

## Full-Length Article

**Relaxation Effects of Musically Guided Resonance Breathing: A Randomized Controlled Pilot Study**Dominik Fuchs<sup>1</sup>, Thomas K. Hillecke<sup>2</sup>, Marco Warth<sup>3</sup><sup>1</sup>University of Applied Sciences Kempten, Kempten, Germany<sup>2</sup>School of Therapeutic Sciences, SRH University Heidelberg, Heidelberg, Germany<sup>3</sup>Heidelberg University, Heidelberg, Germany**Abstract**

Music therapy and resonance breathing (breathing at about 0.1 Hz) may be effective in treating stress-related symptoms and promoting relaxation. However, no identified study has explicitly explored the potential of integrating the working mechanisms into a combined approach using live played music to guide respiration. Therefore, the objective of the present pilot study was to evaluate the psychophysiological effects of a combined intervention. A total of 60 healthy adults were randomized to either the experimental group or the control group (where participants listened to prerecorded relaxation music). Heart rate and heart rate variability were extracted for the following 5-minute segments: Resting baseline, stress task, intervention, resting post-intervention. Additionally, self-evaluation scores for relaxation and general well-being were assessed with visual analogue scales. Significant time  $\times$  group interaction effects were found for general well-being ( $p = .028$ ) and heart rate variability as measured by RMSSD ( $p < .001$ ), indicative of increased parasympathetic outflow in the experimental group. In conclusion, the combination of music therapy and resonance breathing seems to be a well-received and effective way to induce relaxation and well-being in healthy adults.

**Keywords:** *Music Therapy, Heart Rate Variability, Relaxation, Respiration*multilingual abstract | [mmd.iammonline.com](http://mmd.iammonline.com)

Stress generally describes “an actual or anticipated disruption of homeostasis or an anticipated threat to well-being” [1]. Challenging stimuli require adaptive behavior that involves a set of involuntary physiological changes (e.g. increases in heart rate (HR), blood pressure and respiration rate) known as the stress response or fight-or-flight response [2,3]. These physiological responses are mainly triggered by increased arousal in the sympathetic branch of the autonomic nervous system (ANS) [3]. Psychological stress has a considerable impact on health and well-being in general [4]. In case of ongoing or chronic psychological or physical stress, the stress response can be detrimental to health and lead to the onset or progression of diseases [5,2]. Chronic stress, for instance, can increase the risk of cardiovascular disease [6].

In a similar manner, a coordinated set of reproducible physiological changes have been observed during physical conditions of rest and relaxation, involving parasympathetic modulation of the ANS that manifest in decreases in HR and blood pressure, and an increase in heart rate variability (HRV). It is also referred to as the relaxation response (RR) [2,3]. The RR can be voluntarily elicited and has thus been therapeutically harnessed to alleviate several stress-related symptoms [2,3].

As a non-invasive and accurate index of the ANS activity, HRV (the variation in the time interval between heartbeats) has become a popular tool both in clinical and investigational contexts and is now widely seen as a psychophysiological marker of mental and physical well-being [7,8]. HRV reflects the complex relationship of the sympathetic and parasympathetic divisions of the ANS and attempts to depict their relative contributions [9]. High HRV is associated with emotional resilience and lower stress vulnerability [10,11] as well as an individual’s overall physical health and autonomic flexibility and is characteristically higher during periods of rest and relaxation [12–14]. On the contrary, HRV is typically lower in illness [15,14] as well as mental, occupational (work-related) and physiological stress [16–19].

Large increases in HRV are generated when the ANS is rhythmically stimulated by a respiration rate of approximately 6 breaths per minute [20]. An individual’s ideal breathing rate for generating utmost increases in both HRV and baroreflex

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activation (their “resonance frequency”) varies slightly from person to person (mainly based on individual differences in physiology) and is usually found in the range of 4.5 and 6.5 breaths per minute [20,21]. The maximization of HRV is predominantly due to resonance properties of the cardiovascular system linked to the baroreflex and the respiratory sinus arrhythmia (RSA), a physiological phenomenon that causes increases and decreases in HR in accordance with inhalation and exhalation [21,20]. A fairly new way to augment vagal (i.e., parasympathetic) HR regulation is respiratory training to increase HRV, also called resonance (or resonant) breathing (RB) or HRV biofeedback (if biofeedback training is involved and the individual resonance frequency for each participant is ascertained).

Yasuma & Hayano [22] have also shown improvement in respiratory gas exchange by increased RSA, which in turn promotes respiratory efficiency. But heartbeat synchronizes with respiratory rhythms only when people breathe at about 6 breaths per minute [23,24]. A growing body of research shows a wide variety of disorders that seem to respond well to RB and HRV biofeedback, including stress-related diseases like depression [25], post-traumatic stress disorder [26], various anxiety disorders and stress symptoms, as well as hypertension [27].

Thus far, most studies focused on the long-term effects of biofeedback-based RB over 10 or more sessions. However, some studies have also investigated short term effects of a single session [28]. For instance, Prinsloo et al. [29] found improved cognitive performance during a stress task, a state of “alert relaxation”, increased HRV [18] and a short term carry-over effect during the following periods in healthy adults. They suggest it may be a valuable tool to include in the management of acute stress.

Music interventions are frequently used to induce psychophysiological relaxation, as measured by HR, respiration rate and HRV [9]. In music therapy (MT), the therapeutic relationship between patient and therapist, which is built up on music, is essential (whether the music is live or prerecorded). The client either listens to music (receptive MT) or creates music (active MT) [30,31]. The most common goal for receptive MT is relaxation [31]. A meta-analysis by Pelletier [32], which included prerecorded music only, showed that in 22 studies, music or music assisted interventions induced relaxation and decreased arousal ( $d = .67$ ). Despite the heterogeneity of the studies included, Hodges [33] found that music can alter blood pressure and HR. While stimulating music generally increases HR, blood pressure and accelerates respiration, sedative music (i.e., slow tempo, legato phrasing, only marginal dynamic contrasts [9]) usually has opposite effects [34]. Despite the mentioned benefits of HRV as an outcome, the literature on HRV and music is still quite sparse [9].

Few studies compared live music with recorded music. Investigations in hospice setting [35], with children [36] and with preterm infants [37] showed superior results for live music for reducing stress and promoting relaxation.

To guide respiration, Grossman & Taylor [38] consider „an auditory signal that patterns inspiration and expiration times to be most effective, in terms of comfort, ease, and quickness to learn” (p.267). However, these signals are usually artificial and not played by a trained music therapist with live instruments.

Breathing is an endogenous rhythm. Rhythm is also an important working factor of music in therapeutic contexts and is considered the “missing link” between music, physiology and medicine [39]. With a process referred to as *entrainment*, our goal was to couple the endogenous rhythm of respiration with the exogenous rhythm of music [9,40].

The objective of this pilot study was to investigate the feasibility and acute relaxation effects of musically guided RB while comparing it to a music intervention that used prerecorded relaxation music and no RB. We hypothesized that 1) both interventions would yield a psychophysiological RR in the participants (measured by HR and HRV), 2) the interventions would lead to increases in self-rated relaxation and well-being, and 3) psychophysiological effects in the experimental group (EG) would be larger than those of the control group (CG).

## Methods and Materials

### Participants and Design

A total of 60 healthy adults between the ages of 19 and 53 years ( $M = 27.65$ ,  $SD = 8.557$ ), with similar distributions between groups (Table 1), participated in the study. Prior to testing, participants were randomly assigned to either the EG with musically guided RB or the CG using an online software application (Sealed Envelope™; London, UK). Excluded from the study were participants with cardiac arrhythmia, a bodily disease, endocrine dysfunction, or a psychopathological finding. Also excluded were participants under the influence of drugs that affect the nervous system, participants with a cardiac pacemaker, and participants with severe obesity ( $BMI > 35$ ) or anorexia ( $BMI < 17.5$ ). Before signing the informed consent and completing a basic questionnaire, participants were asked to read the schedule of the study. Participation was entirely voluntary and could be terminated at any time. The study was conducted from March 13, 2015 to June 11, 2015 in the Lab for Pain Research in Heidelberg, Germany. It has been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Table 1  
Baseline Participant Characteristics by Treatment Group

	EG (n = 30)	CG (n = 30)	P-value
Age (years)	26.77 ± 6.78	28.53 ± 10.07	.43
Gender (M/F)	7/23	10/20	.39
BMI	22.19 ± 2.71	22.51 ± 2.80	.65
Good Relaxation Ability (yes)	24	18	.09
Psychological Stress (yes)	13	14	.80
Smokers (>10 Cigs/day)	7	10	.39
Time of session (p.m.)	3.57 ± 2.56	3.20 ± 2.77	.60

Note. Values are expressed as M ± SD. BMI, Body mass index. Good Relaxation Ability, a good subjective ability to relax. Psychological Stress, acute psychological stress.

**Procedure**

**Stress task.** Prior to the onset of the interventions, participants participated in a stress task adapted from the “Maastricht Acute Stress Test” (MAST), which is a brief and simple laboratory stress test. It entails stressful features of the commonly used *Trier Social Stress Test* (cognitive tasks) and the *Cold Pressor Test* (physical stressor), and is capable of eliciting the stress response [41]. In our study, it consisted of a short instruction phase (about 5 minutes) and the actual task (about 5 minutes). For a procedure outline of the entire study, s. Table 2.

**Interventions.** In the EG, the music therapist received direct physiological feedback information which was made visible on a computer screen. The information consisted of the current respiratory frequency (numbers with one decimal place) and a respiration curve. With the aid of this feedback information, the therapist tried to musically guide the participant to breathe at a low frequency (ideally at about 6 breaths/minute). In addition, participants were told to use abdominal breathing and were instructed to relax and breathe comfortably without straining [18,42]. They were instructed to follow the music with their breathing. The musical stimuli consisted of a monochord sound as the signal for inspiration, and simple humming or toning (1 – 3 notes with the monochord-tone as the keynote) as the signal for expiration. These specific sounds were chosen, because we wanted the signals to be sufficiently different, yet pleasant and relaxing. Both monochord sounds and humming are known to have relaxation benefits [43]. These sounds can be easily distinguished and blend well to generate a pleasant musical environment.

In the CG, participants listened to relaxation music (“Peaceful Journey” by composer and sound therapist Jonathan Goldman [click here to listen](#)). The music was chosen according to recommendations for physiologically relaxing music by Pelletier [32] and Grocke & Wigram [31]. Participants listened for 15 minutes over headphones that enabled them to adjust the volume to their convenient level. Participants were asked to breathe calmly and to relax to the

best of their ability. Participants of both groups were advised to keep their eyes closed during the intervention.

The interventions were delivered by skilled music therapists (with academic degree, at least B.A.) that were trained for the specific intervention prior to administration.



Figure 1. Image of the Monochord used, all strings were tuned to the same note, Middle C.

**Outcome Measures and Equipment**

HRV was our primary outcome. We used a *Polar Watch* model *RS800CX* and an appropriate chest belt that was applied prior to baseline for continuous recording of beat-to-beat intervals of the HR in milliseconds during the measurement time points (Table 2). Physiological raw data were prepared with *Polar ProTrainer 5*. With the program *Kubios v2.1*, we then transformed these tables into HRV parameters based on successive 5-minute samples for further statistical analyses with *IBM SPSS Statistics 20*.

During the 15-minutes intervention and a 5-minute post-intervention resting period we additionally measured respiratory data as feedback for the therapist. Respiration was measured with a belt around the belly. A *NeXus-16*® interface sent the signal to the *BioTrace+* software on a computer via *Bluetooth*.

Two different visual analogue scales (VAS) were utilized to assess participants’ subjective feelings of relaxation (from 0=*very tense* to 10=*very relaxed*) and general well-being (from 0=*very bad* to 10=*very good*). Subjective ratings were assessed at baseline, post-task and post-intervention (Table 2). After randomization and signing the informed consent, and before the first VAS measurement, participants were asked to fill out a basic questionnaire on general health (exclusion criteria) and a demographic interview. Concerning the self-

report scales, we chose “general well-being” and “relaxation” to have an estimate of the subjective state of relaxation pre-task, post-task, and post-intervention. These VAS allowed for a more comprehensive interpretation of the experiment.

**Data Reduction**

For short-term HRV measurements, 5-minute segments are most appropriate [44]. Segments were extracted from the continuous HRV data for baseline, task, the intermediate 5 minutes of the intervention, and 5-minute resting post-intervention. We analyzed mean HR, the Root Mean Square of the Successive Differences (RMSSD), low frequency (LF) power and high frequency (HF) power. HR is an important marker of stress and relaxation [45,13,3]. Studies that involve RSA measurements should report mean HR along with RSA in order to provide a better basis for interpretation [38]. RMSSD is a recommended marker of parasympathetic activity in short term measurements [44,46]. Furthermore, RMSSD provides a good assessment of RSA [47,46]. We also used frequency-domain measures, since they allow for a more accurate analysis of the relative contributions of the physiological mechanism of the ANS [44]. Low frequency is the band of power spectrum range between 0.04 and 0.15 Hz, and represents both sympathetic and parasympathetic nervous system activity. The high frequency spectrum ranges between 0.15 and 0.4 Hz and is an estimate of cardiac vagal tone [46]. HF power usually represents RSA. In case of low respiration rates (below 8.5 breaths per minute), however, RSA falls within the LF band. Thus, when participants are relaxed or breathe slowly, the LF values can be very high, indicating increased vagal outflow rather than increased sympathetic activity [8,46].

**Data Analysis**

Independent t-tests and Chi<sup>2</sup>-tests were conducted in order to investigate group characteristics pre-intervention.

We carried out 2 (Group: EG, CG) × 4 (Time: baseline, task, intervention, post-intervention) repeated measures analyses of variance (ANOVAs) to test for differences and changes in mean HR and each of the abovementioned HRV measures separately. Specifically, main effects of group and time, as well as group × time interaction effects were assessed. For our statistical analyses, we used log-transformed values of LF power (LF HRV) and HF power (HF HRV) to control for skewness and meet the assumptions for homogeneity (tested by Levene’s test). In case of asphericity, the Greenhouse-Geisser adjustment was used.

Post hoc comparisons were made, to determine in which part of the experiment the effects were located, with the Bonferroni correction for significance. Since the presence of interaction limits the generalizability of main effects, we tested simple main effects (i.e., pairwise comparisons) in case of interaction effects, to determine in which way the variable in question has its significant effect (i.e., comparing the combinations at the different levels of the independent variables).

VAS were analyzed using a 2(group: EG, CG) × 3(Time: baseline, post-task, post-intervention) repeated measures ANOVA. With any of the ANOVAs, we calculated partial eta squared ( $\eta_p^2$ ) to quantify the size of the observed effects.

For all study hypotheses tests, type-I error probability is set to  $\alpha=.05$ . Statistical analysis was conducted using SPSS Version 20.

**Table 2. Procedure Overview with measurement time points**

	5	10	15	20	25	30	35	40	45	50
Baseline	VAS 1									
		HRV 1								
Stress Task				HRV 2						
Post-task					VAS 2					
Intervention							HRV 3			
Post-intervention									HRV 4	
										VAS 3

Note. Numbers in the first line describe minutes.

**Results**

**Participant Characteristics**

During baseline, both groups showed statistically comparable distributions of age and gender (Table 1), and were comparable regarding data from the basic questionnaire, BMI, smoking habits, and time of the session (circadian rhythms can influence HRV, see [48]).

**HRV**

Results of mean HR and HRV during baseline revealed no significant differences between groups in autonomic tone prior to the stress task. Table 3 shows means and standard deviations for HR and HRV measures for both groups throughout the four time points.

Mean HR increased during task and decreased below baseline level during intervention and remained on this level afterwards, showing a main effect of time,  $F(2.05, 119.13) = 50.26, p < .001, \eta_p^2 = .46$  (Figure 1). Subsequent post hoc testing revealed that, compared to baseline ( $M = 78.46, SD = 14.94$ ), HR increased significantly ( $p = .006$ ) during task ( $M = 84.27, SD = 14.51$ ) and decreased significantly ( $p < .001$ ) during intervention ( $M = 71.51, SD = 10.28$ ) and post-intervention ( $M = 71.83, SD = 9.92$ ).

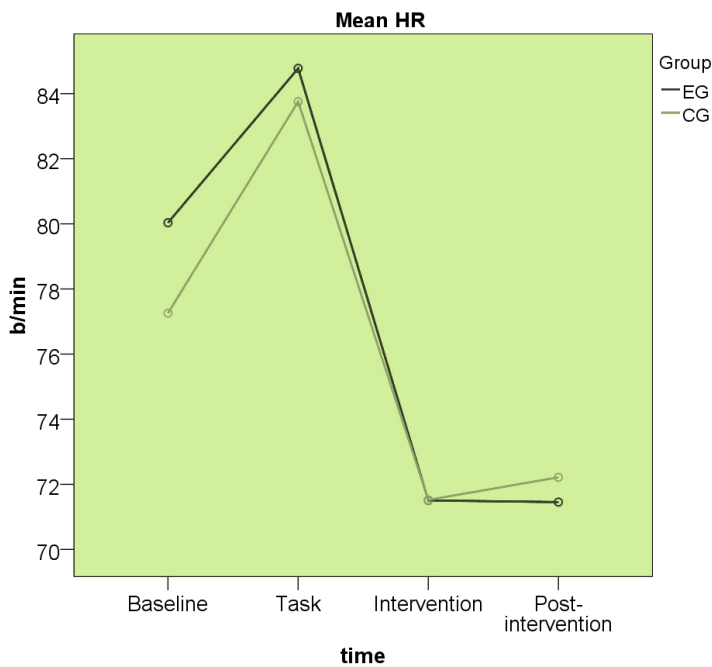


Figure 1. Mean HR (beats per minute). EG = Experimental group. CG = Control group.

RMSSD was lowered during stress task and augmented during intervention in both groups (Figure 2) with a significant main effect of time,  $F(2.53, 146.51) = 24.46, p < .001, \eta_p^2 = .30$ . There was also an interaction effect,  $F(2.53, 146.51) = 6.60, p =$

$.001, \eta_p^2 = .10$ . Post hoc analyses revealed that during intervention, RMSSD in the EG and CG differed significantly ( $p = .029$ ). Furthermore, pairwise comparisons for each of the variables uncovered that only in the EG, RMSSD was significantly larger during intervention and post-intervention compared to baseline ( $p < .001$  and  $p = .001$ , respectively).

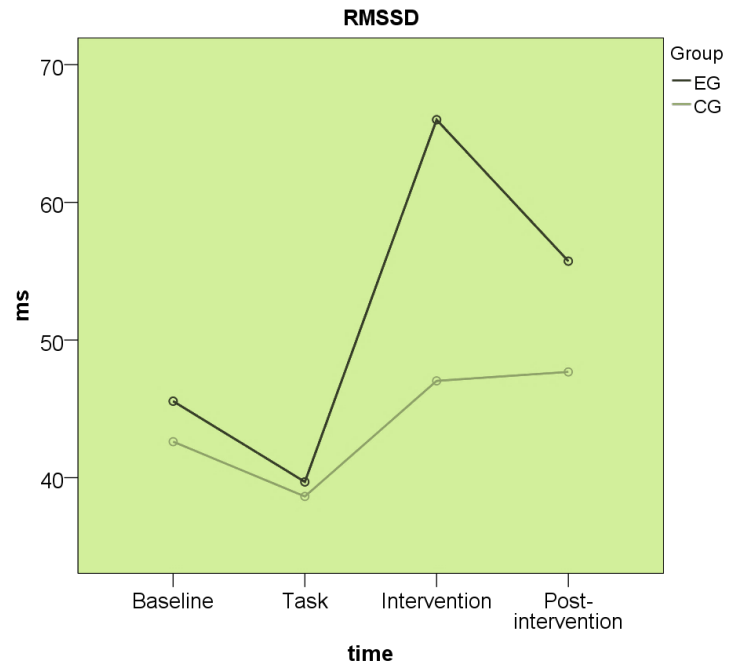


Figure 2. RMSSD (milliseconds). EG = Experimental group. CG = Control group.

LF HRV increased during task and intervention and decreased in both groups afterwards, resulting in a main effect of time,  $F(2.65, 153.79) = 12.84, p < .001, \eta_p^2 = .18$ . Analysis also revealed a main effect of group,  $F(1, 58) = 8.12, p = .006, \eta_p^2 = .12$ . Similar to RMSSD, a significant interaction effect,  $F(2.65, 153.79) = 14.12, p < .001, \eta_p^2 = .20$ , with a large effect size was found, mainly due to a strong augmentation within the EG during intervention. Simple effects showed a significant group difference in intervention ( $p < .001$ ) and post-intervention ( $p = .015$ ), as well as a significant difference from baseline to intervention, and post-intervention only in the EG ( $p < .001$  and  $p = .001$ , respectively).

A significant main effect of time was detected for HF HRV,  $F(3, 174) = 6.45, p < .001, \eta_p^2 = .10$ , which decreased during task and increased both during intervention and post-intervention in a comparable manner within participants (Figure 4). Post hoc tests showed a significant effect by comparing baseline ( $M = 6.29, SD = 1.16$ ) with post-intervention ( $M = 6.56, SD = 1.21$ ),  $p = .036$ .

**Table 3 HR and HRV Measures Throughout Testing in the EG and CG**

Variable	Group	Baseline	Stress Task	Relaxation Intervention	Post-Intervention
HR (b/min)	EG	80.03 ± 16.84	84.78 ± 13.35	71.51 ± 10.92	71.45 ± 10.02
	CG	77.26 ± 12.90	83.76 ± 15.80	71.52 ± 9.78	72.21 ± 9.98
RMSSD (ms)	EG	45.55 ± 24.85	39.70 ± 20.78	66.00 ± 38.00	55.73 ± 31.72
	CG	42.62 ± 26.05	38.64 ± 18.91	47.03 ± 26.72	47.68 ± 24.86
LF HRV	EG	6.91 ± .86	7.38 ± .78	8.64 ± 1.10	7.66 ± 1.08
	CG	7.07 ± .94	7.37 ± .84	7.11 ± 1.13	7.00 ± .94
HF HRV	EG	6.40 ± 1.23	6.21 ± 1.07	6.56 ± 1.31	6.64 ± 1.30
	CG	6.17 ± 1.09	6.13 ± .88	6.42 ± 1.07	6.49 ± 1.13

Note. Values are expressed as M ± SD.

**VAS**

Comparable distributions during baseline were shown for the VAS. No main effects of group were found in either of the VAS. For means and standard deviations, see Table 4. Subjective relaxation showed a main effect of time,  $F(2, 116) = 123.39, p < .001, \eta_p^2 = .68$ . Compared to baseline level, values first significantly decreased and then significantly increased,  $p < .001$ , as post hoc tests revealed. VAS for general well-being displayed both a significant main effect for time,  $F(1.62, 94.04) = 74.78, p < .001, \eta_p^2 = .56$ , and a significant interaction effect,  $F(1.62, 94.04) = 4.07, p = .028, \eta_p^2 = .07$ . Post hoc analyses didn't show significant group difference during the 3 measurement points, but Table 4 shows that differences between time points were larger in the EG. Especially the difference between baseline and post-intervention is larger in the EG ( $p < .001$ ) than in the CG ( $p = .011$ ).

**Table 4 VAS Data**

Variable	Group	Baseline	Post-Task	Post-Intervention
VAS relaxation	EG	6.16 ± 8.40	4.48 ± 8.33	8.95 ± 8.91
	CG	6.14 ± 7.98	4.85 ± 8.29	8.23 ± 8.24
VAS general well-being	EG	7.08 ± 8.33	4.94 ± 8.05	8.48 ± 8.66
	CG	7.24 ± 8.18	5.70 ± 7.92	7.89 ± 8.17

Note. Values are expressed as M ± SD.

**Discussion**

In this study, we tried to examine the feasibility of a combined MT and RB intervention and we showed that MT and RB can be coupled in an intervention that is able to induce relaxation. We expected a psychophysiological RR reflecting in both the cardiorespiratory and the self-evaluation data in either group, with larger effects in the EG. Our findings broadly confirmed these hypotheses.

**HRV**

ANS markers indicated a RR in both groups, represented by a significant drop of HR below baseline level and an increase in

parasympathetic mediated HRV (RMSSD and HF HRV) above baseline level during intervention. During the stress task, a stress response could be detected.

The expected between-group differences could be seen in the results of RMSSD. During intervention, RMSSD in the EG increased significantly more than in the CG and remained on a higher level after intervention, suggesting a stronger parasympathetic activation and a short-term carry over effect in the EG. Group differences during intervention in these measures were expected based on our literature review.

HF HRV showed a roughly similar progression, that is, lowered values during stress task (suggesting decreased vagal tone) and increased values (suggesting increased vagal tone) afterwards. LF HRV increased during stress task (while HF HRV decreased), indicative of increased sympathetic influence. The LF HRV increase is interpreted as being sympathetically driven, because it was a stressful situation with normal or accelerated breathing. However, it is important to remember how the LF band reflects both the sympathetic and the parasympathetic nervous system, and particularly that it almost entirely represents parasympathetic activity during slow breathing [46,23]. During intervention, LF HRV decreased in the CG, while it profoundly increased in the EG (similar to RMSSD), which is representative of RSA and PNS activity, since the respiration rate was substantially lowered.

The decreased respiration rate was likely the main therapeutic mechanism to increase HRV by such a degree. While we did not measure respiration rate, we have no reason to believe that the CG breathed as slowly as the EG. In fact, HRV data suggests that the respiration rate in the EG was at about 6/minute during the intervention for most participants, which can be comprehended with a look at the HRV frequency spectra: There is a fairly narrow and large LF peak at about 0.1 Hz in the EG compared to a broader and smaller LF peak in the CG.

Controlled breathing requires an amount of mental concentration and thus might inhibit parasympathetic nerve activity [49]. The positive results concerning subjective relaxation, well-being (VAS) and markers of PNS activity could be an indication that we might have been able to reduce the mental effort for participants to a minimum. Additionally,

the relaxation would presumably have been larger when participants would have been in supine position during intervention (which we avoided to keep the different time points comparable).

### VAS

By including self-evaluation measures, we aimed at a more comprehensive understanding of the interplay of emotional and cardiorespiratory changes. Results of the two scales were similar to each other in two ways: Firstly, both are lower after the task and both are higher than baseline after the intervention, which is what we expected and hypothesized based on past research (e.g., [18,50,32]). Secondly, in both VAS, the changes from post-task to post-intervention are larger in the EG. While this difference from peak to valley in the VAS of relaxation only reached trend level, general well-being differed significantly between groups.

### The role of music

Music and its relaxing effects have a large emotional element, which involves the brain's motivation and reward pathways [51,52]. Therefore, it is not surprising that both interventions yielded a psychophysiological RR, since they both make use of the affective impact of music to calm a person. The intervention in the CG contained neither a therapeutic relationship nor live music. The EG, however, had an element of therapeutic relation through music. We assume that the superior results for the EG regarding subjective relaxation and especially well-being can be at least to an extent assigned to the human interaction and the associated live music.

Auditory or musical stimuli give participants the opportunity to close their eyes during training, which arguably helps them to relax faster and deeper (which wouldn't be possible with visual feedback). Regarding the actual sounds, we chose for the pacing, we decided to use monochrome and smooth sounds that are frequently used to promote relaxation. The monochord and vocal toning were suggested by other therapists for relaxation [43] and proved to be appropriate both for the purpose of inducing relaxation and signaling respiration.

### Limitations and Future Directions

Our sample mainly consisted of students (convenience sample) and is therefore not representative of a larger population (i.e., limited external validity). Internal validity, however, was satisfactory due to randomization and the laboratory environment.

The exact contributions of the two main aspects (live music and paced breathing) to the state of relaxation would have to be investigated in studies where differences between groups are more limited. For example, the contribution of music as a pacer could be investigated with visual pacing in the CG.

A similar approach, device-guided breathing with musical sounds as a pacing signal, has already been studied in experiments and proven to be effective, especially in the treatment of hypertension [40,9,53]. In a typical design, tone duration is controlled by a device which monitors respiration, and gradually lengthens the tones or sounds that trigger inspiration and expiration [9,40]. Studies on device-guided breathing indicate that reduction in blood pressure is generally achieved by slowing down the breathing frequency and thereby affecting cardiovascular mechanisms [54]. In contrast to our approach, however, the goal of device-guided breathing usually is not to lead participants to breathe at the resonant frequency of approximately 6 breaths/minute. Furthermore, there is neither a human interaction nor live played music in device-guided breathing. However, differences in efficiency would have to be tested in future studies.

### Conclusion

Overall, the psychophysiological effects of an incorporation of MT and RB were consistent with expectations. The described intervention resulted in a RR, as HRV measures increased substantially, while HR significantly decreased. Both cardiovascular and self-evaluation results showed differences between groups and indicate a higher overall efficiency of musically guided RB. Past research suggests that the decreased respiration rate was the main factor for change in HR and HRV. Using live played music to signal inspiration and expiration appears to be a viable approach and was quickly understood and well-received by the participants.

Further research is required to examine the effects that certain aspects of the combined intervention have on specific outcomes and to draw conclusions on the effectiveness in comparison to similar interventions.

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