JUST BREATHE:
COMPARING VISUAL AND MUSICAL BREATHING CUES IN RESONANCE FREQUENCY BREATHING

Molly Rastin
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Department of Music, Art, and Culture Studies
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Tiivistelmä – Abstract

Heart rate variability (HRV) is related to stress management, emotional well-being, and hypertension. In general, greater HRV correlates with better health. Resonance frequency breathing (RFB), a systematic form of slow breathing, has been used successfully to maximize HRV. Thus, RFB has been used with success in a number of therapeutic settings. However, RFB is currently conducted without musical stimuli. Previous research indicates that musical interventions may achieve results similar to those of using RFB when targeting hypertension, and relaxation effects of music are well-documented. Therefore, including music in RFB interventions could improve the effects of RFB on HRV and relaxation.

To examine the influence of music in RFB, two conditions of 10-minute RFB interventions were compared, using a within-subjects design with healthy adult subjects. In the control condition, RFB was conducted with a visual cueing system. In the experimental condition, RFB was conducted with a musical cueing system. HRV data, as well as Likert scales pertaining to perceived relaxation and attentiveness, were collected in both conditions. Additionally, participants were able to comment in open feedback about their experiences. Experimentation found no significant difference between the visual or musical conditions in HRV or Likert scale indices. However, the application of ABC relaxation theory to qualitative data indicates that perceived experiences in these conditions may differ. Furthermore, the musical condition performed similarly to the visual condition in terms of HRV data; thus, a musical version of RFB could be useful for people who prefer auditory stimulation or who are seeking a different kind of relaxation.

Asiasanat – Keywords

Heart Rate Variability, Breathing, Music Therapy, Polyvagal Theory, Resonance Frequency, Heart Rate Variability Biofeedback, Resonance Frequency Breathing, ABC Relaxation Theory, Window of Tolerance

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CONTENTS

1 INTRODUCTION

Approximately 111,000 times per day, the human heart beats. It is one of the first sounds heard from the womb; it slows as we crawl into bed; it seems to pound when we see the people we love. The heart can even continue beating when removed from the body—yet most of the time, we barely give it a second thought. Every moment, the heart acts to ensure our existence, but we rarely notice that it is beating at all. Still, we can—at times—control it.

Greater heart rate variability—that is, greater change between beat-to-beat heart rates—is associated with physical longevity, relaxation, and emotional health. Heart rate variability, or HRV, has been manipulated for short-term benefits, particularly in sufferers of hypertension and mood disorders. Using a specific breathing technique called resonance frequency breathing (RFB), the manipulation of HRV has been linked to better emotional and physical wellness. However, this breathing technique may be improved or altered to suit a more diverse population.

As the heart is taken for granted, so is music. Long appreciated for its recreational uses, music has recently become more and more integrated into the realm of health, particularly within the relatively young field of music therapy. Since its incarnation, music therapists have debated the role which music plays in therapy; some believe music is the most therapeutic element, whereas others use music as an auxiliary tool. Recently, RFB (a non-musical exercise) has been used as a tool in music therapy sessions, but this raises an interesting question: Can music itself be integrated into this program? This is the central issue of the current study.

The maximization of HRV should be of great interest to many music therapists. In a clinical setting, for example, HRV analysis could be used for the assessment and treatment of non-musical goals. A hypertensive patient could benefit from continual assessment of resting and short-term HRV, as this could maintain and improve that patient's physical health. On the other hand, maximal HRV can also allow for the exploration of deeper, more meaningful issues within a therapeutic setting. Again, as the literature review will discuss in-depth, RFB has already been implemented within a music therapy setting. Results have been promising.

Otherwise, this phenomenon relates generally to physical and emotional health, which are of course major domains for any music therapist.

To contribute to general health, RFB should be developed within the best of its potential. Music may be incorporated within this in the form of precomposed, specific music played within the RFB activity. Thus, the current research question for the study is this: Is a musical cue more effective than a visual cue in increasing HRV during RFB? A secondary research question asks (more generally and qualitatively): Does the presence of specific precomposed music within an RFB activity, rather than a visual cue, change the perceived experience of RFB?

An ideal outcome of this study would be an improved form of RFB training which includes precomposed music as part of the cueing process. The products of this research could extend beyond music therapy with minimal training. For example, a fully-developed breathing program could be used in non-musical psychotherapy, physiotherapy, hypertension treatment, and other medical environments. Music programming could become as important to HRVB/RFB as the breathing itself. Perhaps, in turn, this could lead to greater recognition of music therapy as a general practice across the world. Music therapy is still a growing profession that requires high levels of advocacy; this research could bolster appreciation from other professionals for the field.

Even with no significant difference between musical and non-musical RFB, this study can serve as a valuable source of information regarding the general effectiveness of RFB across varying demographics under multiple conditions. Furthermore, it can contribute to the growing body of knowledge regarding the general psychotherapeutic and physiological properties of receptive music. Meanwhile, by exploring perceptions of relaxation, this study can collect some rich data regarding the differing experiences of relaxation states. Significant quantitative results are not the only driving element of this study.

This study compared RFB under two conditions: Visual cueing and musical cueing. While it was hypothesized that HRV would be greater in the musical cueing condition, no significant differences were found between the two conditions in HRV or Likert scale indices. However, important implications remain; this is only the beginning of a broad future of including music in RFB training.

2 LITERATURE REVIEW

In this study, heart rate variability and relaxation were compared between two groups completing a resonance frequency breathing task. Thus, extensive research explored the topics of heart rate variability, resonance frequency breathing, sedative music, and music therapy. Theories relating to these subjects were also examined and have been presented in this text. It is crucial, then, to first reveal what heart rate variability is and how it influences the body and mind.

2.1 Heart Rate Variability

To truly understand the core of this study, one must first understand the implications of heart rate variability, or HRV. HRV describes the variation between individual heartbeats, as measured within the interval of time. Greater HRV is connected to greater resilience in emotional and physical venues (Lehrer & Gevirtz, 2014; Lehrer, Vaschillo, & Vaschillo, 2000). This includes cardiovascular, autonomic, and psychological health, to the degree that low HRV is associated with sudden cardiac death (Lehrer & Gevirtz, 2014; Lehrer et al., 2000; Kleiger, Stein, & Bigger, 2005; Perkiömäki et al., 1997). It is suggested that the core of HRV's connection to better health lies in its regulation of the body (Lehrer & Gevirtz, 2014). As heart rate quickens, blood pressure falls, which stimulates the heart rate to continue quickening. Conversely, as heart rate falls, blood pressure rises, which stimulates the heart rate to continue falling. Therefore, when HRV is more complex, the rise and fall of one's heart rate exercises these feedback loops, which assists in regulating both heart rate and blood pressure (Lehrer & Gevirtz, 2014).

The reflex in use during these fluctuations is called the baroreflex, a mechanism which exists within the body to alter heart rate for the sake of homeostasis. Using a negative feedback loop, the baroreflex detects and responds to increased blood pressure by decreasing the heart rate through vasodilation; if blood pressure decreases, the baroreflex increases the heart rate through vasoconstriction (Lehrer & Gevirtz, 2014; "Baroreflex," n.d.). Long-term practice in increasing HRV has shown some increase in resting baroreflex activity, which would suggest that these exercises could improve the regulatory system even when not directly in use (Lehrer & Gevirtz, 2014). Indeed, there are known correlations between HRV and health, and the baroreflex is surely entwined in this phenomenon.

People with greater and more complex HRV are often healthier than those who live otherwise. In fact, HRV can be used for diagnostic and predictive criteria of numerous diseases and disorders (Kleiger et al., 2005; Perkiömäki et al., 1997). To further support the connection between high HRV and better health, HRV tends to decrease as people age and the body deteriorates (Lehrer et al., 2000; Vaschillo, Vaschillo, & Lehrer, 2006). Furthermore, this link seems to be at least partly causal, as efforts to increase HRV tend to result in better health (Gevirtz, 2013; Lehrer & Gevirtz, 2014; Lehrer et al., 2000; Vaschillo et al., 2006). Meanwhile, deliberately increasing HRV in patients with autoimmune disorders shows promise for restoring autonomic activity, particularly in the activation of the inflammatory reflex (Gevirtz, 2013; Huston & Tracey, 2011).

HRV is related not only to physical health, but emotional health. This can be described under two potential models: polyvagal theory and the model of neurovisceral integration.

2.1.1 Polyvagal theory

Polyvagal theory is a theory which relates to the autonomic nervous system (ANS), the body’s control system for regulating unconscious bodily functions. Conventional theory states that the ANS controls both the sympathetic nervous system (SNS), which is active during periods of stress, and the parasympathetic nervous system (PNS), which is active during period of relaxation. The systems are triggered by the vagus nerve and are believed to be in opposition. Under this theory, when the SNS is in use—for example, when responding to a dangerous situation—the functions of the PNS, such as digesting, cannot take place, and vice versa. Polyvagal theory, however, offers a more complex view of the ANS.

According to polyvagal theory, the ANS has not two, but three branches: The dorsal vagus, the SNS, and the ventral vagus (Beauchaine, Gatzke-Kopp, & Mead, 2007; Porges, 1995; Porges, 2011). As polyvagal theory is based in evolutionary theory, each of these branches are believed to have formed as humans evolved (Beauchaine et al., 2007; Porges, 1995; Porges, 2007; Porges, 2011). The dorsal vagus is the oldest branch and is connected to basic pre-human instincts (Beauchaine et al., 2007; Porges, 1995; Porges, 2007; Porges, 2011). It allows for metabolic conservation by shutting down many of the body's functions and is associated with "freezing" or submissive responses to danger (Beauchaine et al., 2007; Porges, 1995; Porges, 2007; Porges, 2011). The ventral vagus, however, is the most complex of the systems, and controls social engagement and other evolved functions (Beauchaine et al., 2007; Porges, 1995; Porges, 2007; Porges, 2011). Thus, the dorsal vagus is the most primitive of responses, and the ventral vagus is the most evolved.

The hierarchy of a polyvagal system, which is based on evolutionary progress, can become visible in threat perception. When no threat is perceived, the ventral vagus is active, and one is free to exercise complex mammalian interactions (Porges, 1995; Porges, 2007; Porges, 2011). When a threat is perceived, however, the SNS can be activated, allowing one to respond to the threat. If the threat persists for too long or intensifies, the unsustainable SNS can shut down, and only the most primitive functions of the dorsal vagus become active (Porges, 1995; Porges, 2007; Porges, 2011). A visual representation of this system can be seen in Figure 1.

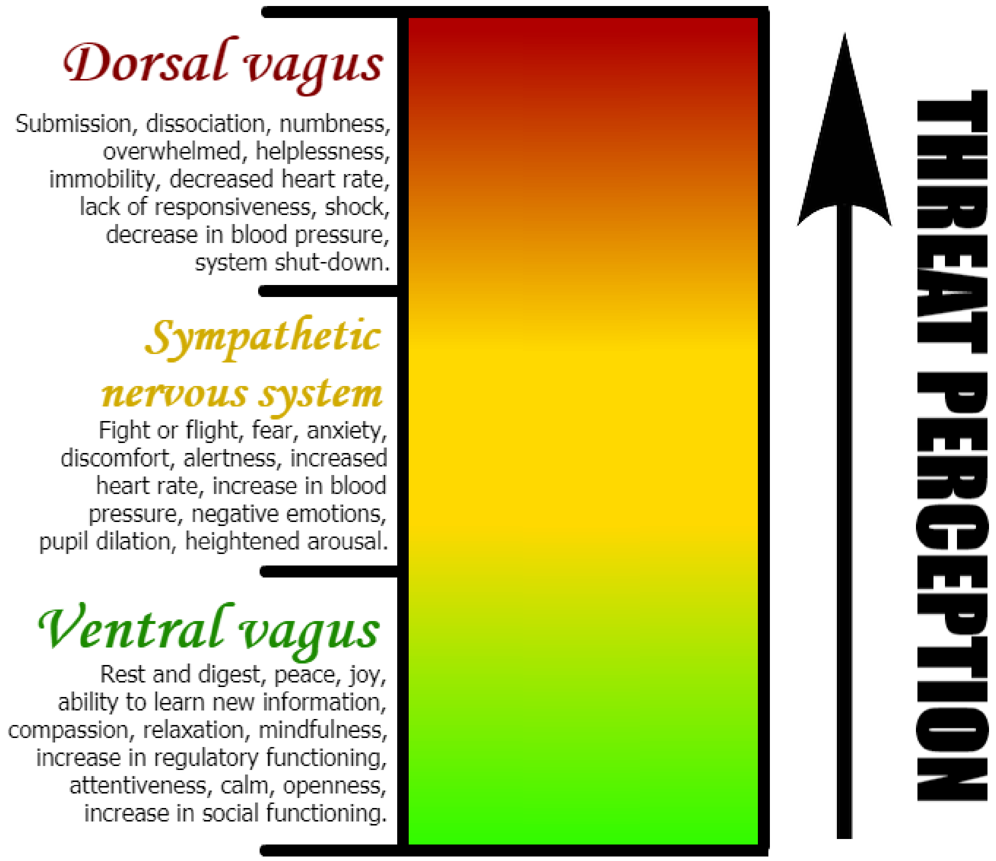

FIGURE 1: Physical responses to a perceived threat as described by polyvagal theory.

Under polyvagal theory, the ventral vagus controls the regulatory systems which influence HRV, as well as the regulation of complicated emotions (Appelhans & Luecken, 2006; Porges, 2007). HRV is not necessarily defined by a decrease in activity (as would be assumed in the dichotomy of PNS and SNS), but rather by a decrease in perceived threat and an increase in mammalian processing. Indeed, when the ventral vagus is active, it is able to provide better social engagement and disengagement by rapidly withdrawing its inhibitory influence on sinoatrial node activity, which manages heart rate (Appelhans & Luecken, 2006; Porges, 2007). Thus, when that ability to withdraw inhibition is no longer sustainable (i.e. because of a perceived threat), HRV lessens and the SNS becomes active, followed by the dorsal vagus if the threat is not de-escalated. Therefore, greater HRV can be assumed to be linked with better emotional processing and health, as both of these are states best achievable when the ventral vagus is active. However, this is not the only frame under which emotions are connected to HRV.

2.1.2 Neurovisceral integration

As in polyvagal theory, neurovisceral integration describes a number of processes working under a greater system. In neurovisceral integration, however, the system is emotion, and the branches are the behavioural, cognitive, and physiological processes which are involved in emotion (Appelhans & Luecken, 2006; Thayer & Lane, 2000). These processes all contribute to experiences of emotion, but they are non-linear and they influence one another (Appelhans & Luecken, 2006; Thayer & Lane, 2000). Under this model, the processing of emotion is controlled by the central autonomic network (CAN). The CAN, like the ventral vagus in polyvagal theory, works by inhibiting response, this time inhibiting responses that do not suit a person’s emotional state (Appelhans & Luecken, 2006; Thayer & Lane, 2000).

When the CAN is best able to manage emotional regulation, HRV is higher (Appelhans & Luecken, 2006; Thayer & Lane, 2000). Lower HRV indicates poorer functioning of the CAN, so emotions are not as well-regulated or understood in this state (Appelhans & Luecken, 2006; Thayer & Lane, 2000). There is some indication that this applies not only to short-term HRV, but to resting HRV (Park & Thayer, 2014). Although neurovisceral integration comes from a different framework than polyvagal theory, it is clear under both models that HRV correlates with emotional health, with greater HRV being linked to better emotional regulation. In particular, HRV seems to relate to the concept of relaxation.

2.2 ABC relaxation theory

The experience of relaxation is multifaceted. Most people would agree, for example, that the sensation of being relaxed in a warm bath is different from the relaxation felt during meditation, or that felt when noticing a friend in an otherwise unfamiliar place. ABC relaxation theory is one attempt to disentangle the many concepts which inform relaxation. Under this theory, relaxation can be described in roughly 15 relaxation states (R-states):

- Sleepiness
- Disengagement
- Physical Relaxation
- Mental Quiet
- Rested/Refreshed
- At Ease/At Peace
- Energized
- Aware
- Joy
- Thankfulness and Love
- Positive Detachment
- Prayerfulness
- Awe and Wonder
- Mystery
- Timeless/Boundless/Infinite (Smith et al., 2000).

2.2.1 Categorization of R-states

Smith (2001) has suggested numerous ways to categorize the 15 R-states. One model is through the 2x2 model, which focuses on affect and abstraction. Multiple R-states may be felt at the same time, but affect and abstraction can impact how they present (Smith et al., 2000; Smith, 2001). Some R-states, such as Sleepiness, have a low affect, whereas others, such as Joy, have a high affect (Smith et al., 2000). On the other hand, Sleepiness and Joy are both considered to be concrete R-states, whereas the R-state Prayerfulness is more abstract (Smith et al., 2000). An understanding of some R-states within this model is represented visually in Figure 2.

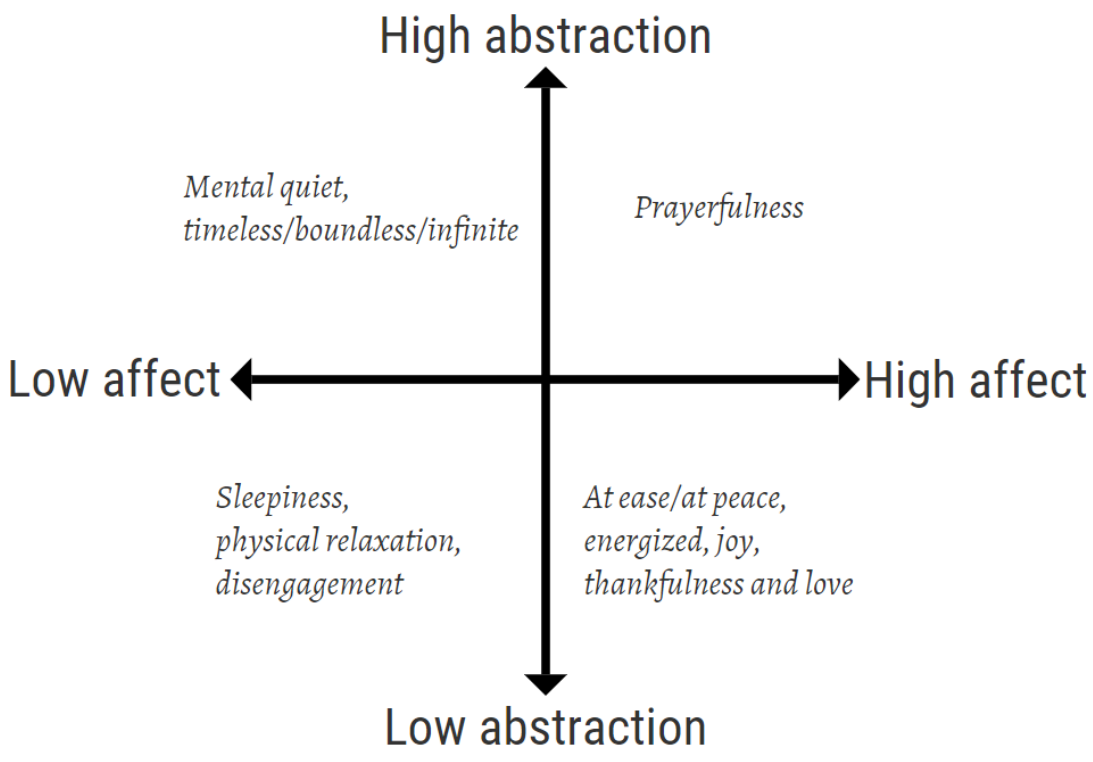

FIGURE 2. The R-states as organized by the 2x2 model of ABC relaxation theory. Through this, one can see that Energized is a concrete, high-affect state, whereas Mental Quiet is an abstract, low-affect state.

The R-states have also been organized as ordered levels: Level 1 (Disengagement, Rested/Refreshed, Energized, Sleepiness), which centres stress relief, Level 2 (Physical Relaxation, At Ease/At Peace, Joy), which centres pleasure and joy, Level 3 (Mental Quiet, Positive Detachment, Thankfulness and Love), which centres selflessness, Level 4 (Mystery, Awe and Wonder, Prayerfulness), which centres spirituality, and Level 5 (Timeless/Boundless/Infinite), which centres transcendence (Smith, 2001). The R-state "Aware" is not directly attributed to any of the five levels. Instead, Aware is considered a meta-state, meaning that it is considered possible for Aware to occur at any level, at any tier (Smith, 2001). In some cases, the R-state of Aware is accompanied by increased cognition, whereas in other cases it can be accompanied by decreased cognition.

Smith's ordered levels may be considered hierarchical in abstraction, meaning that R-states which encompass Level 4 are more abstract than in Level 3 (see Figure 3). However, this should not be understood to mean that those experiencing Level 4 relaxation are necessarily *more relaxed* than those experiencing Level 3 relaxation; in fact, men may generally prefer R-states which correspond better with lower, more concrete levels (Smith, 2001).

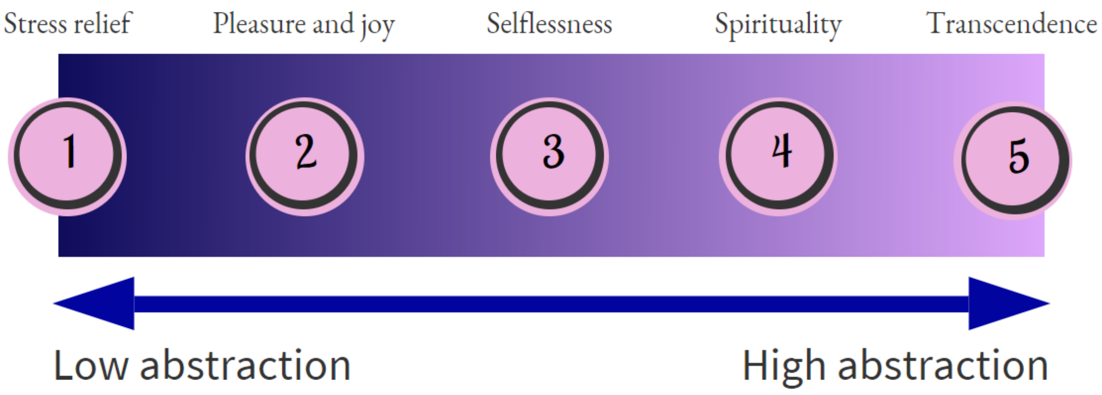

FIGURE 3. A visual representation of Smith's ordered levels for ABC relaxation theory.

2.2.2 Influential factors in R-state experiences

Different people have different access to and appreciation for different R-states. For example, when examining the influence of gender on R-states, it seems that women tend to prefer and experience R-states that are higher in both level and affect, while men prefer and experience R-states that are lower in both level and affect (Smith, 2001). Culture and context can also affect R-states. For example, Smith (2001) found that Black persons tended to experience higher degrees of the R-states Prayerfulness and Thankfulness and Love when compared to White and Asian people. Furthermore, R-states which did not usually occur together, such as Disengagement with Joy, seemed to occur together more often in spiritual contexts (Smith, 2001).

Personality traits similarly impacted R-state preferences and experiences (Smith, 2001; Ghoncheh & Smith, 2004). Thus, every person may have a specific profile which best details their preferred and most often experienced R-states, as influenced by any aspect of their life. Relaxation techniques, then, might change when considering such a profile. What tools are available for relaxation and the other needs encountered when considering HRV?

2.3 Breathing as a therapeutic tool

Many breathing techniques have been developed across the world, clinically and informally, to increase overall wellbeing and relaxation (Brown, Gerbarg, & Muench, 2013; Lehrer et al., 2000). The breath can hold deep cultural significance; in certain cultures, it is considered part of development spiritually, emotionally, and physically (Brown et al., 2013; Raghuraj, Ramakrishnan, Nagendra, & Telles, 1998). Certainly, rhythmic breathing is a part of several meditative practices (An, Kulkarni, Nagarathna & Nagendra, 2010; Peng et al., 1999; Phongsuphap, Phongsuphap, Chandanamattha, & Lursinsap, 2008; Raghuraj et al., 1998). Yogic breathing has even been used in a clinical setting to improve immune functioning, mitigate stress disorders, and fight addiction to tobacco (Kochupillai, 2005; Zope & Zope, 2013). It is not surprising, then, that breathing and HRV seem to be connected—and, in fact, when a person engages in slow, rhythmic breathing, HRV tends to increase (Lehrer & Gevirtz, 2014; Papaioannou, 2007).

2.3.1 Heart Rate Variability Biofeedback

To track and manage HRV, researchers developed a specific breathing program: Heart rate variability biofeedback, or HRVB (Lehrer et al., 2000; Vaschillo et al., 2006). HRVB is an established form of systematic breathing, wherein HRV is tracked over a monitor and a patient attempts to match breathing to slow, visual cues (Lehrer et al., 2000; Vaschillo et al., 2006). As the patient inhales, the heart rate increases, and the baroreflex causes blood pressure to fall. During exhalation, the heart rate decreases, and the baroreflex causes blood pressure to rise. When breathing is controlled at a slow pace, these fluctuations in heart rate become more defined, increasing HRV.

When a patient begins to breathe at a slow and steady pace, there is usually an immediate increase in HRV. The change in heart activity is clear when visually displayed by means of a heart rate monitor. During typical breathing, beat-to-beat intervals seem somewhat random. During HRVB, however, the systemic increase and decrease in heart rate (which is to say, the increased HRV) creates a regular pattern of alternating high and low heart rates. An example of this can be examined in Figure 4.

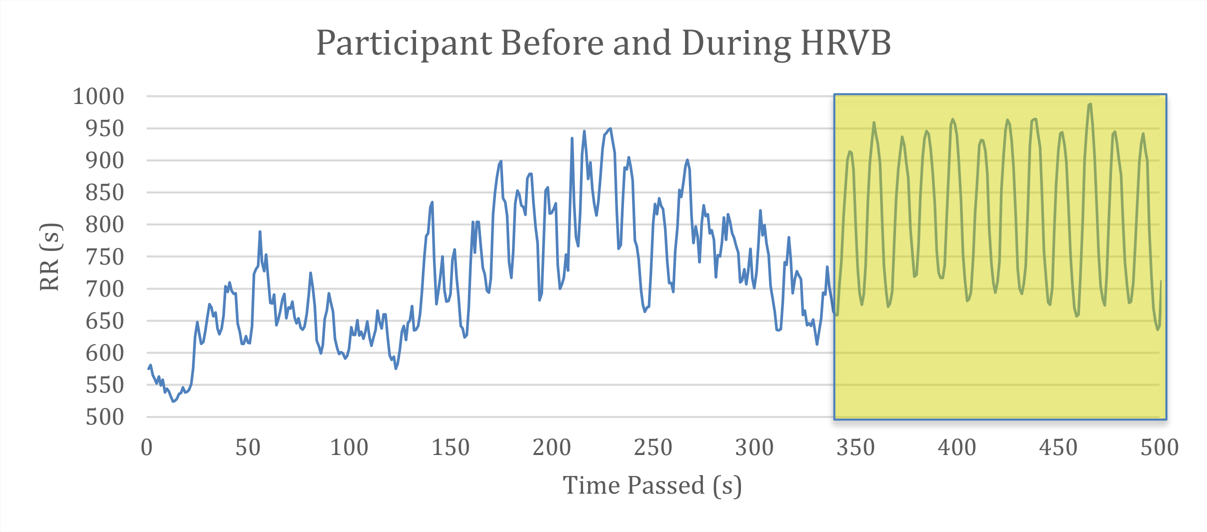

FIGURE 4. A brief recording of a participant's RR interval before and during HRVB. The HRVB begins within the highlighted section, at approximately 350 seconds. The shift from irregular and smaller peaks and falls in heart rate to a greater and more synchronized heart rate is visibly obvious.

HRVB has been used in several health contexts, typically showing influence over three mechanisms: autonomic homeostasis, the vagal afferent nerve, and the cholinergic anti-inflammatory system (Gevirtz, 2013; Huston & Tracey, 2011; Lehrer & Gevirtz, 2014; Lehrer et al., 2000; Vaschillo et al., 2006). If the aim is to increase HRV through exercising the baroreflex, HRVB is an excellent method for doing so, as it trains the baroreflex by manually increasing HRV. Again, this sort of training has numerous implications for better physical and emotional wellness. However, some specific adjustments may further improve at least short-term HRV when conducting HRVB. One element which can influence HRVB is the adherence to a person's resonance through resonance frequency breathing, which will be described in the next section.

2.3.2 Optimization of HRVB and its application in music therapy

HRVB is especially effective when tailored to the recipient's individualized resonance, wherein an individual's heart, blood pressure, and respiratory system find synchrony and maximum HRV is achieved (Brabant et al., 2017; Lehrer & Gevirtz, 2014; Lehrer et al., 2000; Vaschillo et al., 2006). Resonance in breathing is established by measuring a person's HRV while that person breathes at several different speeds; the optimal speed of breath is determined over at least three training sessions (Lehrer et al., 2000; Vaschillo et al., 2006). If a person's breathing speed is too slow, hyperventilation may occur (Lehrer et al., 2000; Vaschillo et al., 2006). Thus, it is important that those engaging in HRVB are instructed not to completely fill or empty their lungs, and adjustment to faster breathing speeds for certain people can create a more productive breathing session.

Optimal breathing speed appears to be related to blood volume, as maximal HRV is typically achieved at a lower breathing rate for men and/or taller people when compared to their female or shorter counterparts (Lehrer & Gevirtz, 2014; Vaschillo et al., 2006). When resonance is included as an important element of HRVB training, the training may be called resonance frequency breathing, or RFB (Brabant et al., 2017). Research suggests that resonant breathing has significant beneficial effects on experiences of depression, anxiety, and stress in both clinical and professional environments (Lehrer et al., 2000; Sutarto, Wahab, & Zin, 2012; Vaschillo et al., 2006). It may also enhance creativity and the capacity for emotional regulation (Brabant et al., 2017). Essentially, the benefits of HRVB in general apply to RFB, but arguably at a greater degree (Brabant et al., 2017).

In general (and without accounting for resonance), HRV is maximized when the recipient of HRVB breathes at approximately 6 breaths per minute, although some argue that a slower rate of 5.5 breaths per minute is preferable (Lehrer & Gevirtz, 2014; Lin, Tai, & Fan, 2014; Van Diest et al., 2014). Additionally, given the apparent importance of the baroreflex in maximizing HRV, breathing techniques may be particularly effective if exhalations are longer than inhalations (Lehrer & Gevritz, 2014; Van Diest et al., 2014). This seems to relate to the negative feedback loop that occurs through the baroreflex, wherein heart rate increases during exhalation and decreases during inhalation (Lehrer & Gevirtz, 2014; Papaioannou, 2007). On the other hand, Lin, Tai, and Fan (2014) produced research suggesting that an equal inhalation-to-exhalation ratio at a slower breathing rate is more effective than faster breathing with longer exhalations. In this case, however, there was no accounting for resonance in the rate of breathing, and in general results in this matter are mixed (Lehrer & Gevirtz, 2014; Lin, Tai, & Fan, 2014; Van Diest et al., 2014). At the very least, it is accepted that inhalation should not last longer than exhalation in efforts to relieve stress or maximize HRV (Cappo & Holmes, 1984; Lehrer & Gevirtz, 2014; Lin, Tai, & Fan, 2014; Van Diest et al., 2014). Typically, RFB is completed with longer exhalation than inhalation (Brabant et al., 2017).

Recently, RFB has been used as a specific auxiliary music therapy activity. In trials, a 10-minute RFB exercise was implemented at the beginning of music therapy sessions for clients who were either healthy or who suffered from anxiety and social phobia (Brabant, 2017a; Brabant, 2017b; Brabant et al., 2017). The RFB exercises were proceeded by 45-minute sessions of improvisational music therapy (Brabant, 2017b; Brabant et al., 2017). In comparison between these two groups, Brabant (2017b) found that RFB appears to have an adaptive effect within a music therapy context. In trials with healthy clients, HRV was lower during improvisations which occurred after an RFB exercise; to contrast, a case study with an anxious client showed an opposite effect (Brabant, 2017a; Brabant, 2017b). This dichotomy can be better understood under the model of the window of tolerance.

2.4 The window of tolerance

The model of the window of tolerance works well under polyvagal theory. According to this model, there exists a state of optimal arousal that best allows for emotional processing; if a person is hypo- or hyper-aroused, they must be led to a more moderated state before appropriate functioning can take place (Brabant, 2017a; Brabant, 2017b; Siegel, 2011). In this optimal state, working memory and conscious awareness are accessible, and mentally understanding emotions is more possible (Siegel, 2011). Under polyvagal theory, this can be understood in another way: When the SNS or the dorsal vagus are active, emotional processing is not an available function, and states of arousal must be balanced to activate the ventral vagus for emotional regulation. If a threat to safety (whether emotional or physical) is perceived, that threat must be brought to a manageable level before the less immediate need of emotional regulation can be addressed.

To regulate emotions, levels of arousal must be balanced into an optimal level—that is, a level within a person's window of tolerance. A hyper-aroused person (whose SNS is likely active) has rigid or chaotic thoughts and strong emotional reactivity, and thus arousal must be decreased to healthily approach emotional control or learn new concepts (Siegel, 2011). A hypo-aroused person (whose dorsal vagus is likely active) is at risk of dissociation and emotional distancy, and thus perceived threat must decrease *and* arousal must increase to healthily approach emotional control or learn new concepts (Siegel, 2011). When a person is optimally aroused, however, the ventral vagus is active, which under polyvagal theory indicates that the intake and understanding of new information is possible. Thus, emotions can be addressed appropriately.

Outside polyvagal theory, the window of tolerance model may still be applied. In this case, a person is not navigating the hierarchal polyvagal system, but rather, they are attempting to balance the dichotomy of the PNS and the SNS. However, in both frameworks a person moves from hypo- or hyper-arousal into an optimum state of arousal. This movement is represented visually in Figure 5. When navigating the human psyche (for example, when conducting a therapy session), it is imperative to know when a person is or is not capable of achieving any real progress; if that person's level of arousal is outside their personal window of tolerance, progress is unlikely. Therapists should know how to move into the window of tolerance, and this includes understanding that some people may generally have narrower windows than others.

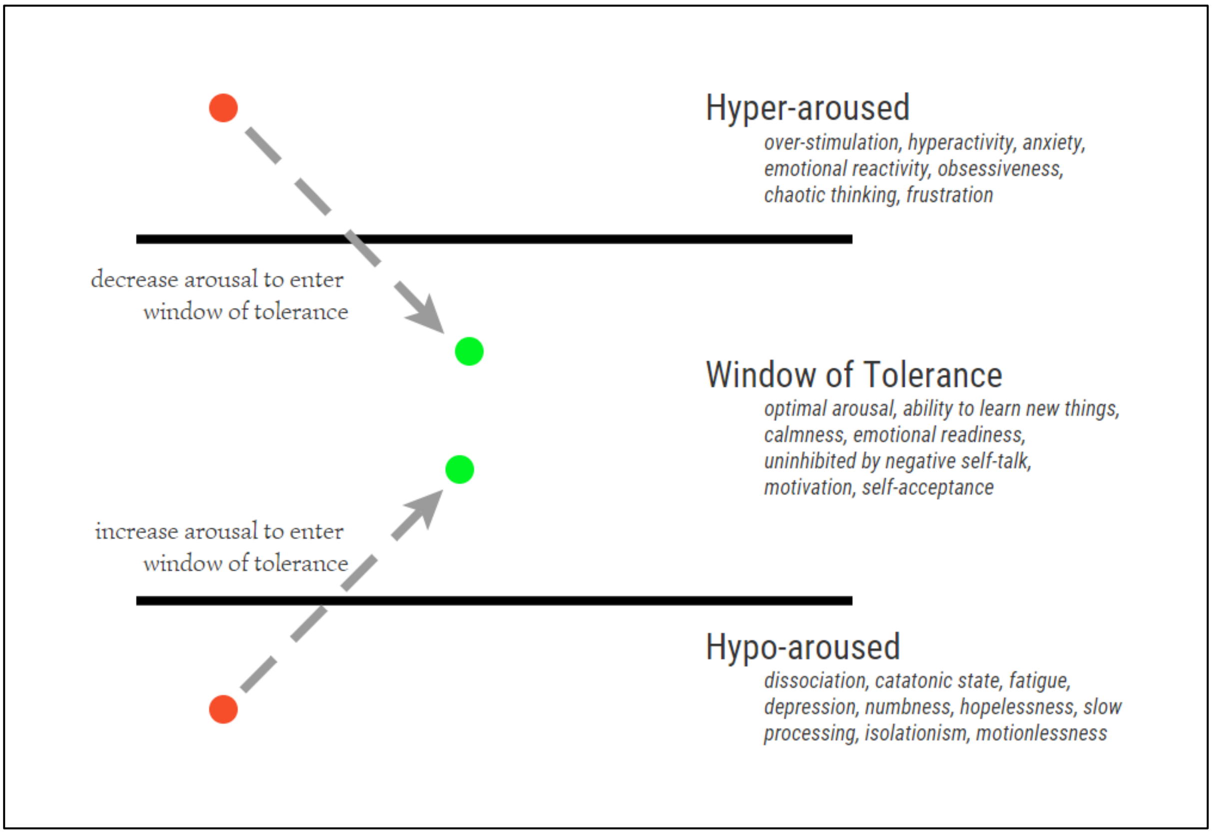

FIGURE 5. The model of the window of tolerance.

2.4.1 Widening the window of tolerance

The window of tolerance may be wider or narrower in different people or at different times. For example, trauma victims generally have a narrower window of tolerance, and environmental influences such as hunger can have a short-term influence on the window of tolerance (Siegel, 2011). A person with a narrower window of tolerance shifts more quickly into hypo-aroused or hyper-aroused states, and states of arousal which could be optimal for a healthy person are outside this person's window of tolerance (see Figure 6). Although emotional processing is more difficult outside the window of tolerance, the presence of emotional input may still be extremely intense (Gupta, 2013). This can lead to destructive behaviours, such as drug abuse and/or suicide planning, as means of self-regulating arousal (Corrigan, Fisher, & Nutt, 2011; Ogden & Minton, 2000). However, regulation need not be physically nor emotionally harmful.

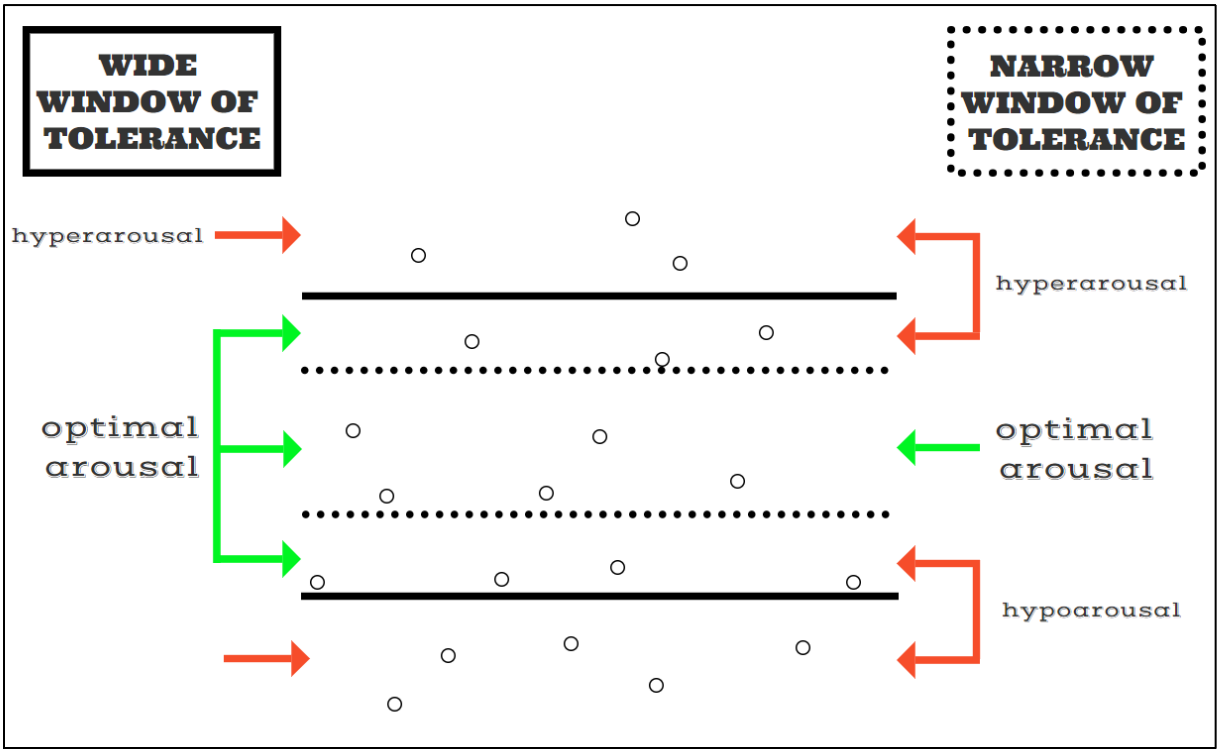

FIGURE 6. A comparison of the window of tolerance in two scenarios: narrow (see dotted black lines) and wide (see solid black lines). Arousal levels which are within the window of tolerance for a healthy person may be experienced as hyper- or hypo-arousal for a person with a narrow window of tolerance.

Healthy methods for regulating arousal, including the gradual expansion of the window of tolerance, do exist. For example, exercising, meditation, humour, mindfulness, and anti-depressants can all bring a person from a hypo- or hyper-aroused state into the window of tolerance (Corrigan et al., 2011). Furthermore, antipsychotics, such as quetiapine and olanzapine, have also been used not only to regulate arousal, but to widen the window of tolerance for victims of trauma (Corrigan et al., 2011). Of course, further study is necessary to make causal claims to the emotional gains made in these cases, but the existing research is promising. HRVB may also contribute to such efforts in regulating arousal.

2.4.2 HRVB as an intervention in achieving optimal arousal

In addition to standard psychiatric methods of arousal regulation, HRVB can be used in the regulation of arousal because of the link between HRV and vagal states. By regulating HRV, HRVB can take a person from a hypo-aroused or hyper-aroused state into an optimal state of arousal. For example, in Brabant's research (2017b), RFB (which as we recall is a form of HRVB) seemed to increase arousal in healthy clients after the activity, which allowed for a deeper exploration of difficult topics. On the other hand, the anxious client that he studied responded with a general sense of relaxation after practicing RFB (Brabant, 2017a; Brabant, 2017b). For healthy clients, a spark in arousal can prompt emotional understanding; for anxious clients, decreasing arousal creates a safe space for emotional processing to take place.

By examining RFB through the lens of the window of arousal model, the role of such an exercise for emotional processing becomes more obvious. The needs of each client in Brabant's research differed, so it is possible that they responded differently to the RFB exercises because of those needs (Brabant, 2017a; Brabant, 2017b; Siegel, 2011). Therefore, under this model, the benefits of RFB alone can be variable and person-dependent. It is also suggested that RFB could contribute to the overall widening of the window of arousal, especially as RFB seems to be linked to emotional regulation in general, but this has not been concretely measured (Brabant et al., 2017). What is known is that RFB seems to sometimes adjust arousal in such a way that those using it are brought into an altered state of consciousness. To understand how this relates to the window of tolerance, one must first understand what it means to be in an altered state.

2.5 Altered State of Consciousness

The achievement of an altered state of consciousness (ASC) has shown numerous therapeutic benefits within and outside therapeutic settings (Bonny, 1975; Bonny, 2002; Brabant, 2017a; Brabant et al., 2017; Bruschia & Grocke, 2002). ASC is described by Ludwig (1969) as:

> Any mental state(s) induced by various physiological, psychological, or pharmacological manoeuvres or agents, which can be recognized subjectively by the individual himself […] as representing a sufficient deviation in subjective experience or psychological functioning from certain general norms for that individual during alert, waking consciousness. (pp. 9-10)

Sensations, perceptions, cognitions, and emotions can all be altered, which thus alters both one's sense of self and one's sense of time (Brabant, 2017a). Within this state, it can be easier to explore and release emotions, which is naturally beneficial within a therapeutic context (Aldridge & Fachner, 2006; Brabant, 2017a; Bruschia & Grocke, 2002; Ludwig, 1969). During and after the altered state experience, more space is created for processing thoughts and feelings. In other words, the safe achievement of an ASC can shift a person's level of arousal to its optimal level within the window of consciousness.

2.5.1 History of ASC and music therapy

An altered state of consciousness has been achieved in a number of therapeutic and non-therapeutic contexts. These include psychoactive drugs, sensory deprivation, fasting, and even music therapy (Brabant, 2017a; Brabant et al., 2017). Indeed, one of the most well-known branches of music therapy, Guided Imagery and Music (GIM), has strong roots in the achievement of ASC (Bonny, 1975; Bonny, 2002; Brabant, 2017a; Bruschia & Grocke, 2002; Meadows, 2010; Grocke & Wigram, 2006).

In its infancy, GIM used music as an auxiliary force in psychedelic psychotherapy to reach peak experiences, release emotions, transcend time, and enter an altered state of consciousness (Aldridge & Fachner, 2006; Bonny, 1975; Bonny, 2002; Brabant, 2017a; Bruschia & Grocke, 2002; Meadows, 2010; Summer, 2011). Over time, the use of psychoactive drugs became less common in psychotherapy, but the music remained (Bonny, 1975; Bonny, 2002; Meadows, 2010). GIM continues to explore consciousness today with specific music-listening programming that has been developed over decades (Bonny, 1975; Bonny, 2002; Bruscia & Grocke, 2002; Meadows, 2010).

2.5.2 Other applications of ASC

GIM is not, by any means, the only musical pathway to an altered state of consciousness. Dance, free improvisation, and monotonous drumming are only some of the additional ways music has been used to transcend time and consciousness (Brabant, 2017a; Fachner, 2011). Frequency spectra, rhythmic repetition, and certain tempi can all contribute to ASC as a result of musical interventions in and out of therapy (Brabant, 2017a; Fachner, 2011). Music has even been used to control the altered state (Bonny, 1975; Aldridge & Fachner, 2006). Furthermore, ASC can have a role within psychotherapeutic, improvisational music therapy to create a potential space, wherein it becomes easier to move a client from not playing to playing, from inaction to action (Erkkilä, Ala-Ruona, Punkanen, & Fachner, 2012; Eschen, 2002).

While ASC is linked to music, it is linked as well to both HRV and specific breathing techniques. It is not uncommon for music therapists to use breathing techniques within sessions, although using RFB specifically in a session is still relatively new (Brabant et al., 2017; Grocke & Wigram, 2007). In fact, from a cultural perspective, breathing, music, HRV, and relaxation are historically connected (Bernardi et al., 2001; Lehrer, Sasaki, & Saito, 1999; Peng et al., 2004; Phongsuphap et al., 2008; Vickhoff et al., 2013). For example, HRV is naturally maximized within many unrelated meditative practices, with breathing speeds showing different effects among individual meditators (An et al., 2010; Lehrer et al., 1999; Peng et al., 2004; Phonsuphap et al., 2008). Additionally, mantra-singing and prayer have been shown to increase HRV and baroreflex sensitivity across multiple spiritualities—even within a secular choral setting (Bernardi et al., 2001; Vickhoff et al., 2013). These, however, are only some of therapeutic qualities associated, formally and informally, with music.

2.6 Utilizing music in HRV domains

Breathing is just one approach to managing anxiety and other issues influenced by HRV. In particular, musical interventions have been used historically in and outside of music therapy to manage physical and emotional states associated with low HRV. HRV itself does not have a strong presence as a measurement tool in many studies relating to the psychological or physiological effects of music, but it has been used on occasion for research purposes. Otherwise, the connection between HRV and music can be explored through states of being which are influenced by both. To understand the apparent "power" of music, especially in terms of relaxation, one can first explore its uses culturally and historically, and then examine specifically its uses in modern, Western music therapy.

2.6.1 Everyday uses of music

One of the most obvious examples of music being used for relaxation comes in a classic song form: the lullaby. Across cultures, parents have used lullabies to relax their children for centuries (Doja, 2014; Mireskandari & Sharbatian, 2015; Rock, Trainor, & Addison, 1999; Shakhkulyan & Khatchadourian, 2016). This suggests a universal element of lullabies within human nature (Doja, 2014; Shakhkulyan & Khatchadourian, 2016). Lullabies are considered calming not only to children, but perhaps also to their caregivers (Friedman, Kaplan, Rosenthal, & Console, 2010). The exact calming properties of lullabies are unclear, although some emotional control may be related to pitch and messaging (Rock et al., 1999; Tsang & Conrad, 2010).

Lullabies are generally considered to be sedative music; in other words, lullabies are intended to calm the listener. The effects of sedative and excitative music have been a subject of wide study. In general, sedative music is associated with perceived calm and greater HRV when compared to excitative music, although in one study these effects were no greater than those achieved through using no music at all (Iwanaga et al., 2005; Roque et al., 2013). Additionally, decibel level may confound results relating to HRV and sedative/excitatory music (Roque et al., 2013). However, it is observable at least from a historical perspective that sedative music has some relationship with relaxation—although its effects are not limited to this.

Lullabies offer not only relaxing effects, but they also facilitate bonding, improve emotional well-being, maintain culture, and decrease stress (Doja, 2014; Erickson Megel, Wagner Houser, & Simons Gleaves, 1998; Trehub & Trainor, 1998). These effects may occur even when the lullabies are audiotaped and lack physical bonding stimuli (Erickson Megel, Wagner Houser, & Simons Gleaves, 1998). Outside lullabies, a 2004 study by Voss et al. revealed that patients who systematically listened to sedative music after receiving open-heart surgery felt not only less anxiety, but less pain when compared to a control group of participants who rested without musical interventions. In a different study, which used music with premature infants, sedative music influenced heart rate, blood pressure, and respiratory rate (Lorch, Lorch, Diefendorf, & Earl, 1994). These cases, when they do not involve a therapeutic relationship, may be considered part of music medicine. However, sedative music can also be used in receptive methods of music therapy.

2.6.2 Music therapy

Music is particularly effective when wielded by a certified music therapist. In music therapy, a trained music therapy professional systematically uses music within a therapeutic relationship to achieve non-musical goals. This may include goals which are sometimes addressed through other means. For example, a study of cancer survivors showed increased relaxation, increased HRV, and decreased fatigue after receiving two hours of music therapy (Chuang, Han, Li, & Young, 2010). This supports the idea of a dichotomy between relaxation and fatigue (as would be argued under the window of tolerance model), and it suggests at least positive short-term effects of music therapy on HRV (Chuang et al., 2010; Smith et al., 2000).

Both RFB and music therapy have been used in varying circumstances to control blood pressure. For example, musical interventions show promise in influencing hypertension, which is also improved through RFB training. Indeed, a study conducted by Zanini et al. (2009), patients with stage 1 hypertension who received 12 weekly music therapy sessions significantly improved blood pressure control and quality of life when compared to a control group receiving standard treatment. In a meta-analysis by Kühlmann et al. (2016), a causal relationship between musical interventions and improved blood pressure control could not be proven nor disproven, but a trend was present which indicated a decrease in blood pressure for hypertensive patients receiving music interventions. This indicates at least a correlation, which should encourage future use of music interventions (and research of this use) with this population.

Music therapists are aware of the general effects of sedative and excitative music. For example, receptive music therapy methods sometimes use lullabies with people of many ages to induce relaxation, with promising results (Grocke & Wigram, 2006; Robb, Nichols, Rutan, Bishop & Parker, 1995). Music therapists also often consider sedation and excitation when planning specific activities; an activity with a hyperactive client, for example, may begin with excitative music and gradually move to activities which include sedative music in a process called entrainment (Thaut, McIntosh, & Hoemberg, 2015). It should be addressed, however, that this is only one small facet of the considerations made within music therapy. The field of music therapy is as broad as that of "health," and thus, only a small fraction of its influence is described within this thesis.

Overall, the research surrounding HRV, music, relaxation, ASC, and breath is quite extensive. RFB has been used recently as an auxiliary activity in music therapy, but the addition of music into an RFB program could have a meaningful impact. Sedative music has shown strong effects in health, including but not limited to relaxation. Music can also increase HRV and improve health conditions which relate to HRV. Furthermore, music can be used within and outside of therapeutic contexts to achieve an altered state of consciousness, something also achieved through RFB. Thus, music and RFB are at least distantly related; now, a stronger relationship may be formed.

3 THE CURRENT STUDY

The existing literature provides important information regarding such issues as the function of HRV, the results of RFB training, the history of sedative and consciousness-altering music therapy interventions, and more. With all this in mind, the research suggests great benefits to arise from RFB training. Under the model of the window of tolerance, RFB training leads to better emotional processing. In music psychotherapy especially, the benefits of this are clear, as clients can better approach difficult topics when neither hypo- nor hyperaroused. Music has already been used as an auxiliary force for ASC during psychedelic therapies; perhaps music can again act to assist in the achievement of ASC. Furthermore, with the knowledge that calm alertness is achieved through RFB, perhaps music may change a person's experience of relaxation when using RFB.

How can music therapists use RFB? Brabant et al.'s 2017 study has already shown its usefulness within improvisational music therapy, allowing depth and peace for those who need each respectively. Already, RFB shows promise as a music therapy tool; this study is only one possible route to improving it and making it truly musical. Perhaps new, uniquely therapeutic experiences may arise within a musical space.

3.1 Aims

Again, this study aims to explore whether music can be used to improve the efficacy and/or change the perceptions of relaxation from RFB training. According to the literature, music and RFB have both been used to achieve similar goals, including relaxation, achievement of ASC, and maximized HRV. Thus, it is possible that they may be able to work in tandem to have an even greater effect when working toward these goals.

3.1.1 Hypotheses

The primary hypothesis of the study is as follows: Participants using RFB with musical breathing cues will have greater HRV than those using visual breathing cues. A secondary hypothesis states: Participants who are cued musically while using RFB will have higher post-test ratings of relaxation in the musical cueing condition than in the visual cueing condition.

Finally, a third hypothesis states: Participants who are cued musically while using RFB will have different post-test ratings of attentiveness in the musical cueing condition than in the visual cueing condition.

3.1.2 Research question

Since this study is intended to include not only quantitative, but also qualitative data, it briefly explores the sensation of relaxation under ABC relaxation theory. Thus, a research question is posed: How does a person experience relaxation when practicing RFB with visual or musical cues?

3.2 Experimental design

This study is based primarily in quantitative methods. This allowed for the collection of clear, numerical data, which best suits the proposed hypotheses. However, some qualitative data was collected with regard to the experiences of participant perceptions. With this data, some rich analysis can also be provided through the study. If music influences the actual perception of relaxation for participants, this is a matter highly worthy of study.

3.2.1 Pre-study musical composition

Before data could be collected for the current study, music needed to be prepared for the musical condition. Strong consideration was taken when choosing the musical cue. It is generally accepted within the realm of music therapy that music which is chosen by a client is more effective than "prescribed" music in most music therapy interventions (Davis & Hadley, 2015; Hanser, 1999; Pelletier, 2004; Shultis & Gallagher, 2015; Smith & Joyce, 2004). However, using participant-preferred music in this study would have been extremely difficult in terms of controlling for variables among participants. Music is extremely variable, given the influence of elements such as harmony, melody, tempo, timbre, texture, articulation, and dynamics. Even preparing a small selection of songs to choose would introduce variables that would dramatically increase the number of participants required to maintain validity. Furthermore, developing breathing cues within participant-preferred music would have been extremely difficult, especially if the music was naturally inclined to give other cues. Finally, most music commonly used for listening is non-static and may contain surprising musical elements (for example, a sforzando or sudden removal of bass tones) which could disrupt the breathing cycles during an RFB session.

Since using participant-preferred music was not feasible, music was specially composed for this project. Johanna Wilson, a master degree student in the Music, Mind, and Technology program at the University of Jyväskylä, composed music that was designed to cue inhalation and exhalation, with an inhalation rate of 40% and an exhalation rate of 60%. The music was composed using MIDI instruments, which meant that the tempo could be changed without influencing any other musical elements. Therefore, six music files were created, allowing for use at 7, 6.5, 6, 5.5, 5, and 4.5 breaths per minute. This was expected to suit the resonant frequency of a wide range of participants. Inhalation was cued by an ascending cello line, while exhalation was cued by a descending harp line. Percussive instruments played a rhythmic ostinato, which was intended to maintain a steady and clear pace. After 6 cycles of just these instruments (with a cycle being defined as 10 musical beats, or the length of an inhale-exhale cycle), a viola line was introduced, which played a countermelody at a relatively soft dynamic. The viola was included to prevent fatigue in the listener by providing an interesting musical development, but the other instruments remained clear and present so that the listener would not be distracted from maintaining the paced breathing. Similarly, the mild modulation from a progression in D minor (i-III-III-♭VII-♭VII-i) to a stepwise-descending progression in G minor (i-♭VII-VI-v-iv-♭VII-i), which uses the D minor chord as an unobtrusive pivot chord and keeps the tonicization almost in the relative major key, makes a gradual change under the same reasoning. The harmonic shift was deliberately slow so as to never “surprise” the listener; all elements were introduced gradually for the sake of a consistent attention to the breath.

3.2.2 Conditions

A within-subjects design was used to compare two conditions: Visual cueing (Condition A) and auditory cueing (Condition B). Thus, the independent variable was cueing method, and the dependent variables were HRV, levels of relaxation, and levels of attentiveness. To control for order effects, counterbalancing was applied to the conditions. Within-subjects designs like this one are recommended for data related to HRV because they help reduce confounds that may relate to individual respiration rates and health concerns (Laborde, Mosley, & Thayer, 2017).

3.2.3 Accounting for resonance

As outlined in the discussion of RFB, HRV is maximized when a person breathes at a speed tailored specifically for them. Resonance is determined by testing a person's HRV by breathing for short periods at different rates. However, the process of determining resonance is long and would require participants to come to an additional meeting with the researcher. This increases the risk of experimental mortality. Furthermore, introducing the participants to an additional RFB session could introduce fatigue effects—especially given that only a visual stimulus could be used in determining resonance, since the musical stimulus had not yet been tested in RFB. With all this in mind, a different technique for determining resonance seemed sensible.

In studying HRVB, Vaschillo, et al. (2006) determined that a person's resonance may be correlated with their height. As resonant frequency seems to be related to blood volume, taller people tend to breathe with resonance at slower rates than shorter people (Vaschillo et al., 2006). It was decided that to prevent experimental mortality, resonance would be estimated using each participant's height, rather than systematically calculated for each participant through extensive testing. Vashcillo et al. (2006) provided a chart indicating the trend of resonance as correlated with height, and this chart was used as a guide for determining resonance. While this method does present a problem in that it is not as exact as using true resonance, the within-subjects design was expected to counteract the inexactitude, since any deviation from a participant's true resonance was accounted for in both conditions.

3.2.4 Ethical considerations

Although there were few obvious risks to participants within this study, it is not uncommon for an untrained person to hyperventilate during RFB. Thus, careful instruction was given to ensure that the participants would not breathe too deeply. Furthermore, participants were informed that they could halt the experiment at any time, and they each signed a consent form clearly detailing the procedures of the experiments. As compensation for their time, each participant was given a voucher for one movie at a local movie theatre. Numbers were assigned to each participant to organize the data and to protect participant anonymity.

3.2.5 Sampling considerations

Because convenience sampling was used and the main researcher is a student of music therapy, it was anticipated that the participant pool would contain an unusually large number of musicians. This was problematic because musicians could be biased toward musical interventions and might find auditory synchrony easier when compared to non-musicians (Doelling & Poeppel, 2015). Because of this, the researcher collected data regarding level of musicianship, which in this case was determined by the number of years a participant had trained formally or informally in learning to sing or play an instrument. Of course, while this may be an acceptable view of musicianship, composition or conducting experience were not considered. Furthermore, this definition may include musicians but exclude non-musicians with high degrees of musicality—that is, non-musicians with natural skill in music. However, determining overall musicality is less quantifiable than operationally defining musicianship, so for the purposes of this study, musicianship was determined and later reframed through covariance adjustment.

In addition to musicianship, the presence of diseases relating to the heart or to the respiratory system were expected to influence HRV data. Thus, information in these areas was requested from participants. Furthermore, smokers show unusual HRV responses to controlled respiration when compared to nonsmokers, so the research controlled also for this population (Barutcu et al., 2005; Karakaya et al., 2007). Finally, only adult participants were recruited for this experiment, because resonant breathing tends to present differently for children than for adults (Lehrer & Gevirtz, 2014).

3.2.6 Demographic distribution

A total of 20 adults participated in the experiment. Their ages ranged from 21-41, with a median age of 26. 18 women and 2 men participated, resulting in a female majority of 90%. All the participants were students from the University of Jyväskylä, recruited through email, social media, and word of mouth. 11 of the participants were musicians, which is operationally defined as having had at least 5 years of informal or formal musical training. Thus, 55% were musicians, and 45% were non-musicians. Heights of the participants ranged from 62″ to 75″, and the median height was 66″. One of the participants reported a diagnosis of asthma, two of the participants reported occasional blood pressure irregularities, and none of the participants smoked regularly.

3.2.7 Environment

Each of the participants met the researcher on two dates, arriving at the same time on both dates to control for the influence of circadian rhythms on HRV (Brabant et al., 2017). The experiments were held in a small room designed for music practice. While this usually allowed for a quiet experience, the room was not entirely soundproof, and sometimes nearby music practicing could be heard.

3.2.8 Materials

During the visual condition, participants were cued by the Kardia – Breath Stress Relief app, accessed on a Huawei ALE-L21 phone running Android version 6. This app can be configured to show a ball growing and shrinking at a specific rate (see Figure 7); when the ball grows, the user breathes in, and when the ball shrinks, the user breathes out. During the musical condition, participants were cued by the musical samples composed by Johanna Wilson, which were played through sound-cancelling headphones connected to the aforementioned phone. HRV data was gathered through use of the standard Tickr heart rate monitor. This monitor is a noninvasive chest strap, which is worn around the chest muscles against the skin. The monitor connected via Bluetooth to the EliteHRV application on a Huawei Y560-L01 phone running Android version 5.1.1. The EliteHRV app allowed for the storage of detailed HRV data. The collected data was analysed through Kubios HRV Standard software. Additional data was collected through self-report pre- and post- Likert scale tests (see Appendices A and B). Finally, demographic information was collected through a survey (see Appendix C).

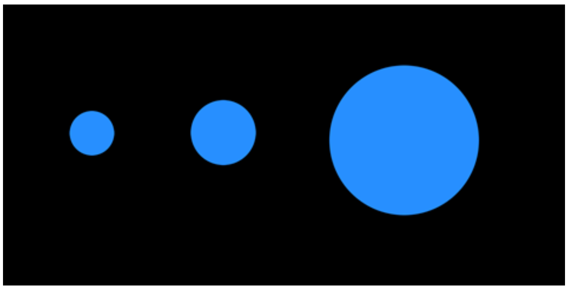

FIGURE 7. The Kardia app ball at three different stages of breath.

3.3 Procedures

3.3.1 Condition A

The researcher prepared the Kardia app, setting the inhalation-exhalation ratio to 40% inhalation and 60% exhalation (identical to the rate of the cues in the musical condition). No in-app sounds were used, and the light blue circle was visible. The app was set to run for 10 minutes, and the number of breathing cycles per minute was adjusted according to each participant's height. Breathing speeds ranged from 5 breaths/min to 6 breaths/min.

If this was the first meeting with the researcher, each participant read and signed a consent form before the researcher instructed the participant in wearing the Tickr monitor and chest strap, which was to lie flat by the chest muscles. If this was the second meeting, the researcher reminded the participant how to use the chest strap. Once the chest strap was in use, the researcher began recording HRV data. During this time, the participant completed two pre-test Likert scales, rating perceived levels of relaxation and attentiveness (see Appendix A). The researcher then introduced the Kardia app, explaining that the participant would breathe in as the on-screen ball expanded and out as the ball contracted. If this was the first meeting, the researcher instructed the participant in the breathing style, using the phrase "low, slow, and circular." The researcher explained that the breath should be felt low in the abdomen, rather than in the chest; that the breath should be slow but not deep, breathing the same amount of air as usual but at a slower pace; and that the breath should not be held, but rather should be a continuous circle of inhalation and exhalation. The participant was given an opportunity to practice this style of breathing with the ball. When the participant felt secure in the breathing technique, the researcher began the experiment.

The participant breathed with the Kardia app for 10 minutes, during which time the researcher recorded the participant's HRV. At the culmination of the 10-minute exercise, which was indicated by the termination of the ball's movement, the participant was given a post-test (see Appendix B) to rate levels of relaxation and attentiveness. The post-test also included a section for the participant to describe the breathing experience. If this was the second meeting, the participant was encouraged to also compare this breathing exercise to the musical condition within the descriptive section. Finally, if this was the second meeting, the participant completed a demographic survey (see Appendix C) and was given a voucher for one free movie ticket at the local theatre. HRV data was collected up to the point when the client finished the demographic survey.

3.3.2 Condition B

The researcher prepared the music for the client. The number of breathing cycles per minute was chosen according to each participant's height.

If this was the first meeting with the researcher, each participant read and signed a consent form before the researcher instructed the participant in wearing the Tickr monitor and chest strap, which was to lie flat by the chest muscles. If this was the second meeting, the researcher reminded the participant how to use the chest strap. Once the chest strap was in use, the researcher began recording HRV data. During this time, the participant completed two pre-test Likert scales, rating perceived levels of relaxation and attentiveness (see Appendix A). The researcher then introduced the music, explaining that the participant would breathe in during an ascending cello line and breathe out during a descending harp line. If this was the first meeting, the researcher instructed the participant in the breathing style, using the phrase "low, slow, and circular." The researcher explained that the breath should be felt low in the abdomen, rather than in the chest; that the breath should be slow but not deep, breathing the same amount of air as usual but at a slower pace; and that the breath should not be held, but rather should be a continuous circle of inhalation and exhalation. The participant was given an opportunity to practice this style of breathing with the music. When the participant felt secure in the breathing technique, the researcher began the experiment.

Each participant breathed with music for 10 minutes, during which time the researcher recorded the participant's HRV. At the culmination of the 10-minute exercise, which was indicated by the termination of the music, the participant was given a post-test (see Appendix B) to rate levels of relaxation and attentiveness. The post-test also included a section for the participant to describe the breathing experience. If this was the second meeting, the participant was encouraged to also compare this breathing exercise to the visual condition within the descriptive section. Finally, if this was the second meeting, the participant completed a demographic survey (see Appendix C) and was given a voucher for one free movie ticket at the local theatre. HRV data was collected up to the point when the client finished the demographic survey.

3.4 Analysis

3.4.1 HRV data

HRV data was exported from the EliteHRV app and analysed using the Kubios HRV standard software. A 6-minute sample was selected from each RFB session. The sample began exactly 2 minutes into the 10-minute RFB session, and ended exactly 2 minutes before each session's conclusion. This sample is approximately the length recommended by the Task Force of the European Society of Cardiology and the North American Society of Pacing (1996) for short-term HRV analysis. It also accounts for the time needed for the participant to adapt to the activity.

Artifacts, or ectopic beats, were removed on all samples within Kubios. Kubios artifact correction removes beat-to-beat intervals which deviate from the local average by 0.45 seconds (very low), 0.35 seconds (low), 0.25 seconds (medium), 0.15 seconds (strong), or 0.05 seconds (very strong). Artifacts are replaced through cubic spline interpolation. For analysis, the threshold setting which removed artifacts at the lowest possible sensitivity was chosen, thus preventing distortion of the rest of the data. A smoothness priors approach was applied to all samples, acting to detrend the data. This is recommended in analysis with RFB because it minimizes distortion and treats the heart rate signal as more stationary (Brabant et al., 2017).

The metrics selected for HRV analysis in this study were those recommended by Laborde et al. (2017). To determine variance, beat-to-beat (N-N) intervals were analysed. The standard deviation of N-N intervals (SDNN) was calculated as a measure of the global variance, while short-term variance was calculated through the root mean square differences among successive N-N intervals (RMSSD).

When all indices of the samples were collected, the mean for each index was calculated. A paired t-test was used in SPSS to compare indices between the conditions.

3.4.2 Pre- and post-test data

Likert scale data from pre- and post- tests was recorded. The scales were treated as nonparametric data, and the change for each scale, as well as overall pre- and post-test scores, was determined and compared between conditions.

3.4.3 Qualitative data

Two coders, the main researcher and an unrelated coder with minimal knowledge of the project, analysed the written responses to the breathing exercises through conventional content analysis. Furthermore, written words which pertained to relaxation were categorized within the 15 relaxation states as proposed by ABC relaxation theory, using directed content analysis.

4 RESULTS

4.1 HRV analysis

Paired samples t-tests were used to compare SDNN, RMSSD, and HF, which were found to be normally distributed in both the task with visual cueing (Condition A) and the task with musical cueing (Condition B). As HFnu data were found to not be normally distributed, a Wilcoxon signed-ranks test was performed with these data. A significant positive correlation was found between scores for SDNN, where r(19) = .74, $p < .001$, RMSSD, where r(19) = .71, $p < .001$, and HF, where r(19) = .69, $p < .001$. No significant difference was found between scores for the SDNN of Condition A (*M* = 78.65, *SD* = 31.11) and Condition B (*M* = 79.84, *SD* = 30.45); *t*(19) = -.24, *p* = .814. No significant difference was found between scores for the RMSSD of Condition A (*M* = 49.18, *SD* = 24.70) and Condition B (*M* = 47.71, *SD* = 21.88); *t*(19) = .37, *p* = .719. No significant difference was found between scores for the HF of Condition A (*M* = 6.04, *SD* = 1.16) and Condition B (*M* = 6.10, *SD* = 1.09); *t*(19) = -.31, *p* = .761. No significant difference was found between the scores for the HFnu of Condition A (*Mdn* = 8.36) and Condition B (*Mdn* = 7.53); (*Z* = -.08, *p* = .94).

4.2 Likert scale data

The pre- and post- difference between scores for relaxation and attentiveness were compared among conditions using a Wilcoxon signed-ranks test. No significant difference was found between the scores for the pre-post difference in relaxation score for Condition A and B (*Z* = -.11, *p* = .914). In fact, the median for both conditions was the same (*Mdn* = 1). No significant difference was found between the scores for the pre-post difference in attentiveness score for Condition A and B (*Z* = -1.28, *p* = .199). Once again, the median for both conditions was the same (*Mdn* = 0). Furthermore, the post-test scores alone for relaxation were compared using a Wilcoxon signed-ranks test. No significant difference was found between the post-test scores for relaxation in Condition A (*Mdn* = 4) and Condition B (*Mdn* = 5); (*Z* = -.76, *p* = .449). The post-test scores alone for attentiveness were then compared using a paired t-test. No significant difference was found between the post-test scores for attentiveness in Condition A (*M* = 3.35, *SD* = 1.23) and in Condition B (*M* = 3.75, *SD* = 1.25); *t*(19) = -1.36, *p* = .189.

Finally, paired samples t-tests were run to compare overall difference in scores for relaxation and attentiveness after completing any RFB task. A significant difference was found between scores for overall pre-test relaxation (M = 3.50, SD = .82) and post-test relaxation (M = 4.40, SD = .78); $t(39) = -6.77$, $p < .001$. No significant difference was found between scores for overall pre-test attentiveness (M = 3.58, SD = .84) and post-test attentiveness (M = 3.55, SD = .20); $t(39) = -.11$, $p = .911$. Within conditions, similar results were found; a significant difference was found between scores for pre-test relaxation in Condition A (M = 3.45, SD = .89) and post-test relaxation in Condition A (M = 4.30, SD = .73); $t(19) = -4.68$, $p < .001$. A significant difference was also found between scores for pre-test relaxation in Condition B (M = 3.55, SD = .76) and post-test relaxation in Condition B (M = 4.50, SD = .83); $t(19) = -4.80$, $p < .001$. No significant difference was found between scores for pre-test attentiveness in Condition A (M = 3.70, SD = .66) and post-test attentiveness in Condition A (M = 3.35, SD = 1.23); $t(19) = 1.07$, $p = .297$. No significant difference was found between scores for pre-test attentiveness in Condition B (M = 3.45, SD = 1.00) and post-test attentiveness in Condition B (M = 3.75, SD = 1.25); $t(19) = -1.03$, $p = .316$.

4.3 Qualitative data

4.3.1 Conventional content analysis

Two coders, the main researcher and an unrelated coder with minimal knowledge of the project, analysed the written responses to the breathing exercises through conventional content analysis. Cohen’s κ determined substantial agreement between the coders, κ = .741. Several codes were identified within the text by both coders. The codes were compared and adjusted as the coders debated and discussed the codes. Eventually, the coders came to agree upon seven major themes:

- Relaxation
- Attentiveness
- “Zoning out”
- Bodily sensations
- Ease of use
- Enjoyment

- Distraction from outside sources

The frequency of a concept was determined and compared across conditions. Reference to relaxation occurred 19 times in text responding to Condition A (the visual condition) and 33 times in text responding to Condition B (the musical condition). Reference to attentiveness occurred 17 times in text responding to Condition A and 11 times in text responding to Condition B. Reference to "zoning out" occurred 5 times in text responding to Condition A and 2 times in text responding to Condition B. Reference to bodily sensations occurred 7 times in text responding to Condition A and 15 times in text responding to Condition B. Reference to ease of use occurred 13 times in text responding to Condition A and 16 times in text responding to Condition B. Reference to enjoyment occurred 4 times in text responding to Condition A and 9 times in text responding to Condition B. Reference to distraction from outside sources occurred 8 times in text responding to Condition A and 2 times in text responding to Condition B.

4.3.2 Directed content analysis

The coders explored the theme of relaxation in particular and, using directed content analysis, attempted to place statements of relaxation within the context of ABC relaxation theory. Statements relating to relaxation were identified, and the coders determined which relaxation state could be represented by each statement. The possible relaxation states were the 15 R-states proposed by ABC relaxation theory: Sleepiness, Disengagement, Physical Relaxation, Mental Quiet, Rested/Refreshed, At Ease/At Peace, Energized, Aware, Joy, Thankfulness and Love, Positive Detachment, Prayerfulness, Awe and Wonder, Mystery, and Timeless/Boundless/Infinite.

None of the statements which referenced relaxation indicated experiencing the following states: Rested/Refreshed, Aware, Thankfulness and Love, Positive Detachment, Prayerfulness, Awe and Wonder, Mystery. 8 statements referenced Sleepiness, with 4 statements corresponding to Condition A and 4 statements corresponding to Condition B. 1 statement referenced Disengagement, and that statement corresponded to Condition B. 2 statements referenced Physical Relaxation, with 1 statement corresponding to Condition A and 1 statement corresponding to Condition B. 1 statement referenced Mental Quiet, and that statement corresponded to Condition B. 3 statements referenced At Ease/At Peace, with 1 statement corresponding to Condition A and 2 statements corresponding to Condition B. 1 statement referenced Energized, and that statement corresponded to Condition B. 7 statements referenced Timeless/Boundless/Infinite, with 4 statements corresponding to Condition A and 3 statements corresponding to Condition B.

Statements were further plotted within Smith's (2001) proposed levels of abstraction of R-states. 10 statements were grouped into Level 1, with 4 statements from Condition A and 6 statements from Condition B. 6 statements were grouped into Level 2, with 2 statements from Condition A and 4 statements from Condition B. 1 statement was grouped into Level 3, and that statement was from Condition B. No statements were grouped into Level 4. 7 statements were grouped into Level 5, with 4 statements from Condition A and 3 statements from Condition B.

5 DISCUSSION

The musical condition (Condition B) was, overall, not significantly more effective than the visual condition (Condition A) in maximizing HRV, relaxation, or attentiveness. However, the musical condition was also not significantly *less* effective than the visual condition. In terms of cueing, musical cueing seemed as effective as visual cueing, even if additional therapeutic effects were not observed. Furthermore, qualitative analysis indicates that the experience of breathing to a visual cue was *perceived* as different from breathing to a musical cue, even if direct physical data showed no difference. Indeed, participants often showed a preference for a certain condition. This is exhibited in qualitative results, which identified enjoyment as a theme across respondents.

5.1 Themes

The coders came to agree upon seven major themes: Relaxation, attentiveness, “zoning out,” bodily sensations, ease of use, enjoyment, and distraction from outside sources. Each theme was established through repeated discussion between the coders, and certain themes occurred more in one condition than another. The frequency of statements corresponding to each theme is represented as a clustered bar graph in Figure 8.

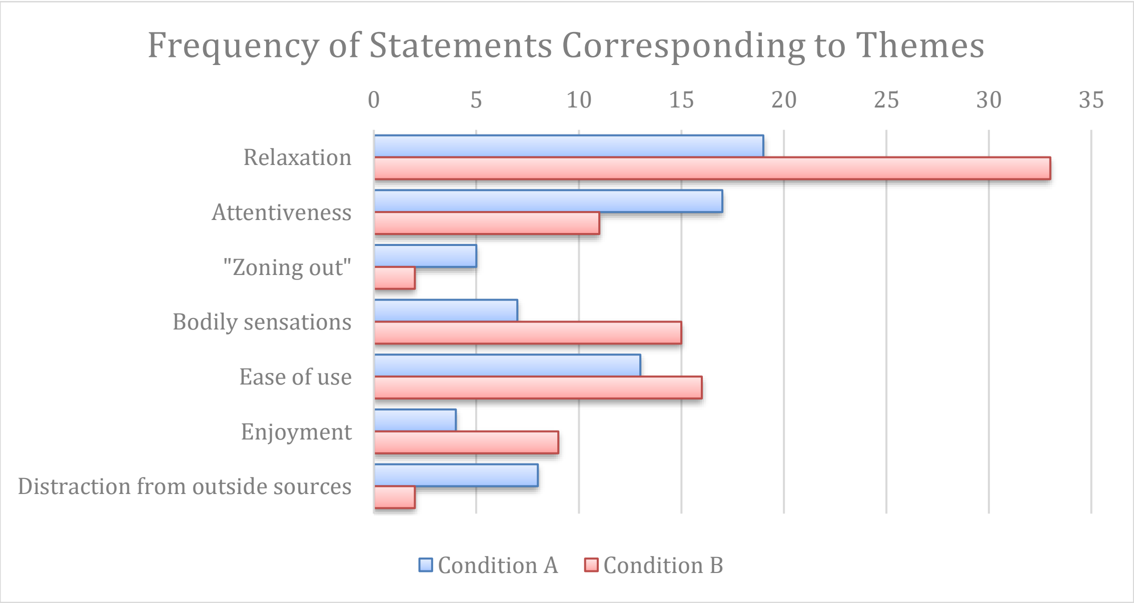

FIGURE 8. Frequency of statements according to themes in the visual condition (Condition A) and the musical condition (Condition B).

5.1.1 Relaxation

> The exercise was very peaceful. I felt extremely relaxed by the end of it.

With 52 relevant statements in total, such as the above quote from the visual condition, relaxation was an unsurprisingly common topic in the study. Typically, participants reported feeling relaxed during and immediately after RFB; indeed, in Likert scale assessment, relaxation scores were significantly likely to rise after completing RFB regardless of condition. However, the specific experience of relaxation was reported differently. For example, one participant had conflicting feelings of relaxation after the musical experiment:

> In general, I felt "physically" relaxed, but "mentally" or "emotionally" not as relaxed or attentive as before the experiment.

This sort of conflict was explored in depth by applying ABC relaxation theory in directed content analysis. Statements relating to relaxation were coded into R-states: Sleepiness, Disengagement, Physical Relaxation, Mental Quiet, Rested/Refreshed, At Ease/At Peace, Energized, Aware, Joy, Thankfulness and Love, Positive Detachment, Prayerfulness, Awe and Wonder, Mystery, and Timeless/Boundless/Infinite. The frequency of statements indicating R-states, separated by condition, are represented as a cluster column graph in Figure 9.

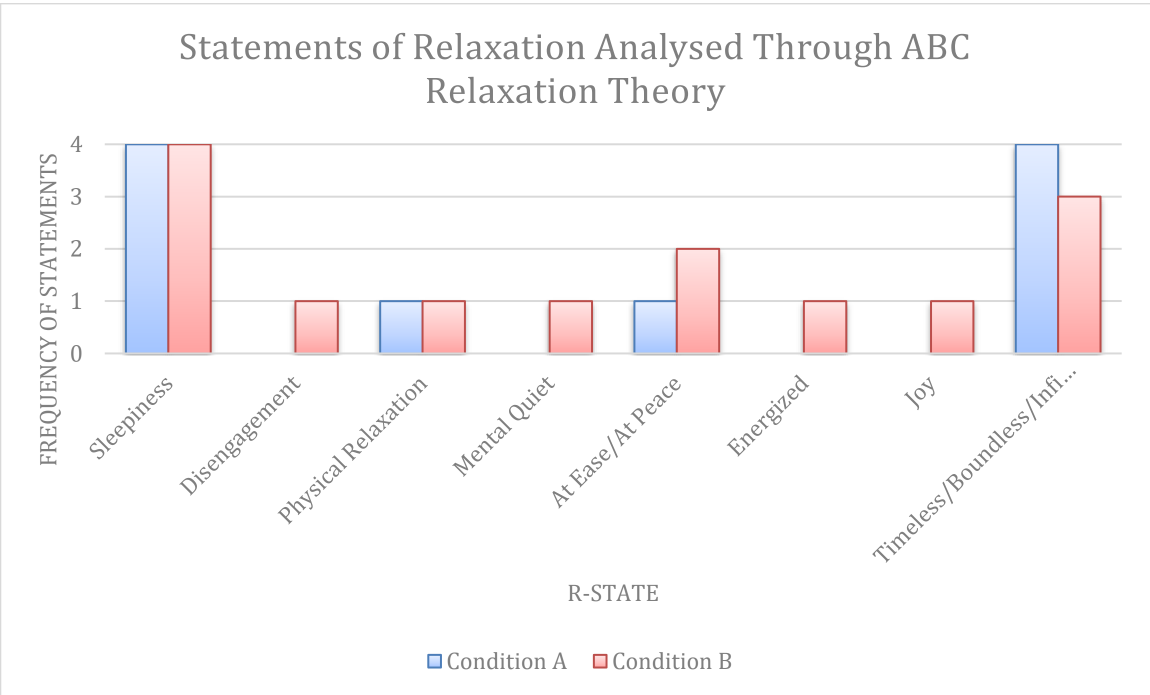

FIGURE 9. Statements of relaxation in Condition A (the visual condition) and Condition B (the musical condition) as analysed through ABC relaxation theory.

As the bar graph shows, some R-states were represented solely in Condition B (the musical condition). No R-states were represented solely by Condition A (the visual condition), and the only R-state more highly represented by Condition A was Timeless/Boundless/Infinite. Extrapolating information from these results is difficult; perhaps part of the musical stimulus made participants more descriptive about how they experienced relaxation, or perhaps the experience itself was different.

On the other hand, by further examining the statements under Smith's (2001) levels of abstraction, one could wonder whether the relaxation experience under a visual cue is more abstract than under a musical one. The one meta R-state, Aware, did not correspond with any of the statements, although it may have been present in either condition. Meanwhile, when re-organized under levels of abstraction and plotted as a column graph (see Figure 10), the statements indicating R-states seem to suggest differing experiences of relaxation.

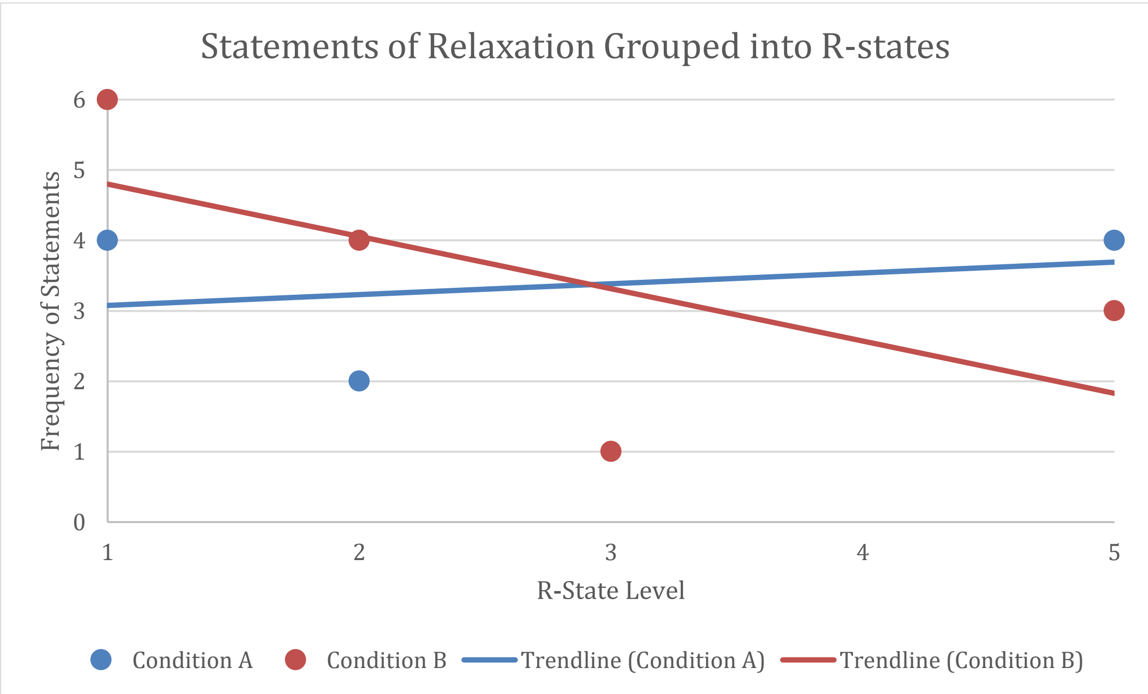

FIGURE 10. Statements of relaxation grouped into R-states. Trendlines are included to illustrate how statements corresponding to Condition A trended toward abstraction, whereas statements corresponding to Condition B trended toward concreteness. However, this interpretation is limited.

Interestingly, no values exist in either Condition A or Condition B which refer to Level 4 relaxation, which centres spirituality. Perhaps spirituality was not accessed because of the nonspiritual context; there is evidence that context can influence relaxation states (Smith, 2001). On the other hand, perhaps spiritual statements would be present in a larger sample size.

When examining trends, statements from Condition B did trend away and statements from Condition A did trend toward abstraction. It is unclear why these trends are present, and it is unclear why any R-state level was more present in one condition over another. Furthermore, the majority of the relaxation statements in Condition A were pertained to the more concrete Levels 1 and 2, and a large portion of statements in Condition B did pertain to Level 5. Thus, it is certainly not impossible for the musical cueing system to access abstract states of relaxation, and the visual cueing system may indeed create a very concrete experience of relaxation. Additionally, given the potentially gendered nature of R-states, it is possible that this heavily female sample would fare different from one which included more male participants—and, of course, the small sample size and general lack of numeric data regarding this issue negate any possible claim to generalizability. However, this is certainly an area for potential further study.

To further complicate the matter, it must also be acknowledged that there were some instances wherein a *lack* of relaxation was expressed. Occasionally, the RFB exercises were found to bring participants into an unrelaxed state. For example, in the visual condition, one participant indicated strong discomfort:

> During the study I felt that I can not breathe "fully", almost as if the air could not get to my lungs at all points. I also got a headache and was a bit afraid of my face going numb – a sign I usually get when I'm about to have a panic attack.

It is likely that this participant hyperventilated within the visual condition, which is a risk when engaging in RFB. Under the musical condition, this participant expressed that the music had been relaxing and that the experience of fearing a panic attack had not returned. Additionally, one participant expressed an inability to relax under either condition, citing her affect in both cases:

> I'm usually very high in my energy, so calming down completely is challenging.

Finally, participants would sometimes state that one exercise was more relaxing than another. This occurred in both directions and indicates a perception of difference, although this perception may differ from person to person.

5.1.2 Attentiveness

> I feel less relaxed than I did before the exercise and a little more attentive, because I had to pay attention not to space out and mess up my breathing a lot more easily.

Another theme in frequently-occurring statements was attentiveness, such as in the above quote from the visual condition. Given that the available Likert scales prompted participants to consider their levels of relaxation and attentiveness, this result is also unsurprising. However, it was anticipated that given the experience of "calm alertness" reported in previous usage of RFB, participants would be more attentive after the exercise. Sometimes, this was the case:

> I felt focused and my mind cleared up when listening to the music.

However, inattentiveness, particularly "mind wandering," was reported much more frequently. In particular, sleepiness appeared to hinder concentration and attentiveness, especially during the actual task. When responding to the visual condition, for example, one participant wrote:

> I found it more difficult to maintain focus. It could have been that I am more tired or that I am very auditory oriented. I find that when hearing things, I am more able to focus on them. My mind wandered a lot more this time around and I felt more sleepy.

Additionally, when considering Likert scale data, there was no significant change between pre- and post-test ratings of attentiveness regardless of conditions. This indicates that participants felt neither more nor less attentive after practicing any form of RFB. Perhaps attentiveness only became a prominent theme because of the suggestiveness of the Likert scale. Rating attentiveness, meanwhile, may not have been an accurate measure of "calm alertness."

5.1.3 "Zoning out"

> During the task I found myself zoning out, so once the task was over I was very "out of it", meaning not attentive.

Somewhat perpendicular to the theme of attentiveness was the theme of "zoning out," such as in the above quote, which responded to the visual condition. In a number of instances, participants referred to hypnotism, road daze, and timelessness, all of which could indicate the experience of an altered state of consciousness. This happened both in the visual condition and in the musical condition, but it occurred more often in the visual condition. This could indicate that the visual condition is better suited for inducing ASC, whereas the musical condition might create a different experience of relaxation.

5.1.4 Bodily sensations

> My muscles are also relaxed too, and I feel like my body has spaces, like spaces between bones and muscles. Feel like my body expanded.

Several comments by participants indicated physical responses to RFB. Sometimes, this was an experience of physical relaxation, such as in the above quote, which was in response to the visual condition. Although this participant did not use as much detail when expressing her physical state in the musical condition, she did make mention of movement:

> With the visual cues, I tended to focus on the breathing strictly, which made a bit stressed, and felt limited to move. With the musical cues, I was free to move.

Other references to the body included a general feeling of relaxation and various issues related to the breath. This is unsurprising, given that each participant needed to focus specifically on breathing for an extended period of time. A common response might indicate difficulties with the breathing style:

> The breathing was a little difficult for me, sometimes I wasn't sure if I was breathing low enough, and maybe filling my lungs too much. I wanted to breath [sic] in for longer, sometimes I ran out of breath on the out breath.

Finally, one participant did indicate an unpleasant physical sensation, feeling as though she were about to have a panic attack. It is possible that the participant was breathing too deeply and had begun to hyperventilate, a problem for some when practicing RFB. At the very least, the multiplicity of experiences indicates that RFB is experienced physically in different ways for different people, and that it is specifically a physical experience in some ways.

5.1.5 Ease of use

> I felt distracted last time with the visual cues, but it was much easier to follow the musical cues this time. It was just more natural to me to breathe to the music.

It was not uncommon for participants to reference ease of use in commentary. In some cases, such as in the above quotation, participants found the musical condition to be easier overall.

Some suggested reasons were an auditory orientation, circularity and predictability from the music, and freedom from needing to keep eyes open. On the other hand, some participants found the musical cueing more difficult:

> [It was] more difficult to understand when to stop/start inhaling/exhaling.

Some participants also found the musical condition to be distracting in its variations, which made focusing on the breathing task difficult. Additionally, a number of participants from both conditions referenced difficulties pacing the breath.

Although it cannot be definitively determined whether one exercise is easier than the other, preference was shown in multiple cases. This is also exhibited in the theme of enjoyment.

5.1.6 Enjoyment

> Oh, with musical cues it was much more enjoyable and easier, on the one hand, I didn't have to focus my eyes on the ball, so it was more relaxing, and on the other hand, I felt focused and my mind cleared up when listening to the music. Definitely much nicer experience!

Many of the participants indicated finding one condition more enjoyable than another. Those who preferred the musical condition liked the ability to close eyes, the removal of distractions, and qualities of the music/music-listening. Those who preferred the visual condition liked the sameness of the visual cue. Again, this might indicate that the experiences of visual versus musical cueing are *perceived* differently and that preferences can be strong in this area.

5.1.7 Distraction from outside sources

> I got distracted very easily, especially by the music next door and other sounds from the outside (opening the door, footsteps, etc.).

The above comment, which was a response to the visual condition, was restated in various ways during the study. While one participant did find the musical cue to be distracting in and of itself, most of the distraction occurred in the visual condition. In particular, participants were distracted by noises just outside the experimenting room. These noises were not heard in the musical condition, as the music blocked out any outside noise.

This highlights a substantial issue within the current study: the inability to guarantee a soundproof environment. The visual condition was, at times, interrupted by music from a nearby room; thus, in some cases, the visual condition was no longer amusical. Certainly, this introduced a confound to the results. It is possible that the visual condition would have been stronger than the musical condition without the occasional presence of distractions. These distractions did not occur in every single visual experiment, so its influence is difficult to disentangle.

5.2 Implications

The results of this study offer an exciting glimpse into uncovering how certain stimuli may influence relaxation. It may be that some states are more desirable within a therapeutic setting, especially if such states are person-dependent. On the greater scale, this study is part of the ever-growing body of information which relates to how relaxation is experienced. Certainly, the unfolding of this thesis indicates an area for greater research, using both quantitative and qualitative methods.

The applications of this research are not merely theoretical. Currently, the use of RFB in music therapy is still novel, and it has not been used with many populations. However, by broadening the use of this tool, music therapists may find benefit in managing issues such as mood disorders, hypertension, and PTSD. Furthermore, it could be beneficial to use one kind of RFB cueing system over another in a clinical setting. A music therapist, for example, might find that the visual cueing system is more effective for achieving ASC (an abstract and "timeless" state); thus, the therapist might use the visual system with a client who benefits from timelessness as emotional regulation. On the other hand, a client needing to practice selflessness might benefit more from the musical cueing system, as this system might have better access to Level 3 R-states. Gender, age, ability, and culture could also inform these experiences. Indeed, even preference may influence which intervention is used, as participants in this study frequently stated a clear preference for one cueing system over the other. If differences exist in at least perceived relaxation, variations in RFB may better address different needs for different people, including people for whom RFB was previously inaccessible (e.g. blind and visually-impaired people).

The benefits of this research may not be limited to medical professions. Further development could even allow for this program to be used in a personal, home setting. While this would not be considered music therapy without the presence of a music therapist, general relaxation benefits may persist regardless. Possible applications could include a mobile relaxation program, which are growing in popularity as information regarding the benefits of relaxation and meditation spreads to the general public. As technology improves, more efficient methods of discovering a person's resonance frequency could be developed, making RFB more and more accessible to the public—hopefully with musical assistance. However, further research is necessary, especially given the limitations encountered in this study.

5.3 Limitations

Already, a number of limitations to the current research are obvious. The most obvious limitation is the lack of a perfectly soundproof environment, which could have introduced a confound into the data. It is possible that a lower overall HRV might be more likely in the visual condition than in the musical condition because the music blocked distracting noise. Indeed, since distracting noises were sometimes created by music from nearby rooms, the visual experience for some participants could be considered musical, when musicality should have been filtered out. Furthermore, in the music condition, it was possible for participants to close their eyes. Certainly, resting eyes could have influenced a participant's experience as much as the music itself. Further study to replicate the results of the current study is recommended.

Given that this was a study at the master degree level and limited resources were available, the sample size for the study was relatively small. While having a within-subjects design did increase the amount of available data, only large effects could be visible within this sample size. A greater sample size could reveal more nuanced information regarding cueing in RFB. Additionally, the population of the sample is somewhat problematic. Certainly, one cannot underestimate how musicianship/musicality may have influenced results. Given that the number of musicians in the population was so high, it is possible that success with the musical intervention may not accurately reflect the general population's experience. Even the non-musicians may still have been musical, further distorting the data. However, it may be surmised that musical cues are approximately as effective as visual cues with at least a musical population when practicing RFB.

The experimentation process was also problematic in that the actual resonant frequency was not calculated for each participant. Instead, height-based estimation was used, and it is certainly possible that some participants breathed at speeds that were too fast or too slow for them. Although this was counterbalanced by the within-subjects design, within which any errors in resonance should be consistent across both conditions, one participant did express that it was exceedingly difficult to breathe slowly. This participant's HRV was especially low in the musical condition, which was when she noted her difficulties in breathing. Given that this participant completed the musical condition before the visual condition, practice effects may have contributed to her increased HRV in the visual condition, especially given her difficulties with such a slow breathing speed. It is possible that a faster breathing speed would have circumvented these effects within the musical condition. On the other hand, it is also possible that this participant simply has an affinity for visual stimuli over musical stimuli. Future study should pay careful consideration to actual resonant frequency, so as to eliminate the possibility of significant breathing difficulties that could disrupt data.

Finally, this study lacked participants who would have listened to the music at its extreme tempi. No participants breathed at 4.5 breaths/min, 6.5 breaths/min, or 7 breaths/min, although the actual resonant frequency for each participant may have been at one of these speeds. Since tempo can influence how stimulating a piece of music is perceived to be (Edworthy & Waring, 2006), it seems prudent to experiment with music at extremely slow or fast speeds; the relaxation effect could be dramatically different in these cases. Again, the response to the current results should be the continuation of research in this area.

6 CONCLUSION

This thesis intended to explore whether a visual cueing system or a musical cueing system in RFB would be more effective in maximizing HRV and inducing relaxation and attentiveness. Although the null hypothesis was not rejected, musical cueing can at least be accepted to be *as* effective as visual cueing in these areas, which may broaden RFB's usefulness to people with a preference for auditory stimulation. Furthermore, qualitative analysis through the lens of ABC relaxation theory suggests that visual cueing may instill a different perception of relaxation than musical cueing, which could cause one form of cueing to be more useful in certain circumstances than another. Further research is strongly suggested.

6.1 Future research

The trends observed in R-states as they apply to ABC relaxation theory are perhaps the most interesting and indicate some understanding of how certain stimuli may influence the experience of relaxation. Further study may better unravel how strong this effect truly is. For example, a similar study might guide participants in RFB under both visual and musical conditions, then have participants rate how well they relate to words which correlate with certain R-states. A controlled study with a large sample size may show more generalizable trends in experiences of relaxation; the small sample size in this study, on the other hand, barely scratches the surface of what could be a significant effect of musical vs. visual stimulation in RFB training. Comparatively, if there is a difference in HRV data between these conditions, the effect size is expected to be quite small; a very large sample could be necessary to find any significant difference between the conditions under HRV parameters.

Within this study, exercises were used in an artificial, controlled setting. Applying the musical cueing system into a real-life setting, particularly within music therapy, might raise new ideas about its practical usefulness and about how music influences R-states in different contexts. Furthermore, while the short-term effects of RFB were compared between visual and musical cueing, long-term effects were not. It is possible that a musical cueing system would be more influential—or less influential—on a client's long-term state of being than a visual cueing system. Indeed, comparing these conditions in clients with known emotional or physical disorders might reveal unique results.

Visual and musical cueing systems were examined apart, but not together. Future research could join the two, providing what is beneficial about both styles of cueing (e.g. the visual cue could assist in clarity, while the musical cue could prevent boredom in the participant). R-states in this condition could also be evaluated. While music may not have been stronger than visual cues in maximizing HRV, perhaps it would be more influential as an auxiliary force. On the other hand, participants might encounter an entirely new experience of relaxation. Meanwhile, although participant-preferred music was not viable within the frame of this study, it might be used within research that uses the visual stimulus for cueing, but music as an auxiliary force.

Only one musical piece was used within this study. Thus, any benefits of the music can only be afforded to the music used specifically; music in general has not been tested as a condition of cueing. Using different types of music in RFB could present interesting and variable results, including both participant-preferred and pre-composed music. Furthermore, music-listening is certainly not the only musical method to maximizing HRV. Exploring other musical interventions in this area, particularly in singing, may yield intriguing results.

6.2 Final thoughts

This study offers only an introduction of one musical intervention alongside RFB. The exploration of this issue could encourage studies which use such methods as vibroacoustic therapy, live improvisation, entrainment, or singing in conjunction with RFB. Meanwhile, music therapists can become more aware of this and other breathing methods, as well as their place in music therapy. RFB shows promise as a tool within music therapy; testing this tool under multiple conditions can only strengthen it over time. The future of RFB and music therapy are equally promising, and their entwinement is truly a thrilling taste of what is to come.

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List of abbreviations

ANS: Autonomic nervous system

CAN: Central autonomic network

HRV: Heart rate variability

HRVB: Heart rate variability biofeedback

N-N: Beat-to-beat

PNS: Parasympathetic nervous system

RFB: Resonance frequency breathing

RMSSD: Root mean square differences among successive beat-to-beat intervals

R-states: Relaxation states, as categorized under ABC relaxation theory

SDNN: Standard deviation of beat-to-beat intervals

SNS: Sympathetic nervous system

Appendix A

Condition: ______   Participant #: ______

Breathing Study Pre-Test

1. Please rate how **RELAXED** you **currently** feel by circling a number (1=Totally unrelaxed; 2=Somewhat unrelaxed; 3=Neither relaxed nor unrelaxed; 4=Somewhat relaxed; 5=Extremely relaxed).

Totally unrelaxed	Somewhat unrelaxed	Neither relaxed nor unrelaxed	Somewhat relaxed	Extremely relaxed
1	2	3	4	5

2. Please rate how **ATTENTIVE** you **currently** feel by circling a number (1=Totally inattentive; 2=Somewhat inattentive; 3=Neither attentive nor inattentive; 4=Somewhat attentive; 5=Extremely attentive).

Totally inattentive	Somewhat inattentive	Neither attentive nor inattentive	Somewhat attentive	Extremely attentive
1	2	3	4	5

Appendix B

Condition: ______ Participant #: ______

Breathing Study Post-Test

1. Please rate how **RELAXED** you **currently** feel by circling a number (1=Totally unrelaxed; 2=Somewhat unrelaxed; 3=Neither relaxed nor unrelaxed; 4=Somewhat relaxed; 5=Extremely relaxed).

Totally unrelaxed	Somewhat unrelaxed	Neither relaxed nor unrelaxed	Somewhat relaxed	Extremely relaxed
1	2	3	4	5

2. Please rate how **ATTENTIVE** you **currently** feel by circling a number (1=Totally inattentive; 2=Somewhat inattentive; 3=Neither attentive nor inattentive; 4=Somewhat attentive; 5=Extremely attentive).

Totally inattentive	Somewhat inattentive	Neither attentive nor inattentive	Somewhat attentive	Extremely attentive
1	2	3	4	5

3. Do you have any additional comments for the researcher regarding your experiences during this breathing task? (If needed, use the back side of the page for additional commentary.)

Appendix C

Participant #: _______

Demographic Information for Breathing Study

1. Please indicate your gender.

____

2. Please indicate your height.

____

3. Please indicate your age.

____

4. Do you play an instrument and/or are you a vocalist?

☐ Yes ☐ No

5. If you answered yes to Question 4, please indicate approximately how many years you have studied your primary instrument.

____

6. Do you smoke?

☐ Yes ☐ No

7. Do you have a respiratory disease, such as asthma, chronic obstructive pulmonary disease, etc.?

☐ Yes ☐ No

8. If yes, please specify which disease.

____ ☐ Prefer not to say

9. Do you have a cardiovascular disease, such as coronary artery disease, chronic heart arrhythmia, etc.?

☐ Yes ☐ No

10. If yes, please specify which disease.

____ ☐ Prefer not to say