (Intensität) signifikant niedriger und die emotionale Wertigkeit (Wertung) signifikant positiver als nach der nicht-hypnotischen Aufnahme. Die entspannenden Effekte von Hypnose, die Entspannungssuggestionen beinhaltet, scheinen auf der subjektiven jedoch nicht auf der peripheren physiologischen Ebene zu liegen.

STEPHANIE RIEGEL, M.D.

Les effets d’une brève induction de relaxation hypnotique sur les états psychologiques subjectifs, l’activité vagale cardiaque et la fréquence respiratoire

SYLVAIN LABORDE, SEBASTIAN HEUER ET EMMA MOSLEY

Résumé: Les auteurs de cette étude ont examiné les effets d’une brève hypnose comprenant des suggestions de relaxation sur les marqueurs physiologiques de la relaxation, soit l’activité vagale cardiaque et la fréquence respiratoire. Quarante personnes ont participé à une étude de conception intra-sujet. Les participants ont écouté une séance d’hypnose enregistrée et un enregistrement non hypnotique. Aucune différence n’a été observée concernant l’activité vagale cardiaque. De façon significative, les participants respiraient plus rapidement pendant qu’ils écoutaient l’enregistrement (hypnotique et non hypnotique) que lorsqu’ils étaient au repos. Après l’hypnose, l’excitation subjective était significativement plus faible et la valence émotionnelle était significativement plus positive qu’elles ne l’étaient après l’écoute de l’enregistrement non hypnotique. Les effets relaxants de l’hypnose qui comprend des suggestions de détente semblent se situer au niveau subjectif, et non au niveau physiologique périphérique.

JOHANNE RAYNAULT
C. Tr. (STIBC)

Efectos de una inducción hipnótica breve de relajación sobre estados psicológicos subjetivos, actividad vagal cardíaca y frecuencia respiratoria.

SYLVAIN LABORDE, SEBASTIAN HEUER Y EMMA MOSLEY

Resumen: Este estudio investigó los efectos de una inducción hipnótica breve con sugerencias de relación sobre indicadores fisiológicos de relajación, actividad vagal cardíaca y frecuencia de respiración. Se evaluaron a 40 participantes en un diseño intra-sujeto. Los participantes escucharon una sesión hipnótica grabada y una grabación no-hipnótica. No se
encontraron diferencias en la actividad vagal cardiaca. Los participantes respiraron significativamente más rápido durante las sesiones de audio (grabaciones con y sin hipnosis) en comparación a las mediciones en reposo. Después de hipnosis, la vigilia subjetiva fue significativamente menor mientras la valencia emocional fue significativamente más positiva que después de las grabaciones no-hipnóticas. Los efectos relajantes de la hipnosis que incluyen sugerencias de relajación parecen estar localizadas a nivel subjetivo pero no a nivel fisiológico periférico.

OMAR SÁNCHEZ-ARMÁSS CAPPELLO

Autonomous University of San Luis Potosi, Mexico