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Music-guided resonance breathing – An exploratory sequential mixed-methods study for development and testing of a music intervention for pre- or perioperative stress reduction

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ABSTRACT

Music-Guided Resonance Breathing (MGRB) is a combination of a technique for consciously slowed breathing and attentive music listening in health care contexts. MGRB is intended for clinical application to reduce anxiety and stress in patients undergoing strenuous medical treatment. The article sets out the basic principles and effects of resonance breathing and describes the development process of MGRB in form of an exploratory sequential mixed-methods study. Music therapy experts, healthy subjects and a professional composer have contributed to the research, aiming to understand the optimal musical characteristics of MGRB and anticipating feasibility as well as effects on the psychological and physical states of future patients. The results encourage to conduct a controlled clinical trial with MGRB.

1. Introduction: goals and objectives

Music therapy and music medicine are umbrella terms, encompassing a multitude of approaches that have proven effective in many fields of application. Active or receptive music interventions have been developed in clinical practice, based on the patients' abilities, the contextual conditions, and the therapeutic goals. It seems, however, that the development of a particular music intervention has rarely been advanced as a systematic research process. This article offers a step-by-step presentation of an exploratory sequential mixed-method study (Burzlaff et al., 2023) for the development of music-guided resonance breathing (MGRB) – a combination of two interventions which have proven effective independently, resonance breathing (RB) and attentive music listening. The mixed-method study design, including 3 sub-studies and an artistic process, illustrates a characteristic feature of the therapeutic use of music: the mediation of extreme contrasts between nomothetic, idiographic, and artistic fields of knowledge. The study also demonstrates that decisions on research methods are closely associated with questions on the appropriateness and feasibility of a specific music intervention in a particular context, and that transferability and generalizability are, at least initially, of secondary importance.

The development of MGRB began in the coronavirus pandemic when it became necessary to use anesthesiologic resources as sparingly as possible and to perform more surgeries with local instead of general anesthesia. Since this trend has not been completely reversed since the pandemic, medical staff have become increasingly concerned with reducing preoperative anxiety and stress for surgical patients, to avoid unfavorable effects on the course of surgery, anesthesia, and recovery.

The use of music to reduce anxiety and stress has been researched since the 1970s (Spintge, 2015, p. 73), and positive effects have now been demonstrated in a wide range of medical applications (e.g. Bradt et al., 2013; Patiyal et al., 2021). However, as the relevant publications usually do not describe the music used, it is unclear which musical characteristics have a beneficial effect (Ding & Metzner, 2023). The only aspect that seems to be widely agreed upon is a slow tempo to promote relaxation (ibid., p. 211).

The basic assumption for developing MGRB is that music, being structured in a certain way, could be suitable for guiding consciously

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slowed breathing in order to reduce stress and anxiety and to enhance overall psychosocial well-being before and/or during surgery under local anesthesia. Essentially, three impact factors for MGRB were considered: the activation of favorable psychophysical regulation through breathing activity and sound perception; strengthening the patient's sense of self-efficacy through a certain degree of personal responsibility; and distraction from an alien and sterile environment by drawing attention to music as an aesthetic object.

2. Resonance breathing: introduction to the technique and effect

In this context, the term "resonance" refers to the optimum synchronization of heart, respiratory, and blood pressure rhythms for a particular person. Of these physiological parameters, the only one that a person can actively influence is breathing. While spontaneous breathing in adults normally entails between 12 and 20 cycles per minute (cpm) (Koehler et al., 2017), a consciously reduced tempo down to around 6 cpm (Lehrer & Gevirtz, 2014), with a longer exhalation than inhalation in a ratio of 4:6 (Lehrer, 2013), boosts heart rate variability (HRV) (Yasuma & Hayano, 2004). The aim of RB is to maximize the activity of the vagus nerve and the parasympathetic system (Lehrer, 2013), to stimulate the baroreflex which maintains the cardiovascular homeostasis between heart rate and blood pressure (Bernardi et al., 2002), and to improve the oxygen supply to the body and brain (Noble & Hochman, 2019; Zaccaro et al., 2018; Mather & Thayer, 2018). These physiological processes are considered beneficial for emotion regulation and cognitive abilities and are explained by the neuronal connection between the cardiorespiratory system and the limbic and prefrontal areas via the brain stem (Critchley et al., 2015).

Resonance breathing (RB) has become a technique that is used to reduce psychophysiological arousal in stressful situations, e.g. in athletes before competitions (Gross et al., 2016) or musicians before public performances (Wells et al., 2012). It is also used to help regulate stress and emotions in various mental disorders (Lehrer et al., 2020). RB is easy to learn and is guided by a visual, auditory, kinesthetic (Laborde et al., 2019) or haptic pacemaker (Bouny et al., 2023). According to Lalanza et al. (2023), there are different approaches to performing RB in the literature:

1. the optimum breathing rate for maximum HRV increase is determined for each participant before the start of training,
2. a biofeedback system is used to actively modify the current breathing rate towards an optimal breathing rate – also known as heart rate variability biofeedback (HRVB)
3. a fixed breathing rate is specified, normally 6 cpm.

The number of treatment sessions does not appear to affect the outcome in pre-post measurements (Lehrer, 2020). It is therefore considered that short training periods can be sufficient, at least for coping with acute stress situations (Wells et al., 2012; Prinsloo et al., 2013; You et al., 2021). According to the review by Lehrer et al. (2020), however, the effect size for stress reduction tends to be low (Hegde's $g = 0.16$, p = n.s.). The authors attribute this to the suboptimal measurement instruments. In contrast, the effect size for anxiety reduction – relevant for the intended application of MGRB – was found to be moderate (Hedge's $g = 0.56$, $p = <0.05$).

2.1. Music therapy and resonance breathing

In the field of music therapy, there have only been a few studies to date that include RB in the intervention. A two-arm randomized controlled pilot study conducted by Fuchs et al. (2018) investigated the effect of RB (guided by live monochord playing and vocal accents) on HRV and subjective relaxation, in 60 healthy adults who had to perform a stress task. The 15-minute music intervention was based on the individual breathing rate of the healthy subjects and aimed at a frequency of around 6 cpm. This was compared with a control group with pre-recorded relaxation music of the same duration. HRV and subjective relaxation were measured at four time points. Significant interaction effects were demonstrated, showing higher efficiency in the experimental group (RB) with regard to HRV and relaxation.

In an experimental single-case study by Brabant et al. (2017), RB was investigated within music therapy for anxiety disorders. The breathing technique, used in 12 sessions of improvisational music therapy, was compared with vibro-acoustic therapy. According to the HRV measurements, RB led to less arousal at the start of each music therapy session, as well as to more relaxation during music improvisations, especially in the more emotionally intense first phase of therapy.

Erkkilä et al. (2021) built on this study, taking a well-established model of outpatient music therapy for adults with depression (integrative improvisational music therapy, IIMT) and adding two "enhancers": 10 min of RB at the beginning of the IIMT session and attentive music listening at home. In a randomized controlled trial with 2×2 factorial design, 70 participants received 12 bi-weekly sessions of IIMT and were allocated into groups based on four conditions derived from either the presence or absence of enhancers. The reduction in symptomatology post-intervention, at follow-up, or both was greatest in the group that received RB intervention.

3. Preconditions, research design and questions

When it comes to different ways to combine RB with music for therapeutic purposes, MGRB would have to be a simplified form of RB to increase the uptake of MGRB in everyday clinical practice. Until the efficacy of MGRB has been proven, it is unlikely that any real-time biofeedback equipment (as in HRVB) will be used, or that individual resonance breathing frequency will be assessed during standard surgical preparations (Lehrer, 2007; Shaffer & Meehan, 2020). We therefore decided to build on Fuchs et al. (2018), but using a composed piece of music rather than a live music intervention to provide more flexibility in a medical setting.

The first step in our exploratory sequential mixed-method study was to evaluate the optimal musical characteristics of MGRB by involving music therapy experts. The second step, based on our conviction that music is more than an acoustic signal for RB, was to engage a professional composer to create the music. This intermediate step, an artistic composition based on qualitative data, is one option of arts-based research (ABR; Viega & Forinash, 2016; Schreier, 2017). Although ABR is controversial among both scientists and artists (Mersch, 2020), we believe that the opacity of an artistic process is outweighed by the quality of the product, whose efficacy can become apparent during application and in the further course of research.

Our third step was to assess clinical feasibility and anticipate possible effects on the psychological and physical states of future patients. We aimed to do this by testing MGRB on healthy subjects and collecting quantitative and qualitative data. The sequence of the individual sub-studies is shown in Fig. 1.

The research questions underlying the individual sub-studies are as follows:

1. What kind of music should be used to a) stimulate breathing that is consciously slowed down to approx. 6 cpm and b) support well-being? (sub-study I – see Section 4.)
2. Which aesthetic qualities do the professionally created compositions have? (intermediate step / music description – see Section 5.)
3. How does MGRB affect healthy subjects in terms of a) stress experience, b) current state of well-being, and c) breathing perception? (sub-study II – see Section 6.1)
4. How are the music and its impact described by healthy subjects and what are the implications for clinical application in a future medical setting? (sub-study III – see Section 6.2.)

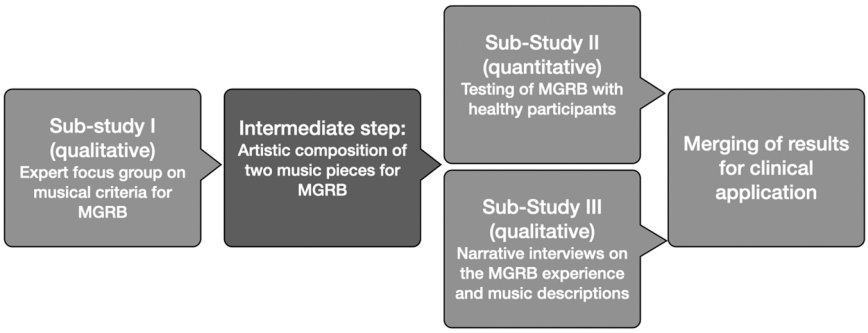

Fig. 1. Exploratory sequential mixed-method design for developing and testing MGRB.

4. Sub-study I (qualitative): Musical characteristics suitable for MGRB

To establish what kind of music is suitable for consciously slow breathing, six sound samples were created, and their musical characteristics and psychophysical effects were discussed in an expert focus group.

4.1. Creation and characteristics of sound samples

The sound samples were created by Dominik Fuchs using the *Cubase 11* software from *Steinberg*. They were standardized with regard to the following characteristics: basic volume, major/minor tonality, pitch range max. 2 octaves (c-c''), duration (1 min), tempo to guide breathing of 6 cpm, with shorter inhalation and longer exhalation in a ratio of 4:6. The differences between the six sound samples related firstly to the indicators for inhalation and exhalation and secondly to grades of harmonic and polyphonic complexity, instrumentation and musical idiom. A detailed list of the musical properties can be found in the supplemental material (Table 1).

4.2. Sampling and procedure of the expert focus group

Inclusion criteria for participation in the expert focus group were academic training in music therapy and more than 3 years of practical experience in the adult sector. Six female music therapists who fulfilled the inclusion criteria were recruited. Due to the pandemic, the expert focus group took place as an online video conference via the Zoom platform. It lasted 90 min and was recorded in audio and video.

After an introduction, the experts were informed about the purpose of MGRB (i.e. to reduce preoperative stress and anxiety) and about the planned course of the online video conference. After the experts had given their verbal consent to the audio and video recording and to the pseudonymized evaluation, the recording was started.

Phase 1: The experts listened twice to each sound sample through headphones, paying attention to their breathing, body sensations, feelings, thoughts, and mental images. The video image was switched off while the experts listened to the music. After each sound sample, the moderator asked for comments from each expert, which were later transcribed from the audio recording. For each sound sample, the transcribed statements were clustered in a mind map regarding a) music properties, b) breathing and c) emotions/thoughts/images.

In phase 2, the experts were asked to discuss the advantages and disadvantages of individual musical features and possible ways to

Table 1
Characteristics of the 6 sound examples for the music therapy expert focus group.

No.	1	2	3	4	5	6
Instrumentation	Double bass with background noise	Monochord and solo voice	Piano, violin, viola, cello	String quartet	Orchestra with Synthesizers and tonewoods	Woodwind and brass ensemble
Form	Free form with occasional repetitions	Varying sound durations, decrescendo	Structured form with evolving sections	Recurring, structured form	Cycles with variations and repetitions fetches	Similar to No. 4, with additional variations
Structure	Solo with ambient influences	Monophonic, repetitive patterns	Polyphonic, arpeggiated and harmonious	Homophone, choral-like	Homophone with drone elements	Homophone
Harmonics/ Melodics	Long single notes, second steps	Fundamental, fifth, overtones	Tonic dominant change	Chords in tonic and subdominant range; major second downwards	Chords in tonic (sub) dominant range; fourth down	Like No. 4, with modulations
Rhythmics/ Dynamics	Slow rhythms, dynamic decrescendo	Varying rhythms, dynamic decrescendo	Moderate rhythms, dynamic contrasts	Calm rhythms, dynamic crescendo/ decrescendo	Broad dynamic spectrum, rhythmic variety	Stable rhythms, dynamic nuances
Additional Information	Emphasizing the silence between the notes	Use of overtone singing or chanting	Use of Legato and Staccato phrases	Introduction of counterpoint elements	Integration of surround sound and echo techniques	Use of space and movement in the performance
Indicator for Inhalation and Exhalation	Tone changes correspond with breathing rhythm	Synchronization with breathing cycles	Change of harmony with breathing phases	Crescendo/ decrescendo with chord changes	Chord changes with breath	Stereo effect, right/ left breath coupling
Basic Idea of the Composition	Minimalism and simplicity	Sound therapy approach	Dynamic ascent and descent	Sacred or spiritual inspiration; classical music	Meditative and immersive sound experience	Connection of breathing and laterality

improve the sound samples favored by the majority of the experts. Finally, the expert focus group was asked to summarize their ideas about the conditions of application of MGRB in a surgical setting and to formulate a general description as a stimulus for the composer. These comments were also transcribed.

4.3. Results: criteria for music to be used in MGRB

In phase 1 of the procedure, the experts were able to adjust to the slowed breathing rhythm in the sound samples. They made nuanced statements about their subjective musical preferences and the psychophysical reactions triggered by the music. For illustration, the mind map for sound sample no. 1 is provided in color as supplemental material (Fig. 2).

The analyses of these individual statements and the findings of the group discussion in phase 2 are summarized as follows:

A change of harmony or of melodic direction was considered a suitable indicator for inhalation and exhalation. Major tonality and familiar classical instruments (piano, wind and string instruments) were preferred. It was felt that lower sounds (instrumental or vocal) could serve as a support for abdominal breathing. Regarding the guidance function of the music, two different requirements became apparent. On the one hand, a transparent harmonic-melodic structure with clearly recognizable indicators for the breathing rhythm was preferred, on the other hand, it was emphasized that the music should offer freedom for the future patients' own breathing rhythm.

In terms of the psychosocial functions of music, the experts emphasized the specific requirements of a surgical setting. Here, in contrast to other music interventions, emotionality should not be intensified, and excessively vivid images could distract from conscious breathing. Using the first person to identify with future patients, the experts formulated two general descriptions:

1. The music should distract me mentally, guide me but not force me. It should have a clear structure and not be irritating, so that I remain in control.
2. The music should carry me and give me space so that I can breathe freely. It should give me the feeling of being supported and not feeling alone in a situation that scares me.

The findings of the expert focus group were passed on to the composer Peter Michael von der Nahmer, along with the following parameters, which he was asked to fulfill as precisely as possible:

- The duration of the pieces of music, one for piano, the other for wind instruments, strings and/or voices, should be 15 min.
- The tempo should stimulate a breathing rhythm with 4 s for inhalation and 6 s for exhalation.
- The first 3 min should act as a settling phase, allowing the listener to concentrate on breathing and recognize the indicators for the alternation of inhalation and exhalation.
- Melodic and harmonic repetitions should convey feelings of security, while variations should stimulate attention.

5. Intermediate step: composition "Waves"

Two compositions, one for choir and the other for piano, were created by Peter Michael von der Nahmer. They have a few things in common, such as the duration, the rhythmic structure to guide the breathing tempo, the use of recognizable melodic motifs, the variety of harmonic development, etc. However, according to the results from the expert group (see above), they differ in terms of guidance or support. This section gives a detailed explanation of the basic compositional ideas and construction used in "Waves," composed for piano, with subtle wind instruments in the background. It is a composition that seamlessly integrates musical elements – rhythmic structure, harmonic texture, dynamic range, and instrumentation – with biopsychosocial principles. The piece lasts 15 min and has three large parts that merge into one another. Its microstructure meticulously follows the resonance breathing pattern, 4 s of inhalation and 6 s of exhalation. This breathing rhythm is reflected in the tempo, melodic phrasing, and dynamic shifts of the music.

The piece is intended to be listened to with headphones, creating an immersive auditory environment. To prepare the listener for slow-paced breathing, "Waves" starts in 4/4 time (quarter note = 96) with steady pulse of half notes, which change to quarter notes at bar 37. At bar 57 the time signature changes to 10/4 (quarter note = 60) maintaining a sense of continuous movement and embodying the fluidity and progression of the piece.

In terms of melody, "Waves" opens with a distinctive piano motif, characterized by flowing arpeggios (see Fig. 3) that mimic the rhythmic movement of waves. This motif is not just an artistic choice but enables the listener to focus on controlled slow-paced breathing and to recognize the indicators for in- and exhalation.

Recognizable motifs and new variations are used throughout the piece without abandoning the basic impression of wave movement. At the above-mentioned bar 57, there is a significant tempo change to quarter note = 60, marked by a ritardando (see Fig. 4). This reduction in tempo leads to the actual resonance breathing tempo of 6 cpm. At the same time, this is meant to open the focus of perception from the musical indicators towards an aesthetic awareness of oneself breathing and listening.

The choice of instrumentation, centered around the piano with its expansive dynamic range, in conjunction with the expressive capabilities of wind instruments in the background, serves to both mirror and amplify the resonance breathing process and maintain cognitive awareness.

Harmonically, the music traverses a multitude of both major and minor tonalities. The use of dissonance and consonance, and the balance between them, create a soundscape that is meant to give emotionally resonant guidance. The harmonic progression, characterized by the interplay of tension and resolution, mirrors an emotional ebb and flow experienced by the patient and contains depth and complexity. At the same time, the constant tempo, dynamics, and recurring motifs of "Waves" are meant to give the patient a sense of gentle and non-judgmental social support.

6. Sub-studies II and III: testing MGRB with healthy subjects

Prior to any clinical application of MGRB, an experiment with healthy subjects was conducted, including quantitative measurements and qualitative inquiries. The research was focused on subjective assessments of the valence of the music and its effects on subjective breathing rate, stress experience and current state of well-being. A further aim was to collect qualitative descriptions of the characteristics of the two pieces of music, as indications of possible modes of reception in a clinical application.

6.1. Sub-study II (quantitative)

6.1.1. Method

A purposive sampling method was used to gather insights into the psychophysical processes triggered by MGRB. The idea was to enable participants to verbalize their thoughts, body sensations and emotions, and to describe musical phenomena that caught their attention. To capture a broad spectrum of experiences and viewpoints across the widest possible range of adult ages, an equal distribution of men and women and of active musicians and non-musicians was aimed for.

Participants were asked to indicate their daily stress level on a 100-millimeter visual analog scale. VAS was also used for measurement of subjective stress perception before and after the experiment. The psychological effect of MGRB on subjects' current state of well-being was

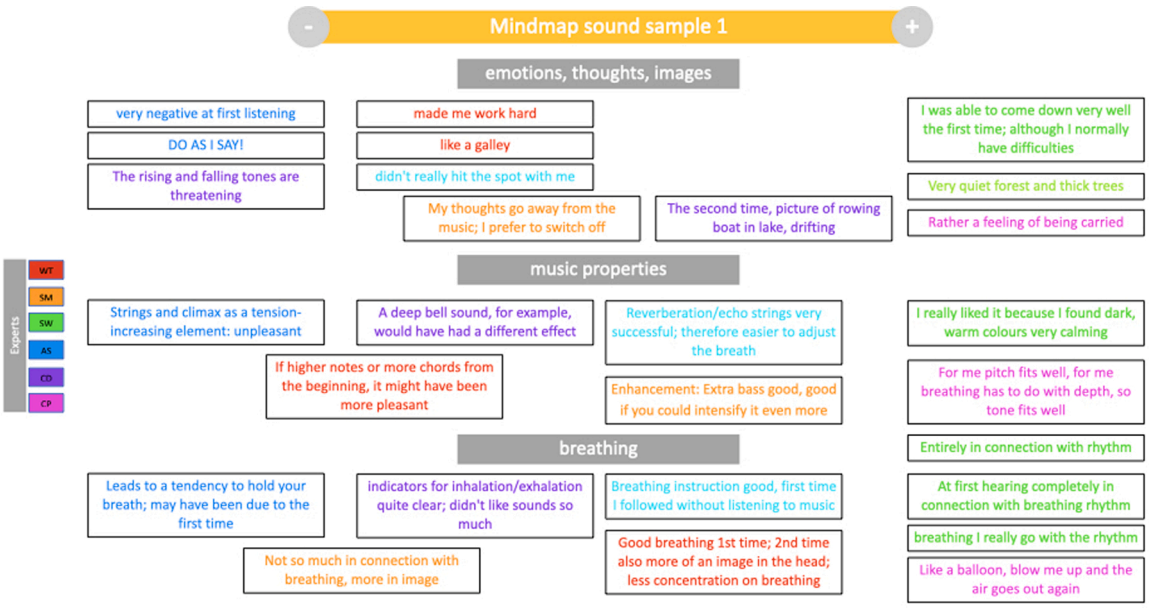

Fig. 2. Example for clustering with regard to music properties, breathing and emotions/thoughts/images.

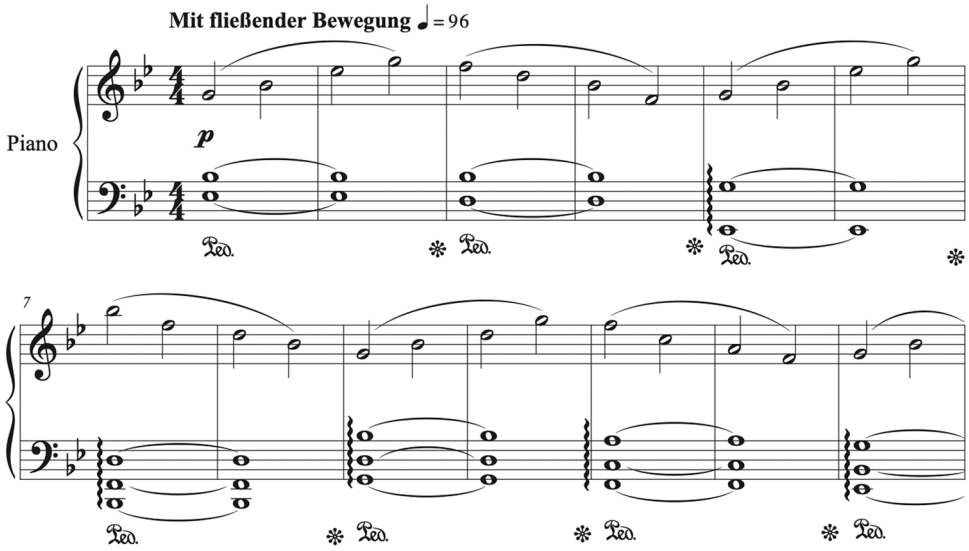

Fig. 3. Distinctive Piano Motif at the beginning of Composition "Waves" by Peter Michael von der Nahmer.

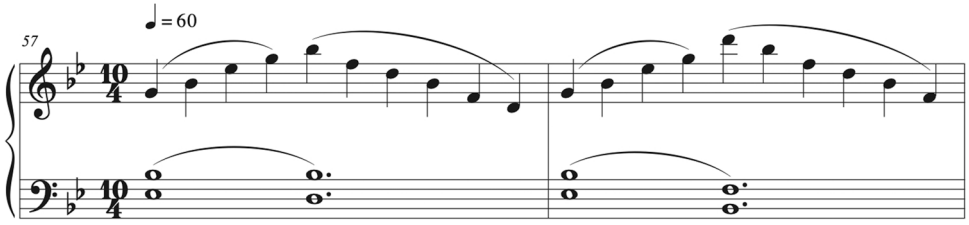

Fig. 4. Reduction in tempo at bar 57 in composition "Waves" by Peter Michael von der Nahmer.

measured using the Basler Befindlichkeitsskala (BBS [Basel Well-being Scale]; Hobi, 1985), as it is well known for its sensitivity to short-term changes in subjective feelings of well-being ("Befindlichkeit"). The BBS is a standardized, self-rating scale, which can be used for both healthy and mentally ill people. To assess subjects' current state of well-being, 16 pairs of adjectives arranged as a semantic differential are used. The bipolar items are grouped into four factors[4]:

[4] Translated by S.M.

1. vitality (well-rested vs. tired, strengthened vs. weakened, energetic vs. listless, healthy vs. ill')
2. intrapsychic balance (balanced vs. unbalanced, confident vs unconfident, calm vs. nervous, not anxious vs. anxious),
3. social extroversion (talkative vs. silent, communicative vs. uncommunicative, outgoing vs. shy, sociable vs. withdrawn.), and
4. vigilance (attentive vs. inattentive, determined vs. distractable, alert vs. absent-minded, focused vs. unfocused.

The music valence and the subjective influence on the breathing rate were measured after the intervention using Likert scales. The statistical calculations were carried out using the Wilcoxon test and Spearman's rank correlation.

6.1.2. Intervention

Once the participants had been informed about the study and signed the consent form, pre-measurement data (active involvement in music, daily stress level) were collected. Two one-minute excerpts of the two pieces of music ('Waves' and the choir piece) were then played, and the subjects were asked to choose one of the pieces based on personal preference. After this the following instructions were given regarding MGRB:

- Please pay attention to your breath, your hands should lie on lower abdomen.
- In order to inhale and exhale slowly and regularly, you can let yourself be stimulated by the music.
- Prolonged exhalation may be facilitated with pursed lips.

The participants got into a comfortable position and listened to their chosen piece of music for its duration of 15 min via headphones (Bose Noise Canceling Headphones 700). The study leader left the room for this time so as not to distract the subjects.

6.1.3. Results

14 subjects (9 female) aged between 25 and 70 (M=41.4 yrs, SD=12.6) took part. Half of them stated that they played an instrument or sang in a choir in everyday life. The mean daily stress level was given on a VAS of 100 millimeters at M= 58.7 (SD= 17.4) (see Table 2).

All participants received the complete intervention and took part in the data collection. Six chose the choir piece, eight the piano piece. As our quantitative data sets had some outliers, which may be related to the heterogeneity of the sample targeted for the qualitative part of the study (wide age range, different levels of musical activity), we decided to use the median value (Mdn) to find a central tendency in the results for stress level (VAS) and current well-being (BBS). As the groups listening to the two pieces (piano and choir) did not differ notably, the results are summarized.

The current stress level (pre) was Mdn= 30.5 and decreased to Mdn= 4.5 after the intervention ($p < .001$ ***, $r = 0.77$). The current state of well-being measured by the total score of BBS showed no significant pre-post change, but in the subscale "intrapsychic balance" there was a significant increase from Mdn= 23 to Mdn= 26 ($p < .005$ ***, $r = 0.808$) (see Table 3).

The majority of the subjects perceived the valence of the music as very pleasant (56 %) or extremely pleasant (13 %). 80 % perceived a slowing of breathing stimulated by the music (see Table 4).

Correlation calculations between the variables did not yield any significant results.

Table 2
Sample description.

	Choir (n = 6)	Piano (n = 8)	Total (N = 14)
Age	37 (25-50)	46 (27-70)	41
Gender (F/M)	3/3	6/2	9/5
Active musicians	4	3	7
General stress level	61.38 ± 12.55	56 ± 21.85	58.7 ± 17.4

*M ± SD

Table 3
Effects of MGRB on stress experience measured by VAS and State of Mind measured by Basler Befindlichkeitsskala BBS.

Outcome	Median		p-value	Effect size
	pre	post		
Current stress level	30.5	4.5	.001 * **	.77
State of mind	85.5	81	.889	
Vitality	22	20	1	
intrapsychic balance	23	26	*.005* * **	.808
social extraversion	21	17.5	.055	
Vigility	22	11	.697	

6.2. Sub-study III (qualitative)

All the participants of sub-study II were interviewed about their experience with the combination of conscious slow breathing and attentive listening to the music. Their responses are summarized here. The musical indicators for the change between inhalation and exhalation were recognized by all the subjects without exception. The same applies to observations of asynchrony of breathing and musical rhythms: the music was neither perceived as irritating nor did it make the recipients feel they were breathing incorrectly or being put under pressure.

In the interview, the participants were asked open questions about their perception of the music's characteristics. The narratives were summarized (in collaboration with the subjects) and written down either as individual terms or as core statements, some of which were descriptive and others metaphorical. The collection comprised 172 terms (examples: "not monotonous", "distracting", "pastoral") and 53 core statements (examples: "I was taken on a journey through a beautiful landscape"; "The increase in chord changes was confusing at first, the simply played melody too rigid"). All the terms and core statements were clustered and analyzed by summarizing and contrasting, following a basic strategy of qualitative content analysis (Schreier, 2014). This yielded two main categories (MCs) and several subcategories (SCs) as follows:

MC 1: Perception of the expressive qualities of the music pieces (SCs: characteristics of musical parameters, movement, popularity).

The pieces of music were regarded as generally comprehensible. Although the participants recognized the plainness of the microstructure with indicators for the breathing rhythm, they did not experience the music as monotonous. Instead, it was felt that the variations led to increased awareness. One person classified the choir piece as "sacred music", another found the voice(s) "too high". One participant described the melody of the piano piece as "rigid" or like a "piano étude". However, the movement was mostly experienced as flowing,

Table 4
Change in breathing tempo and music valence measured by Likert Scales.

	Absolute frequency	Relative frequency (%)
Change in breathing tempo		
slowing down	12	80
constant	2	13
getting faster	1	7
Music valence		
extremely unpleasant	-	-
very unpleasant	1	6
unpleasant	-	-
neutral	-	-
pleasant	4	25
very pleasant	9	56
extremely pleasant	2	13

wave-like or spatially expanding. Both pieces were described as a blend of familiarity and novelty, which was connoted as "positive" and/or "beautiful", with the choir piece also described as "sublime".

MC 2: Induction of psychophysical processes by the music compositions (SCs: mental images and thoughts, arousal, attention, emotions, bodily sensations).

The words associated with the piano piece were "travel", "companionship", "friend". Regarding arousal, the piece was felt to have a warm and comforting effect, and one in a soporific effect. The choir piece, on the other hand, was associated with a church or mountain environment and the effect was perceived as stimulating. One participant thought that the music evoked associations with "an ascent to heaven". Another person was unable to rest her mind during the choir piece; she felt as though she was "charged up" because the human voices came "too close" to her.

The participants felt that both pieces distracted them successfully from their surroundings and gave them a sense of self-acceptance. Reality, time, and place were all but forgotten, and no particularly intense emotions were aroused. No bodily sensations were reported during the choir piece. The piano piece, on the other hand, stimulated interoceptive perceptions of heartbeat and stomach activity. One person with diabetes, who had listened to the piano piece, reported a drop in blood sugar – something she had also experienced with intensive music listening experiences previously.

7. Merging of results and discussion of sub-studies II and III

Even without prolonged practice in the RB technique, the very first encounter with MGRB proved to be significantly stress-reducing in the experiment. The participants' self-reported stress levels (pre) at the beginning of the experiment were already significantly lower than their average self-reported stress level in everyday life, but they showed a further significant reduction with a medium to high effect size after the intervention (post). The current state of overall well-being, measured by BBS (Hobi, 1985), did not change during our experiment, but improved significantly on the subscale for "intrapsychic balance". In a clinical population this would be a desirable effect.

MGRB aims to achieve a breathing rhythm of 6 cpm with a shorter inhalation and longer exhalation. According to the qualitative findings, MGRB was well understood by the participants, and the musical indicators for the change between inhalation and exhalation in the compositions were recognized intuitively. The majority of the subjects were stimulated to reduce their breathing rate, but as measurement data on physiological changes (e.g. heart rate or HRV) were not collected, this subjective impression cannot be proved objectively. Since the most effective individual resonance frequency is individually different and situation-dependent (Shaffer & Meehan, 2020), the different psychological situations of subjects or of patients with either somatic or psychiatric disease should be considered as the decisive factor when applying MGRB.

Our two pieces of music were composed not to exert pressure or control but to gently motivate future medical patients to reduce their breathing tempo before or during surgery. From a music psychology perspective, the musical characteristics contribute to self-regulation and a sense of self-efficacy, and prevent the feeling of "breathing wrong", which could in turn increase pre-operative stress. However, further research must first be carried out to judge whether intuitively reduced breathing has the desired effects.

The qualitative findings from sub-study III reflect the original intention of the expert focus group. MGRB was shown to: a) stimulate interoceptive perception, b) independently reduce the pace of breathing, c) maintain attention, d) have a calming effect, and e) not increase emotionality. The pieces of music were predominantly perceived as pleasant by the subjects, and helped to distract them from time, place and participation in a scientific experiment. The qualitative descriptions of the music offer pointers for introducing MGRB to future patients and supporting the selection process. Isolated unpleasant experiences that were reported are valuable because they draw attention to possible personality-related contraindications: some patients might find the straightforward guidance of the piano piece rigid or demanding, while others might react adversely to the intimacy of human voices in the choral piece.

Due to the lack of a comparison condition, the positive effects of MGRB testing cannot be attributed exclusively to MGRB but also to the pleasant and relaxing conditions of the experiment and/or to social desirability bias. Neither is there an option to separate the effect of the slow breathing from the effect of the music. It is clear from many prior studies that both breathing at resonance frequency (Lehrer et al., 2020) and listening to music (Fancourt & Finn, 2019) can improve emotional and physical health and performance in clinical and non-clinical populations. What happens when these two modalities are combined remains an open question (as does the contribution of each modality to the resulting effect). Finally, the significance of our results is limited by our small sample, which is not representative but had to be heterogeneous to meet our requirements for the qualitative data collection. Nonetheless, the results point in the same direction as the above-mentioned music therapy studies (Brabant et al., 2017; Fuchs et al., 2018; Erkkilä et al., 2021).

8. Outlook and additional considerations

In addition to the encouraging results and the undeniable limitations of our exploratory sequential mixed-method study, there are a few other considerations that we have dealt with in our research group and that we believe are worth discussing for clinical applications and further research.

MGRB has been developed by musicians and music therapists, but it cannot be classified as music therapy (Dileo, 2013), as it is primarily a short-term self-help procedure, mainly designed for patients undergoing potentially stress-inducing medical treatment. However, we strongly recommend that MGRB is offered under the assistance of a music therapist or other well-informed medical practitioner. This professional assistance is necessary in cases when a piece of music is not optimally selected by the patient, because this could cause insecurity and discomfort. MGRB should only be used in clinical settings where patients are fully conscious, and they should always be given the option of changing the piece or switching off the music at any time so as not to trigger any undesirable effects.

Another approach combining RB and music, which we were not aware of when developing MGRB has been undertaken by a Finnish research group (O. Brabant, R. Karvonen, N. Loimusalo-Lipiäinen).[5] Their musical compositions are offered to the subjects in different tempi. In our study, we followed the findings of the expert focus group, taking simplicity as one of our guiding principles. We assumed that for direct one-off pre-operative use, patients might be overwhelmed by too many choices.

One question to be discussed is whether an application like HRVB would be desirable, i.e. the use of sensor technology and artificial intelligence to gradually adjust the tempo of the music to the individual resonance frequency. To test this, an experiment (preferably with healthy people) would need to compare different conditions, not only regarding stress reduction and increases in HRV, but also self-efficacy and the quality of the aesthetic perception process, as these are considered to be effective factors of art therapies (de Witte et al., 2021).

From an artistic perspective, digitally controlled tempo changes would have an impact on the quality of the music. An appropriate artistic approach to such tempo fluctuations would have to be actively searched for, as we would like to emphasize that music in MGRB does

[5] https://uasjournal.fi/1–2023/music-for-breathing-an-innovative-research-application/

not function solely as an acoustic stimulus in a functional sense. It can be perceived as a supportive accompaniment or social surrogate (Schäfer et al., 2020) and has an intrinsic value as an aesthetic object of perception. Attentive listening to music, which in MGRB involves consciously attuning one's own breathing rhythm to it, goes beyond the satisfaction of hedonistic needs and comes close to what Reybrouck & Eerola (2022) characterize as eudaimonic enjoyment. This assumption, which touches upon the philosophy of art itself, would have to be investigated more fundamentally. Little research has been conducted so far into the influence of contextual factors on the effect of aesthetic experience (Carbon, 2019). MGRB offers an opportunity to address this desideratum with different research methods and in various contexts.

Although sciences, humanities and creative arts differ in terms of aspirations, rules and conventions, a collaboration between therapists, scientists and artists can prove extremely fruitful for the development of music interventions and beyond. Reflecting on our research, we recognize the transformative potential of creative processes in the discussions and especially in the artistic process – a potential that can point beyond the limits of scientific analysis.

Ethical approval statement

The participants in all the sub-studies gave their written consent to the use of the data collected, which could be revoked at any time. The data protection officer of the University of Augsburg reviewed and approved the collection and processing of the data under applicable legal conditions. The vote of an independent ethics committee was not legally required to conduct this research.

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CRediT authorship contribution statement

Susanne Metzner: Writing – original draft, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Dominik Fuchs:** Writing – review & editing, Investigation, Data curation, Conceptualization. **Peter Michael von der Nahmer:** Writing – original draft.

Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability

Data will be made available on request.

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Appendix A. Supporting information

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.aip.2024.102187.

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