RELATIONAL BIOFEEDBACK: EXPLORING THE ROLE OF SOCIAL SUPPORT IN THE PRACTICE OF BIOFEEDBACK

By

Adrian Weldon Knauss

July, 2024

Director of Dissertation: Dr. Jakob F. Jensen, PhD

Major Department: Human Development and Family Science

Biofeedback is a health intervention that trains people to exert control over physiological processes through real-time monitoring and feedback mechanisms (Schwartz et al., 2016). The practice promotes self-regulation and can be used to improve physical and mental health (Tan et al., 2016). However, biofeedback interventions are often conducted individually and practitioners rarely utilize the patient's social network to assist in the development of self-regulation skills (Frank et al., 2010; Schwartz et al., 2016). This is a notable omission since research has established that social systems impact patients' psychophysiology (Kleinbub, 2017). Therefore, the purpose of this dissertation is to explore how social support persons can be utilized in biofeedback. This concept, which the authors refer to as relational biofeedback, is an underdeveloped, but promising future direction in biofeedback. The dissertation is comprised of six chapters: (a) an introduction to the dissertation, (b) a literature review on the practice and psychophysiological underpinnings of relational biofeedback, with a special emphasis on heart rate variability biofeedback, (c) a systematic review of the literature to identify attempts to use relational biofeedback interventions to date, (d) proposed methodology for an original research study, (e) the results of the mixed-methods research study comparing individual to relational

approaches to heart rate variability biofeedback with romantic partners (N = 12), and (f) a series of recommendations for clinicians and researchers, with an focus on the role medical family therapists can play in the advocacy and advancement of relational biofeedback.

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A Dissertation

Presented to the Faculty of the Department of Human Development and Family Science

East Carolina University

In Partial Fulfillment of the Requirements for the Degree

Doctor of Philosophy, Medical Family Therapy

By

Adrian Weldon Knauss

July, 2024

Director of Dissertation: Jakob F. Jensen, PhD

Dissertation Committee Members:

Andrew Brimhall, PhD

Matthew Fish, PhD

Linda Bolin, PhD

ACKNOWLEDGEMENTS

There are many people I would like to acknowledge and thank for their support. First, I would like to thank my dissertation committee. Drs. Matthew Fish, Linda Bolin, and Andy Brimhall have been so encouraging throughout this process. I truly appreciate their valuable feedback and the excitement they have shared for my work. In particular, I would like to thank my advisor, Dr. Jake Jensen. He has been endlessly patient and supportive throughout this process. I have been fortunate to benefit from his guidance and mentorship.

I would also like to acknowledge my wonderful classmates. Betul Cansever has been a constant reminder for self-care and compassion. Dr. Taylor Young has always helped me remember my purpose and inspired me to take the next step. Frandrea Brown has been generous and willing to talk me through any stumbling block. Without her support, this dissertation would have never been completed.

I would also like to thank my whole family for their love and faith in me. I am very fortunate to have a wonderful, large, and inspiring family who supported me every step of the way. My parents, Michael and Amie, have been especially strong supporters of mine. They have always believed I could accomplish this, even when I was not sure myself. Finally, I want to acknowledge my husband, Tyler.

Tyler, I will be forever grateful for the sacrifices you made so that I may pursue this degree. You have been my rock and my motivation to keep going, no matter how challenging it has been. Thank you.

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CHAPTER 1: INTRODUCTION

Biofeedback training is an active process in which patients' physiological processes are monitored and auditory, visual, and/or somatic feedback is provided to train the patients to exert control over those processes (Schwartz et al., 2016; Shaffer, 2020). Practitioners can utilize various biofeedback modalities that monitor different physiological markers, such as cardiac activity, temperature, respiration, muscle tension, and brain activity (Frank et al., 2010). This feedback can be used by the patient to increase their awareness of internal processes and learn exercises to exert control over these processes to function within a healthy range. Biofeedback is distinct from psychophysiological monitoring in that it is an active process in which the feedback is used as a learning tool and facilitates change. Biofeedback can be done with a clinician trained in a health profession, including medicine, nursing, mental health, rehabilitation, and others (Frank et al., 2010; McKee, 2008). Additionally, with the growth of wearable and mobile applications, biofeedback can also be conducted at home (Castaneda et al., 2018; Pinheiro et al., 2016).

Biofeedback continues to grow more popular within the United States as a complementary or alternative medicine intervention (Frank et al., 2010). As a non-pharmacological intervention, it can be used as a first approach or supplemental approach to treatment for many mental and physical health conditions (Fournié et al., 2021; Kondo et al., 2019). In accordance with the 2008 efficacy criteria established by the Association for Applied Psychophysiology and Biofeedback, biofeedback has been labeled as Level 3 (i.e., "probably efficacious") or higher for managing symptoms of over 30 health conditions, such as: post-traumatic stress disorder, asthma, insomnia, fecal elimination disorders, epilepsy, chronic pain, arthritis, substance use disorders, urinary incontinence, temporomandibular disorders, hypertension, attention deficit hyperactivity disorder, anxiety, depressive disorders, diabetes mellitus, and erectile dysfunction (McKee, 2008; Tan et al., 2016).

Heart rate variability biofeedback (HRVB) is one example of a biofeedback modality. HRVB measures the intervals between normal sinus beats (Lehrer, 2013). Intervals between heartbeats should vary from beat to beat. High variation indicates balance between the two branches of the autonomic nervous system (ANS) as the sympathetic nervous system (SNS) accelerates the heart rate and the parasympathetic nervous system (PNS) decelerates the heart rate (Gibbons, 2019). The SNS controls the stress response, often referred to as “fight, flight, or freeze.” The PNS controls the relaxation response, which is also referred to as “rest and digest.” When these two branches are in balance, it leads to normal, healthy fluctuations in the heart beat (Lehrer, 2013). Low variability generally indicates one branch is more activated than the other. While this is appropriate for a short time, such as the SNS being activated when the person is in danger, it is not healthy for one branch to chronically dominate the other. This can lead to poor health outcomes (Lehrer et al., 2020). For example, people experiencing chronic anxiety often show increased activation of the SNS and chronically low HRV, even when at rest (Held et al., 2021). HRVB can be used to make a patient aware of excessive SNS activity and assist them in practicing to regulate SNS activity and increase vagal tone (Lehrer et al., 2020).

HRVB has been found to have positive effects on symptoms of several chronic diseases: hypertension, inflammation, asthma, anxiety, depression, cognitive performances, sleep, and pain (Fournié et al., 2021). Additionally, there is a growing body of research establishing efficacy for HRVB for other health conditions, such as attention-deficit hyperactivity disorder (ADHD; Groeneveld et al., 2019) and substance use (Wieman & Eddie, 2022). HRVB can also be used for general stress management and improve quality of life (Lehrer et al., 2020). Not only does

HRVB have many uses, but it is also non-invasive, pain free, and cost-effective. While electrocardiography is often considered the best measurement of cardiac activity and ANS regulation, HRVB can also be measured with photoplethysmography (PPG; Castaneda et al., 2018; Pinheiro et al., 2016). Pulse oximeters (a type of PPG) are a convenient, affordable, and less invasive method of measuring HRV (Pinheiro et al., 2016). Using a light source and a photodetector, often placed on a finger or earlobe, the pulse oximeter can detect changes in blood volume and use this information to calculate pulse rate and the intervals between beats (Castaneda et al., 2018).

Despite the promising applications of HRVB, the literature seems to be lacking in one crucial way. Studies with HRVB are often conducted as individual interventions (Lehrer et al., 2020). This may result in clinicians missing a crucial element in how humans regulate their ANS activity through safety and connection with others. Incorporating a relational dynamic into HRVB may create a more realistic context for the patient and access a key resource in psychophysiological regulation that may affect long-term outcomes of treatment.

Social Support and Psychophysiology

It has been well-established that positive perceived social support contributes to better health outcomes and lower mortality rates (Uchino et al., 2018). Positive social support provides a buffer to stress and meets emotional and social needs. However, if social support is viewed negatively, it can lead to increased stress and adversely impact health outcomes (Pietromonaco & Collins, 2017). It is important to note that social support is not just about having someone from an individual’s social network present, but rather how an individual perceives those social interactions, either positively or negatively (Coutinho et al., 2017; Heaphy & Dutton, 2008).

When an individual does experience a positive social connection with another person, it impacts physiological and psychological processes.

Psychologically, the impact of having a buffer to stress through supportive relationships with others cannot be underestimated. According to Cohen and Wills (1985), the stress-buffering hypothesis theorizes that when individuals perceive the availability of positive social support, it reduces the perception of the severity of the stressor and impact of stressor on health and quality of life. This is critical because chronic stress contributes to higher risk for chronic diseases by causing dysregulation in cardiovascular, immune, and endocrine systems (Cohen & Wills, 1985; Schetter & Dolbier, 2011).

The connection between social support and stress-buffering is particularly relevant to the practice of biofeedback. The functioning of the ANS, which triggers the stress and relaxation responses, is directly targeted by biofeedback interventions. Chronic stress leads to excessive activation of the SNS (Lowrance et al., 2016). Biofeedback interventions often use stress management and relaxation techniques to teach patients to regulate their ANS activity in order to see the changes in their physiology (Frank et al., 2010). Since biofeedback interventions aim to regulate the stress response and the stress-buffering hypothesis indicates social support can be crucial to attenuating the response to stressors (Cohen & Wills, 1985; Schetter & Dolbier, 2011), it would follow that incorporating social support persons into biofeedback interventions may improve outcomes.

Another pathway in which social support plays a role in psychophysiology is the impact that social interactions and physical contact can have on autonomic physiological processes. The field of interpersonal/social psychophysiology has developed from evidence that social interactions create changes in various systems (e.g., cardiovascular, immune, endocrine;

Kleinbub, 2017; Palumbo et al., 2017). For example, researchers have found synchronization in heart rate (Coutinho et al., 2021), pulse rate variability (Chatel-Goldman et al., 2014; Coutinho et al., 2021), electrodermal activity (Chatel-Goldman et al., 2014; Karvonen et al., 2016), and respiration rate between romantic partners through touch and positive social interactions. Relationship dynamics, such as empathy (Goldstein et al., 2017) or relationship satisfaction (Pietromonaco & Collins, 2017), influence how partners synchronize with each other. Similar findings of physiological synchrony have been discovered with different types of dyads (Cariolato et al., 2020; Kleinbub, 2017). Since it is clear that social connections influence psychophysiological processes, it is crucial to consider how to leverage social resources to actively create change in dysregulated systems.

Relational Biofeedback

One such way to combine social support with psychophysiology is through relational biofeedback interventions. Relational biofeedback, as defined throughout this dissertation, is a biofeedback intervention that includes more than one participant in the training. The support person(s) may also be simultaneously receiving the intervention or may provide some type of logistical or emotional support to the identified patient. A handful of studies have investigated this type of intervention. However, due to the limited number of studies examining this construct, there are variations in how relational biofeedback interventions are named, defined, and implemented. Examples include the following: interpersonal biofeedback (Kassel & LeMay, 2015), dyadic biofeedback (Levit-Binnun et al., 2010), attachment-informed biofeedback (Ehrenreich, 2018), and Gottman and Gottman's (2008) work in using real-time feedback in couple's therapy. Although each has been advocated for by certain researchers, there is limited or no research that has followed the initial studies to establish standardized protocol or to evaluate efficacy of these interventions. It is clear that, while promising, research on relational biofeedback interventions is underdeveloped.

Theoretical Perspective

For this dissertation, the biopsychosocial-spiritual (BPSS) framework is used to conceptualize the dynamic interplay between different dimensions of health. The biopsychosocial model was originally developed by Engel (1977) and later expanded to include the spiritual component (Wright et al., 1996). The framework proposes that health must be viewed holistically by understanding how physical, mental, and social health mutually influence one another. Dysfunction in any one dimension impacts the other dimensions of health. This framework explains how biofeedback can be a useful intervention by addressing multiple dimensions of health concurrently. Biofeedback connects physical processes (e.g., heart rate, respiration) with psychological experiences and resources (e.g., stress, self-soothing) and spiritual interventions (e.g., meditation, mindfulness) to promote regulation (Frank et al., 2010; McKee, 2008; Shaffer, 2020). The relational or interactive component of relational biofeedback interventions accounts for the social dimension of the BPSS framework.

Coupled helpfully with the BPSS framework, Polyvagal Theory (Porges 2009, 2018) serves to enhance the strength of the theoretical foundation for this dissertation. Polyvagala Theory also incorporates social systems within biofeedback interventions. According to Porges (2009), social connectedness is vital to feelings of safety when in proximity with another person. This sense of safety is not merely a psychological function, but rather a physical process of regulating the stress response and activating the vagus nerve, which is the primary nerve activated by the PNS. To create this sense of connectedness, Porges (2009) proposes there is a Social Engagement System in the brain that uses social cues (e.g., vocalizations, facial expressions) to interpret the existence of either safety or threat when in the presence of another person. These cues activate neural pathways that coordinate the ANS to respond to safety or threats accordingly. As a result, trusted social relationships allow people to co-regulate, creating a sense of safety and security (Porges, 2018; Ülker & Sayar, 2022). Biofeedback interventions aim to decrease excessive sympathetic nervous system and increase vagal tone, which is optimal for health (Schwartz et al., 2016). Since social engagement goes hand in hand with physiological regulation, there are exciting possibilities for the use of social engagement throughout biofeedback training.

Purpose

Social support plays an important role in how people regulate physiologically and may serve as a crucial resource to practitioners and patients using biofeedback to alleviate symptoms of chronic illness, manage stress, and improve overall health and well-being (Cohen & Wills, 1985; Pietromonaco & Collins, 2017; Schetter & Dolbier, 2011; Uchino et al., 2018). As biofeedback is applied more widely for various physical and mental health disorders (Fournié et al., 2021; Kondo et al., 2019), it is crucial that patients have the opportunity to utilize every resource available to make positive changes in their health. Social support is a resource that has been overlooked too frequently. However, additional research is needed to determine how social support impacts the outcomes of biofeedback training (e.g., patient experience, patient health outcomes, adherence to treatment recommendations). Furthermore, the lack of standardization hinders practitioners' ability to define and implement relational biofeedback interventions. Consequently, this dissertation aims to take the first step in growing the literature on relational biofeedback interventions.

Through the lens of the BPSS framework (Engel, 1977; Wright et al., 1996) and the Polyvagal Theory (Porges, 2009, 2018), relational biofeedback, specifically relational HRVB, will be explored with couples in romantic partnerships. Specifically, the dissertation aims to use qualitative and quantitative data to answer the following research questions: (a) Does the presence of a romantic partner change the participant experience during HRVB training?, (b) Does the presence of a romantic partner impact the participant's ability to increase HRV through biofeedback training?, (c) Does perceived BPSS health moderate the relationship between partner presence and HRVB outcomes?, and (d) Does relationship satisfaction moderate the relationship between partner presence and HRVB outcomes?

To address these questions, a study will be conducted comparing relational and individual HRVB interventions. Results from this dissertation will serve as early evidence for the effectiveness of relational biofeedback in assisting patients in achieving mastery in self-regulation skills which, ultimately, will increase HRV and improve overall health. Results will also indicate how relational biofeedback may improve the patient experience in biofeedback training. Additionally, this study will provide key considerations for biofeedback practitioners on the benefits of incorporating social support into training, as well as the challenges that may need to be addressed. Finally, this dissertation will serve as a foundation in relational biofeedback research that may inform future studies examining this topic.

Overview

Looking forward in this dissertation, chapter 2 reviews the literature in greater detail than in this introduction chapter. The literature review includes further information on: (a) biofeedback interventions, with an emphasis on HRVB, (b) allostatic and toxic stress and how HRVB can be used as an intervention for stress management, (c) the role of relationships on health, and (d) literature on relational biofeedback to date. Furthermore, chapter 2 grounds the application of relational biofeedback interventions through the biopsychosocial-spiritual framework (Engel, 1977; Wright et al., 1996) and polyvagal theory (Porges, 2018). This will serve as the theoretical foundation for this dissertation. The literature review concludes with a call for additional research on relational biofeedback to explore how relationships can impact patient outcomes when using biofeedback.

Chapter 3 is a systematic review on the use of relational biofeedback interventions for biological, psychological, social, and spiritual health. The systematic review aims to answer the question: *How have relational biofeedback interventions been used to promote biopsychosocial-spiritual health?* By means of a systematic search through three databases (*PubMed, PsycInfo, CINAHL*), 2,494 articles were identified and screened. Ultimately, 23 articles were included in the final analyses. Articles were reviewed to determine which relational units and modalities were studied with relational biofeedback interventions. Furthermore, articles were reviewed to explore which dimensions of health (biological, psychological, social, spiritual) were targeted. Results from the systematic review highlight the high variability in how relational biofeedback is defined and applied. Additionally, studies on relational biofeedback focus on intervening for biological, psychological, and social health, while failing to consider the dimension of spiritual health. Finally, results of the systematic review emphasize the need to conduct further research on relational biofeedback.

In chapter 4, a mixed-methods research study is proposed to examine the impact of relational biofeedback using HRVB with couples. The proposed study is based on the results of the literature review (chapter 2) and systematic review (chapter 3). Participants will complete an HRVB intervention with either their romantic partner present in the room or absent in a separate room. Qualitative questions will probe participants for their perspective on the experience of completing HRVB individually or with their partner present. Regression analyses will be used to analyze the change in HRV pre- and post-intervention for participants in each condition. Additionally, relationship satisfaction and patient perceived biopsychosocial-spiritual health will be explored as potential moderators. The aims of this study are to explore: (a) the impact of partner presence or absence on outcomes of biofeedback interventions, (b) the impact on partner presence or absence on patient experience of biofeedback, and (c) the influence of relationship satisfaction and patient perceived health on the connection between partner presence and patient outcomes. Chapter 5 will present the data and analyses for the study proposed in chapter 4. Finally, the dissertation will conclude in chapter 6 with a discussion of the results, contribution to the literature, and clinical and research implications.

Summary

Through the BPSS framework (Engel, 1977; Wright et al., 1996), health is viewed as multi-dimensional and interrelated. All dimensions of health must be attended to in order to provide optimal care to patient populations. Biofeedback practitioners understand how physical, mental, and spiritual health are interconnected. Practitioners intervene across these dimensions to assist patients in managing chronic illness and practicing stress management (Frank et al., 2010; Shaffer, 2020). However, the social dimension of the BPSS framework is underutilized in clinical practice and frequently ignored in the biofeedback literature. Through Porges' (2009, 2018) Polyvagal Theory, it is understood that safe, secure relationships regulate ANS activity. Additionally, research has demonstrated that social support persons can serve as a buffer to stressors, which also assists in regulating ANS activity (Cohen & Wills, 1985; Uchino et al., 2018). Biofeedback interventions target dysregulated ANS activity, which leads to chronic disease and poorer health outcomes (Frank et al., 2010; Gibbons, 2019; Shaffer, 2020). Therefore, practitioners should consider incorporating social support persons into biofeedback training to increase resources available to the patient and facilitate co-regulation through social connection. This would be a significant change in standard practices, which most commonly uses individual approaches. This dissertation seeks to facilitate this change by exploring how relational HRVB compares to individual HRVB, with the hope that evidence supporting the use of relational biofeedback will increase practitioners’ willingness and comfort with utilizing similar interventions.

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CHAPTER 2: INTERPERSONAL AUTONOMIC PHYSIOLOGY AND RELATIONAL BIOFEEDBACK: A REVIEW

It is expected that the number of adults in the United States with at least one chronic disease will increase over the next 30 years (Ansah & Chiu, 2022). Simultaneously, the population is experiencing an increasing number and intensity of stressors, which is further detrimental to health (American Psychological Association, 2022). As a result, there is a call to increase whole person care to manage chronic disease (Ansah & Chiu, 2022). Research continues to explore possibilities for interventions and treatments that can assist people in living healthier lives. With the ongoing health crises, it is crucial to identify and utilize all resources available to promote positive, long-term health outcomes.

Biofeedback is a complementary or alternative medicine (CAM) approach to alleviating symptoms of chronic disease, facilitating stress management, and stimulating healthy physical functioning (Frank et al., 2010). Although the literature around biofeedback is growing, it is still limited in scope in one crucial way. To date, most biofeedback interventions are studied as individual interventions (Frank et al., 2010; Schwartz et al., 2016). This puts the impetus of change on one person, without giving sufficient attention to the relational and societal factors they experience in daily life that have a vital impact on their physiology (Chatel-Goldman et al., 2014; Goldstein et al., 2017)(Cohen & Wills, 1985; Konvalinka et al., 2023; Palumbo et al., 2017). By limiting biofeedback to an individual intervention, practitioners may be overlooking an essential source of logistical and emotional support that loved ones can provide. Furthermore, practitioners may not be fully utilizing social support as a key component in physiological regulation.

The purpose of this literature review is to establish the need for more research around relational biofeedback interventions to promote health. Health will be conceptualized holistically through the biopsychosocial-spiritual (BPSS) framework (Engel, 1977; Wright et al., 1996). First, the impact of stress on BPSS health will be reviewed. Second, evidence will be presented demonstrating the effectiveness of biofeedback interventions, particularly focused on heart rate variability biofeedback, for stress management and to manage symptoms of stress-related or stress-exacerbated disorders. Next, the impact of social support on stress management and overall health will be discussed. Using Porges (2009, 2018) polyvagal theory, the connection between social engagement and ANS activity will be reviewed. Finally, the present review will make a case for the importance of combining social support into biofeedback training as a way to further facilitate stress management and alleviate undesirable symptoms. We will argue that relational biofeedback interventions have the potential to improve patient outcomes with biofeedback training and, ultimately, decrease symptomatology and improve overall ANS regulation by increasing skills around stress management.

Biopsychosocial-Spiritual Framework

The biopsychosocial (BPS) model emerged from a need to view health more holistically (Engel, 1977). It contrasted the widely practiced medical model of the time, which viewed disease and illness as disruptions in biological systems. The BPS model challenged this idea by acknowledging multiple dimensions of health that mutually influence each other. Changes in one dimension of health will have a reverberating effect on the other dimensions (Engel, 1977). Biological (e.g., cells, tissues, organ systems), psychological (e.g., cognition, emotions, behaviors), and social (e.g., culture, relationships, social location) processes all interact to create an individual’s overall experience of health. Biological effects of disease can both intensify or be worsened by mental health disorders and psychological stress (Engel, 1977; Wade & Halligan, 2017). Individuals' physical and mental health can both impact and be further impacted by relational distress and sociocultural influences (Engel, 1977; Wade & Halligan, 2017). Therefore, it is crucial to treat illness by intervening in all dimensions. Treating physical illness without addressing psychosocial factors is incomplete. This model has been widely accepted and applied since its inception (Wade & Halligan, 2017).

However, in the late 1990s, Wright and colleagues (1996) suggested there was a crucial piece missing from the BPS model. The spiritual dimension was added to create the BPSS framework. The spiritual dimension includes, but is not limited to, religious beliefs. Spirituality also encompasses values, beliefs, connectedness and how an individual makes meaning of their life and experiences (de Brito Sena et al., 2021). This is important because individuals hold differing values and beliefs around health, which is influential in how they understand and make decisions regarding their health (de Brito Sena et al., 2021; Wright et al., 1996). Figure 1 illustrates the interaction between the biological, psychological, social, and spiritual health dimensions.

Throughout this dissertation, the BPSS framework will be used as a theoretical foundation. Using the BPSS framework, we theorize that interventions which target multiple dimensions of health concurrently will lead to better health outcomes compared to interventions targeting singular dimensions of health. Biofeedback connects physical processes (e.g., heart rate, respiration) with psychological experiences and resources (e.g., stress, self-soothing) and spiritual interventions (e.g., meditation, mindfulness) to promote regulation, consistent with the BPSS framework (Frank et al., 2010; McKee, 2008; Shaffer, 2020). However, social resources are often underutilized in biofeedback training. For this reason, relational biofeedback interventions may be useful. Biofeedback interventions will be explored as a BPSS approach to alleviating symptoms of chronic physical and mental health conditions, improve performance and quality of life, and promote stress management (McKee, 2008; Tan et al., 2016).

Stress

Stress is caused by any internal or external stimulus (stressors) that elicit a biological response (stress response; Porges, 2018). Stress is a healthy, adaptive process that provides warning in times of danger and allows the body to make the many alterations that are required throughout the day to respond to the environment. When a stressor is present, the autonomic nervous system (ANS) prepares the body to respond. The ANS is a branch of the peripheral nervous system that regulates the involuntary physiologic processes (e.g., heart rate, digestion, respiration; Gibbons, 2019). The ANS is further divided into the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). When a stimuli is determined to be a potential threat, the SNS is activated. The SNS signals adrenal glands to release cortisol and adrenaline (Gibbons, 2019; Yaribeygi et al., 2017). The body prepares for a potential threat by increasing muscle tension and blood flow, increasing heart rate, increasing respiration, releasing more glucose (energy) into the bloodstream, and slowing down digestion. This is collectively known as the stress response and it affects multiple systems concurrently (i.e., nervous, musculoskeletal, respiratory, endocrine, cardiovascular, gastrointestinal; American Psychological Association, 2023). This response is commonly referred to as the “fight or flight” response as the body diverts all its resources to preparing to respond to the threat. When the potential threat is resolved, the PNS facilitates the “rest and digest” state (Tindle & Tadi, 2022). The main component of the PNS, the vagus nerve, coordinates many body systems to recover from the stress response. This includes slowing the heart and respiration rate, increasing digestion, and ultimately returning the body to its pre-stress response state.

The stress response varies widely and should be adaptive to the stressor experienced in the environment (Yaribeygi et al., 2017). For example, the sound of a door closing should elicit a lesser stress response over a shorter amount of time compared to a more intense and prolonged stressor, such as a violent threat to one's physical safety or life. While stress is a normal part of healthy functioning, the stress response system can be over activated, which may contribute to negative health outcomes.

Chronic Stress and Allostatic Load

Chronic stress is the prolonged exposure to stressors that leads to frequent, and often overwhelming, activations of the stress response system (Guidi et al., 2021). A continuously activated stress response bathes the body in prolonged and adverse levels of hormones (i.e., cortisol) that can be detrimental to health. Furthermore, continuous activation of the various body systems that are coordinated by the stress response leads to dysregulated systems and increased wear and tear on the body (American Psychological Association, 2023; Guidi et al., 2021).

Daily experiences and life events can lead to cumulative stress responses, which is referred to as allostatic load (Guidi et al., 2021). At the same time, individuals possess resources to help manage and cope with stressors. For example, positive perceived social support acts as a buffer to stress and leads to a reduced appraisal of the severity of the stressor (Cohen & Wills, 1985; Lakey & Orehek, 2011; Pietromonaco & Collins, 2017; Uchino et al., 2018). When chronic stress exceeds the individual's resources, the individual can experience allostatic overload. Allostatic overload resulting from chronic stress is connected to poorer health outcomes (e.g., depression, immune disorders, hypertension, metabolic disorders) and can interfere with daily functioning (American Psychological Association, 2023; Cohen et al., 2007; Guidi et al., 2021; Yaribeygi et al., 2017). However, not all stressors are negative. There can be positive experiences that are also associated with the stress response.

Eustress and Distress

When understanding the effects of stress, it is important to note that not all stress is bad. How a stressor affects an individual depends on various biological, psychological, and environmental factors (Cohen et al., 2007). Selye (1976) named the difference between positive and negative experiences with stressors that have differing effects on the body. Distress is associated with negative experiences with a stressor that leads to feelings of frustration, being overwhelmed, or an inability to cope (Marten, 2017; Selye, 1976). Common examples may include deadlines, financial problems, or loss of a loved one. On the other hand, eustress is associated with positive experiences which, while challenging, lead to growth and fulfillment (Marten, 2017; Selye, 1976). Common examples of eustress include moving, socializing, or achieving a goal. However, stressors may be interpreted differently across individuals. What may be eustress for one could be experienced as highly distressing for another. Additionally, eustress and distress are not mutually exclusive and may occur simultaneously (Marten, 2017). When considering the detrimental effects chronic stress has on health, research most often explores stress in the context of distress.

Impact on Health

Research has established a strong relationship between chronic stress and many adverse BPSS health outcomes. Physically, chronic stress has been linked to both functional and structural changes in the brain, causing lower brain mass and weight (Cohen et al., 2007;

Yaribeygi et al., 2017). Consequently, there is an impact on cognition and memory. Chronic exposure to high concentrations of stress hormones has been linked to memory disorders and impairments in learning abilities. Furthermore, chronic stress is connected to weaker immune system functioning, putting individuals at higher risk for illness and disease (American Psychological Association, 2023; Cohen et al., 2007; Yaribeygi et al., 2017). Individuals who experience chronic stress are also at higher risk for cardiovascular disorders, such as heart disease (Cohen et al., 2007; Yaribeygi et al., 2017). Gastrointestinal distress and appetite changes are also found to result from chronic stress (American Psychological Association, 2023; Yaribeygi et al., 2017). Psychologically, chronic stress contributes to poor mood and creates a higher risk of developing anxiety, mood, and/or depressive disorders (Schneiderman et al., 2005). Stress can also impact social health when individuals experiencing chronic stress react to others with hostility, aggression, or social detachment (Sandi & Haller, 2015). Spiritually, chronic stress can have a negative impact on an individual's overall sense of well-being and satisfaction with their life (Schneiderman et al., 2005).

Given the deleterious impact of stress on one's health, there is a push to mitigate the experience of chronic stress and the subsequent health outcomes. Biofeedback is one such intervention that can be useful in training an individual to regulate their ANS activity, thus ameliorating the impact of a chronic stress response (Schwartz et al., 2016). To understand how biofeedback can be used as a health intervention, it is important to understand the impact of stress on the body. The ANS controls involuntary physiological processes, which were long thought to be outside of an individual's control (Gibbons, 2019). Biofeedback practitioners found that using biofeedback can help individuals exert control over these "involuntary processes" and, as a result, make positive changes in physiological systems (Schwartz et al., 2016; Shaffer, 2020). While biofeedback has many applications, regulating SNS activity and increasing vagal tone of the PNS underlies much of the work done with biofeedback. As a result, biofeedback has been found to be effective with various physical and mental health conditions which result from, or are exacerbated by, stress (Tan et al., 2016). For this dissertation, biofeedback will be used for general stress management, with the understanding of the extensive impact it can have on health outcomes.

Biofeedback

Biofeedback is a human-computer interactive technique used to teach people how to control their physiological processes (Schwartz et al., 2016). A feedback loop is created between a person and instrumentation that monitors their physiology and provides visual or auditory feedback (Figure 2). The person then uses the feedback to enhance their knowledge about their internal physiological processes and make changes to move those processes within the desired range. Using the 2008 efficacy criteria established by the Association for Applied Psychophysiology and Biofeedback, biofeedback has been labeled as Level 3 (probably efficacious) or higher for managing symptoms of over 30 health conditions. Examples of health conditions for which biofeedback is rated at Level 3 or higher include post-traumatic stress disorder, asthma, insomnia, fecal elimination disorders, epilepsy, chronic pain, arthritis, substance use disorders, urinary incontinence, temporomandibular disorders, hypertension, attention deficit hyperactivity disorder, anxiety, depressive disorders, diabetes mellitus, and erectile dysfunction (McKee, 2008; Tan et al., 2016).

Biofeedback is an umbrella term that encompasses various modalities. Depending on the presenting problem and patient goals, biofeedback can be used to train respiration, temperature, heart rate and heart rate variability, skin conductance, muscle tension, proprioception, brain activity (i.e., neurofeedback), and more (McKee, 2008; Schwartz et al., 2016). Biofeedback can be practiced at home with the use of wearables or in clinical settings with a health professional (i.e., nurse, doctor, rehabilitation therapist, mental/behavioral health provider; Frank et al., 2010; McKee, 2008). It is often used as a non-pharmacological intervention to supplement treatment of chronic disease, improve general health and wellness, and/or improve performance (McKee, 2008; Schwartz et al., 2016; Shaffer, 2020). One type of biofeedback that has established empirical support is heart rate variability biofeedback (HRVB). Due to the established efficacy for various health conditions and stress management (Fournié et al., 2021), HRVB will be the biofeedback modality used for this dissertation.

Heart Rate Variability Biofeedback

Heart rate variability is a measure of the variation in time between heartbeats (Lehrer et al., 2020). In a healthy heart, there should be high variation in the intervals between beats. As described above, the body must continuously adapt to changes throughout the day. This requires the SNS and PNS to work in tandem to prepare the body to respond to stimuli. The SNS increases heart rate and the PNS decreases heart rate (Gibbons, 2019). As these two systems work together, it should cause slight changes in heart rate throughout the day, resulting in variation in time between successive beats. This is a sign of healthy ANS activity and a body that is prepared to meet the demands in the environment. In dysregulated systems, HRV is low and indicates one branch of the ANS is more dominant than another (Gibbons, 2019; Lehrer et al., 2020). Chronic stress and anxiety can contribute to chronically low HRV, even when at rest (Held et al., 2021).

HRVB involves using biofeedback techniques to assist people in increasing their HRV (ChuDuc et al., 2013). Goals of HRVB include increasing coherence and optimizing ANS regulation, appropriately activating the vagus nerve, improving the baroreflex, and improving the ability to adapt to daily stressors (ChuDuc et al., 2013; Schumann et al., 2021). There is evidence to support the use of HRVB to manage pain, symptoms of post-traumatic stress disorder, sleep disorders, stress management, asthma, depression, anxiety, and cognitive disorders (Fournié et al., 2021). There are also studies being conducted to evaluate how HRVB may be used with other conditions, such as substance use disorders (Wieman & Eddie, 2022) and attention deficit hyperactivity disorder (Groeneveld et al., 2019). HRVB can also be used for general stress management and to improve quality of life (Lehrer et al., 2020).

HRVB can be measured with electrocardiography, which is often considered the best measurement of cardiac activity. However, it is also commonly measured with photoplethysmography (PPG; Castaneda et al., 2018; Pinheiro et al., 2016). Pulse oximeters (a type of PPG) are convenient, cheaper, and non-invasive method of measuring HRV (Pinheiro et al., 2016), making them a popular choice. PPGs use a light source and photodetector on the surface of the skin (e.g., finger, earlobe) to detect changes in blood volume as the heart beats (Castaneda et al., 2018). This information can be used to calculate the heart rate and changes in time between heart beats.

Since respiration and heart rate are connected processes, breathing exercises and/or respiration biofeedback are frequently paired with HRVB to assist in increasing HRV (Yasuma & Hayano, 2004). A common HRVB technique is to coach people in resonance breathing, which trains the person to breathe at a slow pace (often between 4-7 breaths per minute) that maximizes the respiratory sinus arrythmia (RSA; Yasuma & Hayano, 2004). RSA is maximized when heart and respiration rates are synchronized and is a sign of a healthy heart. Breathing at resonance frequency increases HRV, improves mood, and decreases symptoms of anxiety, depression, stress, and blood pressure (Chaitanya et al., 2022). HRVB can be conducted with a clinician or at home through the use of wearable devices (Castaneda et al., 2018; Pinheiro et al., 2016). HeartMath is an example of a popular HRVB program (*HeartMath*, n.d.).

Interpersonal Physiology

To better understand the relevance of incorporating a relational component into biofeedback training, it is important to first understand the influence of human connection on physiology. The field of interpersonal physiology is dedicated to understanding how autonomic physiological processes impact and are impacted by social interactions (Kleinbub, 2017; Palumbo et al., 2017). The type of impact depends on whether the interaction is viewed as positive or negative (Coutinho et al., 2017; Heaphy & Dutton, 2008). For example, researchers have demonstrated that social interactions impact an individual's cardiovascular, immune, and neuroendocrine systems, both positively (e.g., regulating cortisol rhythm) and adversely (e.g., increased blood pressure levels). Research has found a connection between physiological processes for couples, parent-child dyads, co-workers, teammates, friends/peers, therapist-patient dyads, and strangers (Cariolato et al., 2020; Kleinbub, 2017; McKee, 2008). For the purpose of this dissertation, we will primarily focus on interpersonal physiology within couples.

Physiological Synchrony

Within interpersonal physiology, physiological synchrony is a commonly observed phenomenon. Physiological synchrony occurs when there is an association between the physiological processes of two or more individuals (Marzoratti & Evans, 2022). Other terms that may be used instead of physiological synchrony are physiological linkage (DiMascio et al., 1957; Levenson & Gottman, 1983) or physiological concordance (Palumbo et al., 2017). Research has explored physiological synchrony in cardiovascular activity, respiration, electrodermal activity, and neural activity (Palumbo et al., 2017). Physiological synchrony may be a biological process that evolved as way to meet the human drive for social connection (Marzoratti & Evans, 2022). Coordinating physiologically may play a crucial role in interpersonal bonding, promoting cooperation, and displaying empathy, which then promotes prosocial behavior (Coutinho et al., 2017; Marzoratti & Evans, 2022). Additionally, researchers have found that partners regulate each other to maintain psychophysiological equilibrium in a process referred to as co-regulation (Ferrer & Helm, 2013; Pietromonaco & Collins, 2017). The ability to regulate one's emotional and physical state through interactions with each other is a sign of attachment within the relationship and increases emotional stability for both partners (Butler & Randall, 2013).

Levels of physiological synchrony may fluctuate, especially as the result of the emotional tone and context of the interaction (Coutinho et al., 2017). Interactions that elicit strong emotions are also more likely to illicit stronger physiological synchrony. Although there are natural fluctuations, very low levels and very high levels of physiological synchrony can be maladaptive (Palumbo et al., 2017; Timmons et al., 2015). Low levels of synchrony may indicate detachment and less emotional bonding. Conversely, too high levels of synchrony may result in high emotional reactivity that escalates conflicts and inhibits effective communication.

Interpersonal Physiology within Couples

A systematic review on interpersonal physiology found that couples demonstrate physiological synchrony in respiration, skin conductance, and several markers of cardiac activity (Palumbo et al., 2017). Since the dissertation will be primarily focused on HRVB with couples, it is important to understand how cardiac activity and respiration are impacted by interpersonal dynamics. Respiration, although not a direct marker of cardiac activity, is interconnected with cardiac activity and breathing work is common within HRVB (Yasuma & Hayano, 2004). Couples demonstrated synchrony in heart rate and respiration when connected through eye contact, touch, and even when sitting relaxed next to each other (Ferrer & Helm, 2013; Helm et al., 2012; McAssey et al., 2013). Additionally, synchrony was found in the RSA of dyads in romantic relationships (Gates et al., 2015; Helm et al., 2014). This is noteworthy since maximizing RSA is a goal of HRVB (Chaitanya et al., 2022). However, Helm and colleagues (2014) found this relationship was moderated by relationship satisfaction.

Several studies have explored the connection between interpersonal physiology and relationship satisfaction and quality (Chen et al., 2021; Levenson & Gottman, 1983, 1985; Thomsen & Gilbert, 1998). For example, Levenson and Gottman (Levenson & Gottman, 1983, 1985) explored interpersonal physiology within the context of couples therapy. The researchers studied how physiological linkage between spouses in high conflict is related to marital satisfaction. The researchers found that distressed couples in high-conflict were more likely to demonstrate physiological synchrony regarding negative-affective exchanges compared to couples that reported higher marital satisfaction. Thomsen and Gilbert (1998) also found physiological synchrony between partners during conflict discussions was related to marital satisfaction, but the relationship changed based on individual personality and behavioral differences.

Effective communication can deteriorate as the stress response is triggered and the body goes into "survival mode" which increases reactivity and impacts more logical processes that facilitate conflict resolution. When both partners demonstrate coordinated increased physiological activation during conflict, they are more likely to report lower relationship satisfaction and are at increased risk for marital dissolution (Gottman & Levenson, 1992;

Levenson & Gottman, 1983, 1985). Conversely, shared positive emotions are connected to better relational interactions. Higher physiological linkage during positive-affective exchanges is related to higher relationship quality (Chen et al., 2021).

Porges' Polyvagal Theory

Porges' (2009, 2018) polyvagal theory provides a theoretical foundation for the neurobiological basis of social engagement. While controversial at its conception, it has been studied and discussed extensively within the fields of neurobiology and physiology. Porges (2009, 2018) proposes that the autonomic nervous system (ANS) has evolved three primary neural circuits to maintain homeostasis and allow perception and response to threat in the environment: the ventral vagal complex (VVC), dorsal vagal complex (DVC), and the SNS. The DVC and VVC are pathways that are activated by the vagus nerve, which is the 10th cranial nerve and the primary nerve activated by the PNS (Tindle & Tadi, 2022). The vagus nerve is often referred to as the "brake" of the ANS. It coordinates many body systems to counteract the stress response (Gibbons, 2019; Tindle & Tadi, 2022). It is important to note that the body does not switch between SNS and PNS activation, but rather both systems are continually working in conjunction to respond appropriately to internal and external stimuli (Gibbons, 2019).

The SNS is a slower, longer-lasting response system that prepares the body for mobilization or "fight or flight" response to a threat (Porges, 2018). Conversely, the DVC prepares the body for immobilization (e.g., feigning death, shutdown, freeze) in response to a threat (Porges, 2009, 2018). The DVC is an unmyelinated pathway that is part of the PNS. The SNS inhibits the activation of the DVC to respond to the threat, with the DVC being activated when the SNS response is insufficient to respond to the level of threat being experienced (Porges, 2009, 2018).

The VVC is a myelinated pathway that is also a part of the PNS. It is the fastest acting system. When activated, the VVC adjusts cardiac activity and initiates social engagement behaviors (e.g., turning head, initiating eye contact; Porges, 2018; Shaffer & Venner, 2013). This is typically referred to as the social engagement system or the “tend and befriend” response. When individuals feel secure with another person, it activates the social engagement system, slowing the heart and respiration rate and creating a sense of calm and security (Shaffer & Venner, 2013). This allows for intimacy, connection, and attachment. Through safe social relationships, people are able to decrease defensiveness and co-regulate, which creates an optimal state for mental and physical health (Porges, 2018; Ülker & Sayar, 2022). Given that the target of biofeedback interventions is to down-train excessive sympathetic nervous system activity and to increase regulation (Schwartz et al., 2016), social engagement can serve as a powerful tool to activate the relaxation response.

Relational Biofeedback

Building upon interpersonal physiology, relational biofeedback interventions take the additional step of applying the knowledge of interpersonal autonomic physiology to assist patients in making change. Where interpersonal physiology has made efforts to measure the physiological processes that occur within interpersonal interactions, relational biofeedback is an active intervention that allows patients to witness these processes occur in real time and leverage this to reach their BPSS health goals (Ehrenreich, 2018; Kassel & LeMay, 2015; Levit-Binnun et al., 2010; Oren et al., 2018). To date, there have been a few attempts at relational biofeedback in the literature, particularly in psychotherapy. However, there are inconsistencies in terminology and procedure.

Kassel and LeMay (2015) have used interpersonal biofeedback in couples therapy. The researchers suggested that various biofeedback methods (e.g., skin conductance, heart rate, respiration) could be used to provide feedback to the dyad concurrently. This would allow both partners to practice relaxation and observe each other's physiology, leading to increased understanding of their partner, improved listening and communication, and better problem-solving ability. Similarly, Ehrenreich (2018) proposed attachment-informed biofeedback as an intervention in parent-child, couple, or therapist-patient dyads. With the proposed model, HRVB could be used to increase awareness of each individual's own internal state, as well as expose them to the internal state of the other person. By viewing the dual physiological feedback, it could increase the sense of connection and understanding of each other with the goal of increasing attachment.

Dyadic biofeedback (DBF) with HRVB has also been proposed by Levit-Binnun and colleagues (2010). The researchers recognized that dyads can co-regulate through their relationship with each other. Interpersonal interaction serves as a physiological regulator that helps each individual to maintain psychological and physiological homeostasis. Furthermore, the researchers argued that DBF cand be applied clinically, as well as in real world situations where people are embedded in relational systems. Relational biofeedback offers an intervention that can help people explore regulation skills within their interpersonal context outside of clinical settings (Levit-Binnun et al., 2010). Finally, Oren and colleagues (2018) suggested an integration of biofeedback, mindfulness, and multiple-person oriented therapy (e.g., couples, family). The proposed model consisted of four stages. First, biofeedback and mindfulness can be used to assist each partner in self-regulation to de-escalate conflict. Then, mutual regulation can decrease emotional reactivity towards each other. Third, exposure to the internal state of the other person increases acceptance, which enhances compassion, trust, and interdependence. Finally, developing a sense of togetherness facilitates effective communication.

Although these suggested interventions have some differences in what they are called and how they are implemented, the underlying premise is the same. Recognizing how biofeedback can both enhance and be enhanced by social interactions opens the door to new applications of biofeedback. We use the term relational biofeedback as a broader term to encompass biofeedback interventions that utilize all types of social connections in the training process. Unfortunately, the proposed models of relational biofeedback interventions are primarily theoretical or case studies. Little empirical evidence has been generated regarding relational biofeedback. Additionally, much of the literature has been constrained to relational psychotherapy. However, the ability to regulate through interpersonal interactions can assist with stress management and, subsequently, be a useful intervention in the treatment of many mental and physical health conditions.

There have been studies that have used relational biofeedback, despite the process not being referred to or recognized as relational biofeedback at the time. For example, several studies found that parents or family members were useful in supporting or directly administering biofeedback interventions with children to treat headaches (Allen & McKeen, 1991; Burke & Andrasik, 1989) and regulate emotionally during times of stress (Burton et al., 2018; Kerr et al., 2022; Woodberry et al., 2020). Due to the impressionable nature of children, parents played a crucial role in emotional and logistical support of the biofeedback interventions. Utilizing the help of caregivers may be more convenient, require less time by the practitioner, and allow for more consistent practice outside of clinical settings. Another study found electromyography (EMG) biofeedback (muscle tension) was a helpful adjunct to psychotherapy with heterosexual couples where the female partner was diagnosed with vaginismus (Barnes et al., 1984). The male partner served as a support during the EMG biofeedback sessions and played an active role in facilitating the intervention by inserting the vaginal probe. The combination of couple's therapy and EMG biofeedback sessions helped the couples successfully complete intercourse.

Clearly, several biofeedback practitioners have found social interaction with family and friends to be a potentially beneficial addition to biofeedback interventions. However, to date, the research on relational biofeedback has been disjointed. In order to fully investigate the potential influence of relational biofeedback, more research is needed to establish its efficacy and applicability.

Conclusion

The purpose of this review is to explore literature regarding relational biofeedback, which is an under-researched health intervention with promising potential to support BPSS health. Through the BPSS framework (Engel, 1977; Wright et al., 1996), it is clear that physical, mental, social, and spiritual health are interconnected and all dimensions merit attention for optimal health and well-being. The need for BPSS health interventions continues to grow as the United States population is experiencing chronic disease at an increasing rate (Ansah & Chiu, 2022). Biofeedback interventions are efficacious in the treatment of several health conditions (McKee, 2008; Tan et al., 2016), and HRVB in particular is a well-established modality for treating chronic stress as well as health conditions exacerbated by stress (Fournié et al., 2021). Effective use of biofeedback interventions by clinicians has a wide-reaching impact due to the detrimental effects of chronic stress and dysregulated autonomic activity on physical and mental health (American Psychological Association, 2023; Guidi et al., 2021). However, most biofeedback interventions, including HRVB, are studied as individual interventions, which overlooks the crucial dimension of social health. Positively-perceived social support has been established as a significant resource for stress management (Cohen & Wills, 1985; Pietromonaco & Collins, 2017; Uchino et al., 2018). Furthermore, research has established that many physiological processes, including cardiac activity, are impacted by interpersonal interactions (Kleinbub, 2017; Palumbo et al., 2017). In fact, individuals co-regulate through safe, secure relationships with others (Ferrer & Helm, 2013; Pietromonaco & Collins, 2017).

Since biofeedback targets physiological regulation and interpersonal relationships impact how individuals regulate, it follows that the integration of the two could be a powerful intervention to promote regulation of the ANS and, as a result, improve overall health. Some research has made efforts to explore how relational biofeedback interventions may be used, primarily in relational psychotherapy with couples (Ehrenreich, 2018; Kassel & LeMay, 2015; Levit-Binnun et al., 2010; Oren et al., 2018). However, the research on relational biofeedback interventions is underdeveloped and lacks empirical support. We argue that additional research is needed to determine how to best leverage social support within biofeedback interventions to enhance patient outcomes. Given that researchers have advocated for the consideration of HRVB within romantic partners (Ehrenreich, 2018; Levit-Binnun et al., 2010), this relational biofeedback modality may be a critical foundation in establishing efficacy and exploring applications of relational biofeedback.

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Figure 1

The Biopsychosocial-Spiritual Framework

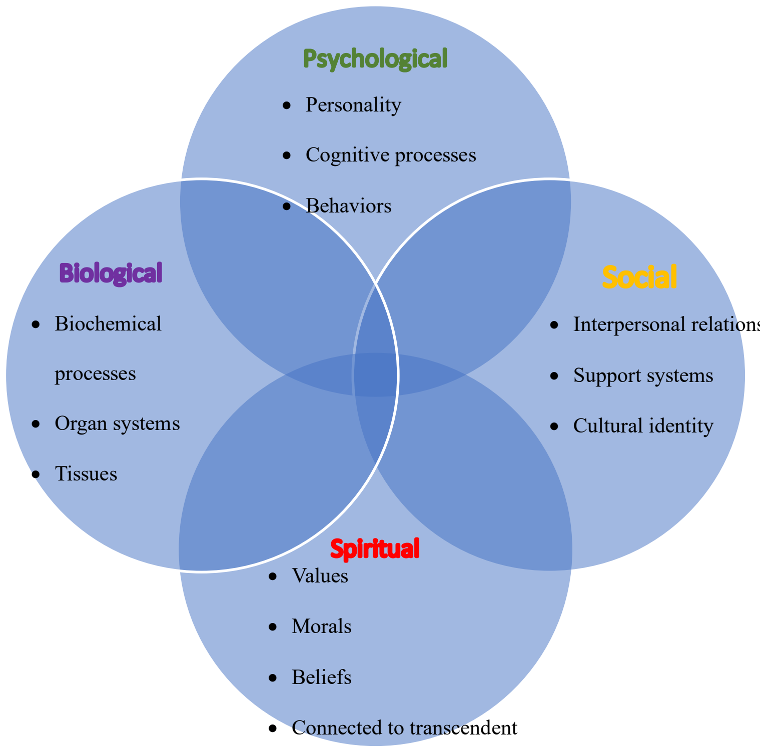
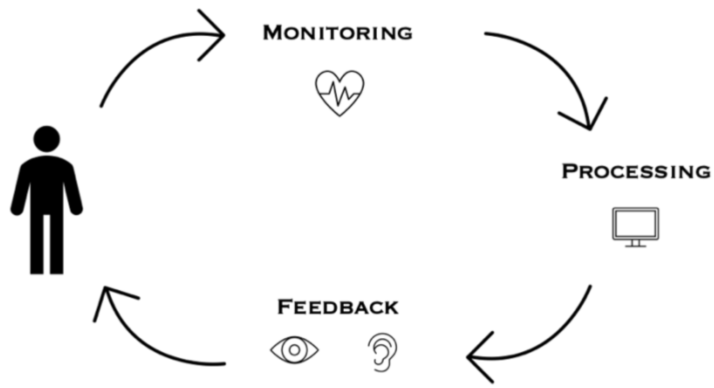


Figure 2

Representation of Biofeedback Loop



CHAPTER 3: RELATIONAL BIOFEEDBACK AND BIOPSYCHOSOCIAL-SPIRITUAL HEALTH: A SYSTEMATIC REVIEW

Biofeedback training involves learning to control one's physiological responses (Schwartz et al., 2016; Shaffer, 2020). Instrumentation monitors an individual's physiological responses and provides that information back to the person so they can practice altering their response. Over time they increase their awareness of their physiological reactions without the instruments so that they may continue to manage their physiology to improve health and performance (Schwartz et al., 2016). Practitioners can utilize several biofeedback modalities as an intervention, such as heart rate, heart rate variability (HRV), skin conductance, skin temperature, respiration rate, surface electromyography (sEMG), and electroencephalography (EEG) feedback (Frank et al., 2010).

Biofeedback has grown in popularity in the United States as a complementary and alternative medicine technique (Frank et al., 2010). In 2008, the Association for Applied Psychophysiology and Biofeedback established efficacy criteria and evaluated the efficacy of biofeedback training for health conditions based on the research at that time. The reviewers rated biofeedback as Level 3 (probably efficacious) or higher for managing symptoms of over thirty health conditions (McKee, 2008; Tan et al., 2016). Biofeedback and applied psychophysiology literature continue to increase as more data emerges on using biofeedback as a clinical intervention for improving health conditions. It is particularly prevalent within recreational and rehabilitation therapy to promote optimal performance and as an intervention for stress-related medical conditions, such as anxiety, depression, trauma and stress disorders, and cardiovascular diseases (Russoniello et al., 2013). There is ample research exploring the use of biofeedback as a intervention for various medical conditions, including pelvic floor dysfunction (Koh et al., 2008), pediatric elimination disorders (Desantis et al., 2011), chronic pain (Arena & Tankersley, 2018; Sielski et al., 2017), migraines (Mullally et al., 2009), hypertension (Bolin et al., 2022; Greenhalgh et al., 2010), cardiovascular functioning (Bolin et al., 2022), and insomnia (Melo et al., 2019). In mental and behavioral health fields, researchers use biofeedback to promote stress management (Yu et al., 2018) and alleviate symptoms of anxiety (Sarkar et al., 1999; Tolin et al., 2020), depression (Caldwell & Steffen, 2018; Lin et al., 2019; Siepmann et al., 2008), substance use disorders (Sokhadze et al., 2008), post-traumatic stress disorder (Schuman & Killian, 2019; Tan et al., 2011), and other psychiatric disorders (Schoenberg & David, 2014). Additionally, some researchers recognize the mind-body impact that chronic illness can have (i.e., physical illness contributing to anxiety and depression symptoms, stress and anxiety exacerbating physical symptoms) and explore the use of biofeedback to treat psychological distress resulting from physical illness (Thabrew et al., 2018). Fournié and colleagues (2021) and Kondo and colleagues (2019) provide a more detailed overview of research on biofeedback training for chronic health conditions to use as a point of reference.

Relational Biofeedback

When conducted by a trained therapist, biofeedback training inherently has a social component, given that the relationship between the patient and therapist is a crucial part of the training process (Shaffer, 2020). Researchers have consequently attempted to understand the impact of the patient-therapist relationship during biofeedback interventions (Ehrenreich, 2018; Levit-Binnun et al., 2010). While this is an important relational component of biofeedback training that merits attention, it is also crucial to consider the patient's social context outside their brief time in biofeedback training. The impact of the social network on an individual's stress level is significant (Cohen & Wills, 1985; Pietromonaco & Powers, 2015).

In psychotherapy, research has found increased levels of physiological arousal when couples discuss relationship challenges (Jensen et al., 2019; Jensen et al., 2018) and during conflict (Gottman & Levenson, 1992; Levenson & Gottman, 1983, 1985). Gottman and Gottman (2008) took this work one step further by using pulse oximeters to measure physiological responses and providing real-time feedback to the couple to improve partners' communication during couples' therapy. Kassel and LeMay (2015) have also promoted the use of interpersonal biofeedback in couples and family therapy. The authors suggested that members of a couple or family could be monitored and receive real-time feedback during sessions to increase awareness of physiological responses and develop strategies to manage them. These research studies demonstrated that interpersonal biofeedback may improve the ability to respond in collaborative ways and create space for communication. Specifically, it can help with conflict that typically leads to a partner's overarousal, disengagement, or defensiveness. However, much of the literature focuses on monitoring physiological arousal and co-regulation rather than working with individuals in a relational context to actively manage physiological responses to improve outcomes and treat health conditions. Relational biofeedback interventions go beyond measuring physiological arousal by applying the knowledge of interpersonal autonomic physiology to assist patients in making change. Where many researchers have made efforts to monitor the physiological processes that occur within interpersonal interactions (Jensen et al., 2018; Jensen et al., 2019; Kleinbub, 2017; Levenson & Gottman, 1983, 1985), relational biofeedback is an active intervention that allows patients to witness these processes occur in real time and leverage this to reach their health goals. Additionally, to date, interpersonal biofeedback interventions are constrained to psychotherapy.

Given that biofeedback is an intervention used to teach individuals to exert control over their physiology, and social interactions impact an individuals' physiology, it would follow that it is crucial to consider their social systems when conducting biofeedback interventions. Levit-Binnun and colleagues (2010) suggested that dyadic biofeedback (DBF) serves as "an enrichment of the original biofeedback model" in which each individual of a dyad serves as a physiological regulator for the other (p. 139). DBF recognizes human interaction's unique role in one's internal physical and psychological state. Despite this, a majority of the research around biofeedback as an intervention continues to include primarily individual training.

In response to the shortcomings in the existing literature surrounding this topic, the present study seeks to explore the use of relational biofeedback techniques to promote health and well-being. Since there have been many terms used to describe similar methods (e.g., DBF, interpersonal biofeedback, attachment-informed biofeedback), the authors use relational biofeedback as a broader term encompassing biofeedback interventions that utilize social connections in the training process. Social support persons significantly contribute to biofeedback training in a variety of ways. Therefore, the authors define relational biofeedback as any biofeedback interventions which actively incorporates two or more persons into the intervention.

Social Support and Health

Researchers have consistently linked social support to better health outcomes and lower mortality rates (Uchino et al., 2018). Positive social support impacts health outcomes through stress buffering, facilitating personal growth, and fulfilling basic emotional and social needs for attachment (Pietromonaco & Collins, 2017). Conversely, negative social interactions such as isolation, rejection, and hostility can lead to increased stress and poorer health outcomes. Uchino and colleagues (2018) theorized that social support is connected to health through biological, psychological, and behavioral pathways. When conducting a biofeedback intervention, it is essential to consider how social support may influence the outcome of the intervention by impacting the patient physically and psychologically.

Interpersonal Autonomic Physiology

Social interactions can influence autonomic physiological processes. This interaction depends on whether the individual views the interaction as positive or negative (Coutinho et al., 2017; Heaphy & Dutton, 2008). For example, researchers have demonstrated that social interactions impact an individual's cardiovascular, immune, and neuroendocrine systems, both positively (e.g., regulating cortisol rhythm) and aversely (e.g., increased blood pressure levels). Furthermore, a growing field of interpersonal physiology is dedicated to understanding how autonomic physiological processes impact and are impacted by social interactions (Kleinbub, 2017; Palumbo et al., 2017).

Physiological synchrony occurs when there is an association between the physiological processes of two or more individuals. Researchers have found that partners regulate each other to maintain psychophysiological equilibrium in a process referred to as co-regulation (Pietromonaco & Collins, 2017). Although this area of research remains underdeveloped, studies have found synchrony of many physiological processes (e.g., pulse rate, skin conductance, heart rate, temperature) during interactions between parent-child dyads, couples, teammates, friends/peers, and therapist-patient interactions (Cariolato et al., 2020; Kleinbub, 2017; McKee, 2008).

Interpersonal Influences on Psychological Responses

While social support has a multifaceted influence on psychological health, one of the most relevant influences a biofeedback clinician should consider is the connection between stress responses and social support. Stress has a profound impact on physiology. In fact, researchers have linked chronic stress to dysregulation of the cardiovascular, immune, and endocrine systems and increased risk of chronic disease (Cohen et al., 2007; Schetter & Dolbier, 2011). As a result, biofeedback training aims towards stress management and regulation to improve long-term health outcomes. Positive perceived social support acts as a buffer to stress and leads to a reduced appraisal of the severity of the stressor (Cohen & Wills, 1985; Lakey & Orehek, 2011; Pietromonaco & Collins, 2017; Uchino et al., 2018). Social support may take the form of groups (e.g., social groups, faith organizations, neighborhoods), families, or individuals (e.g., friends, partners). When training a patient to understand and manage their physiological responses, incorporating a support person may increase a patient's psychological resources to cope with stress and assist them in regulating their stress response.

Theoretical Foundation

The present review was grounded in attachment theory, polyvagal theory, and the biopsychosocial-spiritual (BPSS) framework. Attachment theory initially explored how infants and caregivers develop emotional bonds, which are crucial to the health and development of the infant (Ainsworth et al., 1978; Bowlby, 1988). Since its conception, attachment theory has evolved to explain how individuals are able to form emotional bonds in adulthood (Feeney, 2016; Hazan & Shaver, 1987). Secure attachment is when people feel safe with another person and confident that person will meet their needs. It is related to decreased health risks and affects stress response system functioning (e.g., immune, hypothalamic-pituitary-adrenal; Pietromonaco & Powers, 2015). As social creatures, efforts to connect with others and develop these bonds are crucial to our overall well-being. Researchers further support attachment theory by evidence that social connection goes beyond emotional or psychological dimensions and has physiological ramifications. To that end, researchers have found links between attachment theory and polyvagal theory (Flores & Porges, 2017; Ülker & Sayar, 2022)

Porges' (2009; 2018) polyvagal theory proposes that the autonomic nervous system (ANS) has evolved three primary neural circuits to allow perception and response to safety or threat in the environment. The vagus nerve, which is the primary nerve activated by the parasympathetic nervous system, coordinates many body systems in response to ANS activity. When individuals feel secure with another person, it activates the ventral vagal social engagement system and triggers spontaneous social engagement behaviors (e.g., eye contact, physical contact). Through safe social relationships, people are able to decrease defensiveness and self-regulate physiologically, which creates an optimal state for mental and physical health (Porges, 2018; Ülker & Sayar, 2022). The target of biofeedback interventions is to down-train excessive sympathetic nervous system activity to increase regulation (Schwartz et al., 2016). Several biofeedback interventions also aim to increase vagal tone (e.g., HRV biofeedback). Understanding that social engagement goes hand in hand with physiological regulation has important implications for patient intervention.

Ehrenreich (2018) proposed attachment-informed biofeedback with spousal and parental dyads. Both individuals in the dyads participated in training and recieved real-time feedback about their own physiology and that of the other person. As a result, Ehrenreich (2018) proposed that it offered individuals a unique opportunity to connect to each other in ways previously impossible. By witnessing each other's internal states and seeing what is usually hidden, it created a connection and deeper understanding of each other's physical and emotional experience. This model used interpersonal biofeedback as a therapeutic tool to assist in stress management, conflict resolution, distress tolerance, and enhancing relational dynamics (Ehrenreich, 2018). Interpersonal biofeedback and other types of relational biofeedback interventions may also have important implications beyond targeting social interactions in psychotherapy. It may be a useful intervention to promote physical, mental, and spiritual health as well.

Biopsychosocial-Spiritual Framework

The biopsychosocial model is a holistic approach to viewing the multiple dimensions of a person's health and well-being (Engel, 1977). It serves as a challenge to the traditional biomedical model and encourages practitioners across disciplines to view patients from a holistic lens. Engel (1977) argued the interplay between the physical (e.g., organ systems), mental (e.g., cognitions, emotions), and social (e.g., relationships, support systems, cultural backgrounds) dimensions of health must be taken into consideration to provide best care to patients. This model was further developed by Wright and colleagues (1996) by adding a spiritual component and honoring the crucial role spirituality, values, purpose, and meaning have in experiences of illness and fostering health. Thus, the biopsychosocial-spiritual (BPSS) framework was coined. The BPSS framework has been used in many healthcare fields to better meet patient needs and provide optimal care (Tyndall et al., 2014). Using the BPSS framework allows for healthcare providers to gain a more in-depth understanding of a persons' holistic health and contextual variables that impact their experience of illness or dysfunction (Delbridge et al., 2014; Hodgson et al., 2007). This information can then inform treatment to better meet patient needs.

Biofeedback interventions are uniquely suited to meeting holistic health needs as it recognizes the connection between mental and physical states (Schwartz et al., 2016). They have been used in psychotherapy to facilitate positive social interactions (Ehrenreich, 2018; Kassel & LeMay, 2015). Consequently, biofeedback interventions inherently target various dimensions of health as conceptualized by the BPSS model. Biofeedback connects physical processes (e.g., heart rate, respiration) with psychological experiences and resources (e.g., stress, self-soothing) and spiritual interventions (e.g., meditation, mindfulness) to promote regulation, consistent with the BPSS framework (Frank et al., 2010; McKee, 2008; Shaffer, 2020). However, social resources are often underutilized in biofeedback training. As mentioned previously, relational dynamics impact biological (e.g., physiological synchrony, co-regulation; Kleinbub, 2017; Palumbo et al., 2017) and psychological (e.g., stress buffering; Pietromonaco & Collins, 2017; Uchino et al., 2018) dimensions of health. There is also research that connects social inclusion with a greater sense of meaning and purpose (i.e., spirituality; Stillman et al., 2009). Securely attached, safe relationships can have a positive impact on various components of health (Pietromonaco & Collins, 2017; Pietromonaco & Powers, 2015). For this reason, relational biofeedback interventions may be useful. The present study seeks to discover relational biofeedback interventions used to promote various dimensions of health.

Current Study

This systematic review aimed to answer the following research question: *How have relational biofeedback interventions been used to promote different dimensions of BPSS health?* This systematic review aimed to: (a) explore how biofeedback interventions have included a relational component, (b) explore which social connections are most commonly included in relational biofeedback interventions, and (c) identify the components of BPSS health targeted with relational biofeedback interventions. The authors of the present review used the term "relational" broadly about any social connection to honor and make space for various social ties.

All types of social connections were considered for inclusion (e.g., romantic relationships, familial relationships, professional relationships, new acquaintances). The primary requirement was that multiple people must be included in the biofeedback training process to be considered a relational intervention. To note, “biofeedback” encompasses a wide range of techniques (e.g., electrodermal, electrocardiography, respiratory, sEMG) that measure different physiological responses (e.g., skin conductance, HRV, breathing, muscle tension; Frank et al., 2010). Additionally, biofeedback interventions may include one physiological measure or measure multiple processes concurrently. Given that this study focused on the relational aspect of biofeedback interventions, it included all types of biofeedback to obtain a comprehensive picture of how social ties were incorporated across interventions.

Methods

The research team used a seven-step protocol to synthesize the research for this systematic review (Cooper, 2017). In the first step, formulating the problem, the team developed the research question: *How have relational biofeedback interventions been used to promote BPSS health?* The second step calls for a systematic search of the published literature on this topic. We searched *PubMed*, *PsycINFO*, and *CINAHL* databases for peer-reviewed literature. Search terms were developed from well-known and established concepts in the literature and keywords in related articles. The first author worked in conjunction with a university librarian to review Medical Subject Heading (MeSH) terms (*PubMed*) and Subject terms (*PsycINFO*) to select all relevant search terms for each database. The researchers entered search terms conjointly in each database (e.g., [‘relational’ OR ‘interpersonal’ OR ‘dyadic’] AND [‘biofeedback’ OR ‘neurofeedback’]). Interested readers can find the full table of search terms in Table 1. Prior to conducting the search, the study protocol was registered with Open Science

Framework to promote transparency of the systematic review process. The initial search began in October 2022.

Data Collection

In step three (Cooper, 2017), the research team gathered results from each database and exported them into Covidence. Covidence is a software platform designed to assist in organizing, screening, and evaluating literature for systematic and other literature reviews (*Covidence Systematic Review Software*, 2022). The software screened for duplicates and removed any detected duplicates. The first author reviewed the titles and abstracts of the remaining articles. A research assistant also independently screened the article titles and abstracts to ensure inter-rater consistency. The research team resolved discrepancies through consultation to reach a consensus.

The research team considered articles for full-text review if they met the following inclusion criteria: (a) peer-reviewed publications, (b) published in the English language, (c) included information about a biofeedback intervention, and (d) the biofeedback intervention involved more than one person engaged in the training. The researchers excluded articles referencing psychophysiological monitoring without an active feedback component (i.e., lacking audio, video, or other feedback mechanisms). The researchers also excluded theoretical and conceptual papers which lacked empirical support. Due to a lack of peer review, the review did not include dissertations, theses, and policy (i.e., grey literature). If the title and abstract indicated the study may have met the inclusion criteria, or if it was unclear, we conducted a full-text review to determine whether to include the article. After the researchers selected the final articles, they also reviewed the reference lists to identify other articles which merited a full-text review.

Quality Assessment and Risk of Bias

Continuing Cooper's (2017) protocol, the researchers selected measures to assess quality and risk of bias (step four). The researchers chose the Revised Cochrane risk-of-bias tool for randomized trials (RoB 2; Higgins et al., 2011, 2019) as an appraisal measure for randomized control trials. The RoB 2 assessed bias in the following five domains: randomization process, deviation from intended interventions, missing outcome data, measurement of the outcome, and reporting results. For non-randomized studies, the researchers used the Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) as an appraisal tool (Sterne et al., 2016). The ROBINS-I assessed for bias due to confounding variables, participant selection, intervention classification, deviations from intended interventions, missing data, measurement of outcomes, and reporting results. We assessed qualitative studies using the Critical Review Form – Qualitative Studies (Version 2.0; Law et al., 1998; Letts et al., 2007) for quality in the study purpose, literature, design, sampling, data collection, data analyses, conclusions and implications, and overall rigor.

Data Extraction Process

The process of extracting the final studies for review is outlined in Figure 1 using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Moher et al., 2010). The research team screened the title and abstracts of 2,494 articles and identified 81 articles for full-text review. Twenty-two articles were found to meet the criteria for inclusion. The research team also identified one additional article from the references of the included studies, resulting in 23 articles included in this systematic review.

After the final articles were selected, researchers evaluated the samples of the final studies to extract information about the sample size, demographics, and social structure of the participating units (e.g., parent-child dyads, romantic couples, therapist-client dyads). The researchers also reviewed the relational biofeedback modalities used in the studies. Finally, the outcome measures of the studies were evaluated and categorized as either biological, psychological, social, or spiritual health outcomes, or a combination of these categories. The following sections outline the final steps of the systematic review process—analyzing the studies (step five), interpreting the data (step six), and presenting the results (step seven; Cooper, 2017).

Results

Twenty-three studies containing relational biofeedback intervention were identified. These studies occurred between the years of 1978 and 2023. Of the 23 studies included in this review, 12 used non-randomized study designs, 10 used randomized trials, and one used qualitative methodology. The following sections detail the studies concerning relational biofeedback interventions and BPSS health by exploring how interventions have been used with various social structures. The authors summarize the results and highlight relevant themes below. Table 2 provides additional information about the 23 included studies, including the interventions used, relationships of participants, and the connection to BPSS health. Quality assessment and risk of bias assessment for each of the 23 studies are also described below.

Sample Characteristics

Data was gathered from 2,411 participants who engaged in some type of relational biofeedback intervention. Limited demographic information was provided. The authors of the included studies most commonly reported gender and age of participants. Age varied widely since some interventions were targeted to children while others were targeted to adults. Of the studies that reported gender, the genders were fairly balanced (53% male, 47% female). No other gender identities were reported. Surprisingly, only two studies reported the race or ethnicity of participants. Of these two studies, both samples were predominantly White. The limited demographic information reported, particularly the lack of race/ethnicity represented, brings up concerns about generalization of the results. It is also important to note that many of the studies had small sample sizes, which should also be considered when generalizing results.

Caregivers of Children and Dependents

Nine studies used relational biofeedback with caregivers of children or dependents. Participants of these studies included children with their parents or family members (Allen & McKeen, 1991; Burke & Andrasik, 1989; Burton et al., 2018; Kerr et al., 2022; Nash et al., 2008; Woodberry et al., 2020) and caregivers of persons with disabilities (Blain-Moraes et al., 2013; Frederiks et al., 2015, 2019). These studies are discussed together due to similarities in the amount of care and functional support present in the relationships.

Several studies utilized caregivers for practical and emotional support with the implementation of biofeedback interventions with children to promote physical health. This includes administering biofeedback interventions at home and encouraging practice. Utilizing the help of caregivers may be more convenient, require less time by the therapist, and allow for more consistent practice outside of clinical settings. Emotionally, caregivers can also provide support and direct children's attention to the intervention when needed. For example, Burk and Andrasik (1989) compared parent- or child-administered biofeedback at home with biofeedback at the clinic for the treatment of pediatric headaches. Both home-based approaches had positive outcomes, with the parent-administered biofeedback contributing to improvement of symptoms, which were maintained at the year follow-up. Nash and colleagues (2008) used a potentiometer and EMG biofeedback with children with cerebral palsy, which significantly reduced spasticity in the lower limbs after 10 weeks of training. During the training period, the physiotherapists trained parents to conduct biofeedback interventions at home to supplement the clinical protocol, although consistency of at-home training differed between the families.

While some studies found the caregivers to aid in the implementation of the biofeedback intervention, other studies used biofeedback interventions to improve relational dynamics for the social and psychological health of the relational unit. One study used functional magnetic resonance imaging (fMRI) to provide feedback to a mother of her daughter's brain activity when recalling a stressful event. The mother was then able to use the fMRI to guide their responses in an effort to regulate the child (Kerr et al., 2022). Biofeedback was also particularly useful to aid in communication between caregivers and persons with disabilities that impacted verbal communication and made social interactions challenging. For example, Frederiks and colleagues (2015, 2019) and Blain-Moraes and colleagues (2013) each evaluated the use of biofeedback programs (i.e., Biomusic, Sense) to assist caregivers in understanding the internal emotional state of their loved ones with disabilities and allow persons with disabilities to better direct their caregivers' attention. The biofeedback programs served as a communication tool to increase understanding and allow caregivers to better respond to the needs of people with disabilities. Although these biofeedback programs are early in development, they have the potential to provide useful, accessible tools to aid caregivers in providing optimal care for their dependents.

Strangers and Unspecified Relational Units

Seven studies conducted biofeedback interventions with dyads that were either strangers or did not specify how they were connected (Avila Mireles et al., 2017; Cheung et al., 2016; Dikker et al., 2021; Konvalinka et al., 2023; Müller et al., 2021; Muñoz-González et al., 2022). Similar to those above, one of these studies evaluated the use of the Biomusic program. Cheung and colleagues (2016) developed music samples using electrodermal activity, skin temperature, heart rate, and respiration from children in both relaxed and anxious states. Strangers were able to identify whether the sample was from a child in the anxious or relaxed state in an average of 12.1 seconds. This study indicates Biomusic may be a useful program to aid in the understanding of another person's psychological health, even without the prior relationship that caregivers have with the child.

Most of the studies conducted with strangers or unspecified relationships were connected to social health. Muñoz-González and colleagues (2022) created a multiplayer virtual reality concert and used brain activity of the "audience" to generate visual effects. The authors suggested that this software may be useful in building a sense of unity. Some studies also explored how interpersonal coordination of physiological rhythms are connected to social behaviors and interaction patterns. Dikker and colleagues (2021) did not specify the relationships of the participants, but did note that higher social closeness and length of relationship predicted better synchrony of brain activity. The authors also identified the social behaviors (i.e., eye contact, joint action behaviors) used to increase synchronization of brain activity in an effort to accomplish a task. However, even among strangers in separate rooms, the use of biofeedback was used to synchronize respiration in an effort to accomplish a task (Konvalinka et al., 2023). The presence of another person, even if there is no prior established relationship, may have some impact on the uses and outcomes of biofeedback interventions.

Therapist and Patient

Five studies evaluated the therapist-patient relationship and biofeedback interventions (Borgeat et al., 1980, 1984; Bregman & McAllister, 1983; Hamberger & Lohr, 1981; Malec et al., 1978). These studies were included given that they specifically studied the interaction between the therapist-patient relationship and outcomes of biofeedback. To note, therapists are not a neutral presence, generally holding power, expertise, or influence over the patient, but do bring a relational component to biofeedback training when administering the intervention. The presence of a therapist (also referred to as a trainer or clinician) may have significant influence on the effectiveness of biofeedback interventions and, therefore, impact individuals across different dimensions of health. For example, Borgeat and colleagues (1980) found that the presence of the therapist during EMG biofeedback for chronic headaches actually contributed to higher EMG activation of the frontalis muscle, indicating increased tension and, therefore, pain. The authors were uncertain about the mechanisms underlying these findings. However, a subsequent study found this relationship varied based on the individual therapist (Borgeat et al., 1984). Four psychiatrists with similar training and experience served as trainers during the study, but changes in participants' EMG differed based on which therapist conducted the intervention. Other studies replicated the mixed findings of Borgeat and colleagues. Bregman and McAllister (1983) found that therapist presence made it more challenging for a patient to develop control over skin temperature. Conversely, Hamberger and Lohr (1981) found that therapist presence did not have a significant impact on the outcomes of biofeedback-assisted relaxation training. The mixed results indicate the need for additional research to understand the underlying mechanisms of the therapist-patient relationship with regard to biofeedback interventions.

Competitors

Two studies put strangers in competition with each other using biofeedback interventions. The participants competed with an opponent to produce some type of desirable outcome by controlling a physiological process. Patron and colleagues (2020) had competitors try to produce higher respiratory sinus arrhythmia than their opponent. The study found that competitive biofeedback led to better outcomes in increasing cardiac vagal control than non-competitive biofeedback. Surprisingly, the competitive biofeedback group also demonstrated better physical (e.g., lower resting heart rate, lower systolic blood pressure) and psychological (e.g., reduced anxiety and depressive symptoms) health outcomes compared to the non-competitive dyads serving as controls. Competitive biofeedback may be a useful tool to increase effectiveness of biofeedback interventions and improve health outcomes. Putri and colleagues (2022) used neurofeedback games to put participants in competition on a virtual task and categorizing "winners" and "losers" based on their scores. The findings indicate that participants' innate baseline relative alpha activity was related with the ability to adjust their own brain activity in response to another participant. These results have potentially meaningful implications regarding how individual differences in brain activity impacts their ability to monitor another person's brain activity and, as a result, is related to how they interact socially.

Romantic Partner

Unexpectedly, the present review resulted in only one study on relational biofeedback with romantic partners. Barnes and colleagues (1984) used EMG biofeedback as an adjunct to psychotherapy with couples seeking treatment for vaginismus. The researchers found that all five couples reported successful sexual intercourse after completing treatment, leading to a difference in the physical health of the female partner and social health of the couple. More research is needed to determine whether relational biofeedback with romantic partners can have similar results for couples experiencing other health conditions.

Quality Assessment and Risk of Bias

Due to the diversity of research represented in the final articles, it was challenging to identify assessment tools which could be applied to all the articles. The assessment tools selected were determined to be the best fit for a majority of the articles, but it should be noted there are limitations of applying the tools to the many different types of studies represented in the review. The research team used the ROB 2 (Higgins et al., 2011, 2019) to assess for bias in randomized studies (n = 10) and the ROBINS-I (Sterne et al., 2016) to assess for bias in non-randomized studies (n = 12). High risk was often the result of unclear or missing information about the study design reported in the article rather than a result of poor quality of research. This was especially true for information regarding randomization procedures and assignment to interventions in randomized studies. Another common source of bias was due to the outcome assessors also implementing the intervention, introducing the possibility of bias in the measurement of outcomes. Blinding procedures were often not reported, unclear, or omitted from the research design. Finally, several studies acknowledged that participants were receiving co-interventions in medical or mental health treatment settings, which could be viewed as deviation from the intended intervention and impacted the outcomes of the biofeedback interventions.

Only one study by Blain-Moraes and colleagues (2013) used a qualitative design. The research team used the Critical Review Form – Qualitative Studies Version 2.0 (Law et al., 1998; Letts et al., 2007) to assess for quality of the study. The study was determined to have high analytical rigor, indicating high credibility and dependability. However, the small sample size limited the transferability and confirmability of the study. Although the small sample size was, in part, due to the challenge of recruiting participants from a specific population (i.e., persons with profound multiple disabilities and their families), it limits the generalizability of the research findings. See Table 3 for a summary of the risk of bias assessments.

Discussion

It is clear that relationships can play an important part in biofeedback training. As explained by attachment theory (Feeney, 2016; Hazan & Shaver, 1987) and polyvagal theory (Porges, 2009, 2018), social connections impact an individual's stress response system and how they regulate physiologically. When assisted with biofeedback interventions, dyads are able to better understand each other's internal state, which encourages them to work towards a common goal and increases responsiveness and communication (Kerr et al., 2022; Woodberry et al., 2020). By uncovering each other's internal physical experience, dyads may encounter each other in ways that are not otherwise possible (Ehrenreich, 2018). Therefore, clinicians may be able to use relational biofeedback to uniquely intervene with couples, families, and peers.

Additionally, key social support people can be used during biofeedback training to support the training process. A patient's social network can provide both practical (e.g., conducting training outside of clinical settings) and emotional (e.g., encouragement to practice) support, which biofeedback clinicians may find instrumental for increasing adherence and improving training outcomes. Additionally, utilizing social support may be a type of intervention itself as dyads may serve to physiologically regulate one another (Levit-Binnun et al., 2010). While there are many ways relational biofeedback may serve as an enhancement to biofeedback training, it is crucial to evaluate the empirical evidence supporting the use of relational biofeedback. The findings of this systematic review highlight the importance of examining relational biofeedback interventions broadly to capture the variety of ways that biofeedback interventions and social support systems can mutually influence each other.

However, some studies have found that relational dynamics can impede biofeedback training. To note, the studies which demonstrated poorer outcomes when two or more individuals were present primarily considered clinician-patient relationships (e.g., Bregman & McAllister, 1983). This may be due to patients' feelings of pressure or anxiety to perform with a professional. Additionally, the findings of Borgeat and colleagues (1984) suggest that individual differences of the clinicians and the quality of the clinician-patient relationship may play a role in training outcomes. Further research on relational biofeedback is needed to fully understand how relational dynamics play a role in biofeedback training and how clinicians can intentionally utilize social resources for the benefit of their patients.

Research and Clinical Implications

The reviewers categorized the outcomes of the included articles as three of the four BPSS dimensions: physical, psychological, and social. No outcomes found in the review were consistent with spiritual health. The omission of spiritual health is not surprising since the spiritual component in BPSS health is a more recent addition to the well-known biopsychosocial (BPS) model (Engel, 1977). Spirituality is also less widely studied due to the challenge of conceptualizing and defining the concept (Koenig et al., 2012). However, several spiritual practices around transcendence overlap with stress-management techniques frequently used in biofeedback training, including mindfulness and meditation (Shaffer, 2020). As the research on relational biofeedback interventions evolves, attention should be paid to the impact on spiritual health.

Of the three dimensions represented in the article outcomes, physical health (i.e., biological dimension) appeared the most frequently in 16 of the 23 articles. This is not surprising given that biofeedback is a psychophysiological intervention. While a wide range of health outcomes were represented in the articles, headaches/migraines had the most evidence supporting the use of relational biofeedback interventions to treat symptoms (Allen & McKeen, 1991; Burke & Andrasik, 1989). This was primarily in the context of a parent-child unit. Additionally, the authors found the use of biofeedback programs to assist caregivers in their interactions with people with disabilities in several included articles (Blain-Moraes et al., 2013; Cheung et al., 2016; Frederiks et al., 2015). The use of relational biofeedback interventions across multiple studies for physical ailments such as headaches/migraines and physical disabilities suggests promising potential for successful clinical application in medical settings.

Regarding social health, relational biofeedback interventions have been explored as a tool to aid in communication (Kerr et al., 2022), promote connection and bonding (Frederiks et al., 2015), signal another person to provide support (Blain-Moraes et al., 2013; Woodberry et al., 2020), and accomplish a joint goal (Müller et al., 2021). However, the limited number of articles and small sample sizes indicates further research is needed to determine if these findings hold true. It is curious that only six of the included studies incorporated interpersonal biofeedback, in which two or more people were simultaneously receiving feedback on themselves and/or each other. This may be partially explained by the notion that the studies which did use interpersonal biofeedback were mostly targeted towards exploring synchrony rather than relational dynamics. This is noteworthy because several articles have proposed interpersonal biofeedback as a tool to enhance the social health of a dyad, particularly in relational psychotherapy (Ehrenreich, 2018; Kassel & LeMay, 2015). However, the proposed interpersonal biofeedback intervention seems to be primarily theoretical and additional research is needed to determine if it is an efficacious intervention.

Of the studies which reported psychological health outcomes, the relational biofeedback interventions were primarily used by a parent or caregiver to assist in regulating stress responses and responding to anxiety of their children or dependents (e.g., Blain-Moraes et al., 2013; Kerr et al., 2022). As discussed above, several articles explored the use of biofeedback programs to support caregivers in understanding the psychological state of a person with disabilities, attending to their physical needs, and enhancing their social bond. When communication is limited due to developmental stage or ability, relational biofeedback can offer an alternative to elucidate the internal psychological state of the individual by monitoring their physiological responses. Certain parents were able to use relational biofeedback interventions to identify when their children were stressed or anxious and assist them in regulating this stress, leading to improved psychological health outcomes (Burton et al., 2018; Kerr et al., 2022; Woodberry et al., 2020).

Although the included articles provide an idea of how relational biofeedback interventions can impact BPS health, research on relational biofeedback is in its early stages. Several of the articles included were feasibility studies or pilot studies, demonstrating the novelty of relational biofeedback in the current literature. While the studies presented initial evidence regarding the effectiveness or efficacy of the intervention, they were intended to explore whether a new relational intervention or biofeedback tool was practical. Therefore, caution should be used in assuming representative effectiveness of such interventions across differing health challenges among diverse samples. Additional research is needed to fully establish relational biofeedback as a viable intervention.

Limitations

Due to the scarcity of literature on relational biofeedback interventions, the authors chose to conduct a broad search to be inclusive of all applicable literature. Therefore, the results of included articles cannot be easily compared to one another given that a variety of biofeedback modalities, physiological measures, and protocols are presented in the articles. Future research can build upon this beginning attempt to evaluate more specific facets of the literature on relational biofeedback. Furthermore, each included study did not map seamlessly onto each of the theoretical foundations underlying our study. However, they all met the inclusion criteria by demonstrating an effort to incorporate a relational component into their biofeedback protocol.

This review serves as an initial investigation into the current state of the literature regarding relational biofeedback and highlights the significant gaps in the literature. Readers should be cautious about generalizing the results of the included articles due to the small sample sizes, lack of consistent protocol, and omission of demographic information in the literature. Social scientists conducting relational biofeedback research in the future should examine larger samples with diverse racial and ethnic identities, family structures, gender identities, sexual orientations, and socioeconomic statuses. Diverse samples which are representative of the population are needed to evaluate how relational biofeedback interventions can be applied with a diverse clientele. Additionally, we only included peer-reviewed articles published in the English language. Our search may have missed relevant research published in other languages or not catalogued within our chosen databases.

Despite the limitations, the present review provides noteworthy considerations for biofeedback clinicians. While the literature on interpersonal physiology has grown (Kleinbub, 2017; Palumbo et al., 2017), there has been less emphasis on how biofeedback clinicians can use that information to work with patients on health goals. Rather than solely monitoring physiological processes within interpersonal interactions, these processes can be intentionally used during biofeedback training to enhance patient outcomes. To the authors' knowledge, the present review is the first attempt to gather evidence on relational biofeedback interventions, which has potential to be useful in the biofeedback community and across healthcare settings.

Conclusion

Biofeedback is a growing, interdisciplinary intervention that has been used to foster physical and mental health (Tan et al., 2016). However, biofeedback is often considered an individual intervention. This is concerning given that research has established the relationship between social connection, physiological responses, and health outcomes (Kleinbub, 2017; Palumbo et al., 2017). Relational biofeedback has the potential to be an important tool within biofeedback to enhance training outcomes. The research team conducted a systematic review of the literature to better understand how relational interventions have been used for BPSS health. While some evidence exists suggesting relational biofeedback can impact physical, mental, and social health, relational biofeedback is largely under-researched. Additionally, small sample sizes and lack of diverse samples limit the generalizability of the available research. Furthermore, the present review searched for relational biofeedback interventions broadly, but we recognize the need for research on relational biofeedback with a focus on specific biofeedback modalities, relational units, and health conditions or presenting problems. We encourage researchers to advance the research on relational biofeedback by developing standardized protocol and evaluating the efficacy of relational biofeedback for BPSS health.

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Figure 1

PRISMA Flowchart for Included Articles

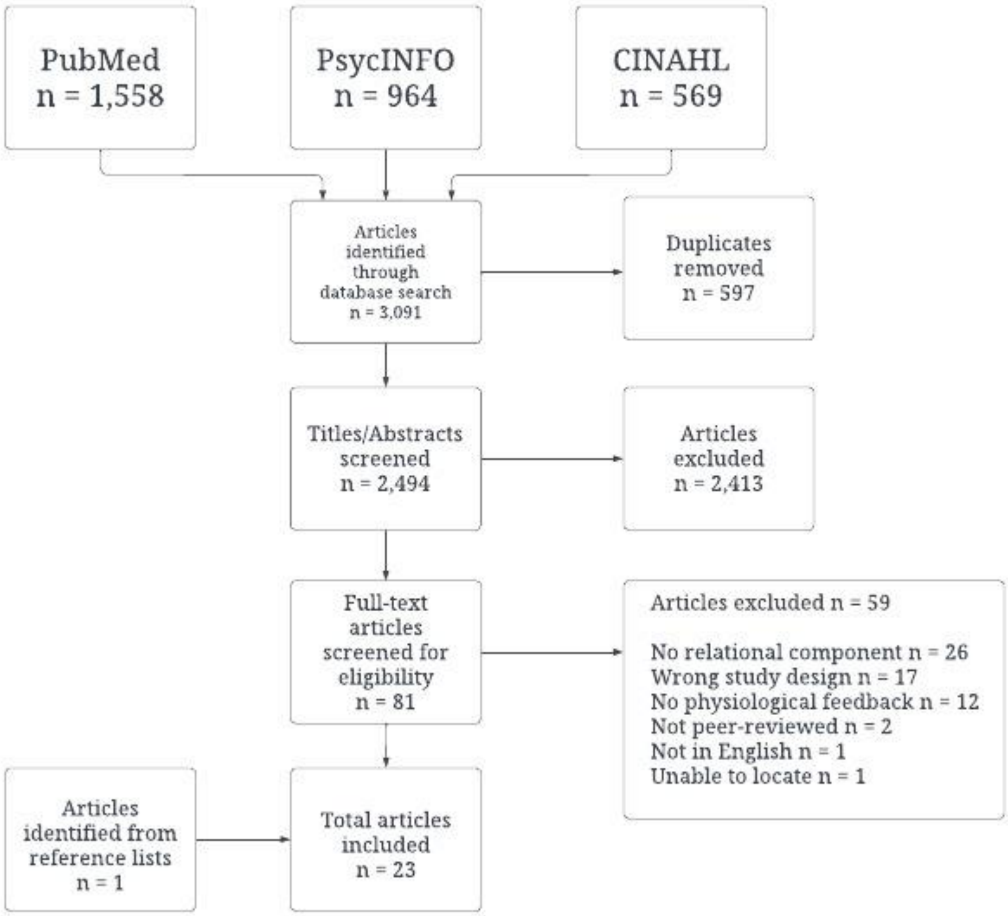

Table 1

Systematic Review Search Terms

Biofeedback	PubMed MeSH Terms	"Biofeedback, Psychological", "Autogenic Training"
	PsycINFO Subject Terms	"Autogenic Training", "Biofeedback", "Biofeedback Training", "Neurotherapy"
	CINAHL Subject Headings	"Biofeedback"
	Keywords	"applied psychophysiology", Biofeedback, biofeedbacks, "biofeedback treatment", "biofeedback interventions", neurofeedback, neurotherapy, "psychophysiological feedback", "physiological feedback", "psychophysiologic feedback", "physiologic feedback", "psychology biofeedback", "psychology biofeedbacks", "physiology biofeedback", "physiology biofeedbacks", "psychophysiological biofeedback", "psychophysiological biofeedbacks", "psychophysiologic biofeedback", "psychophysiologic biofeedbacks", "autogenic training", "EEG biofeedback", "electroencephalograph biofeedback", "EMG biofeedback", "electromyograph biofeedback", myofeedback, myofeedbacks, "surface electromyograph biofeedback", "sEMG biofeedback", "electrocardiograph biofeedback", "ECG biofeedback", "electrodermograph biofeedback", "EDG biofeedback", "respiratory biofeedback", "heart rate biofeedback", "heart rate variability biofeedback", "PPG biofeedback", "peripheral blood flow biofeedback", "EDA biofeedback", "electrodermal biofeedback", "sweat gland activity biofeedback", "temperature biofeedback", "thermal biofeedback", "electrodermograph biofeedback", "Functional magnetic resonance imaging biofeedback", "fMRI biofeedback", "biofeedback training", "biofeedback-assisted relaxation training", BART
Relational	PubMed MeSH Terms	"Friends", "Family", "Interpersonal Relations"
	PsycINFO Subject Terms	"Family", "Biological Family", "Extended Family", "Family Members", "Family of Origin", "Family Relations", "Family Structure", "Nuclear Family", "Stepfamily", "Interpersonal Relationships", "Caregivers", "Close Relationships", "Couples", "Family Relations", "Friendship", "Kinship", "Marital Relations", "Mentor", "Partners", "Peers", "Role Models", "Significant Others"
	CINAHL Subject Headings	"Family+", "Interpersonal Relations+"
	Keywords	Relational, Interpersonal, "Interpersonal relations", "interpersonal relationship", "interpersonal relationships", dyad, dyads, dyadic, couple, couples, "couple relationship", "couple relationships", "romantic relationship", "romantic relationships", "romantic partner", "romantic partners", "intimate relationship", "intimate partner", "intimate relationships", "intimate partners", partner, partners, Marital, Spouse, Spouses, Spousal, Social, "social group", "Social connection", "Social connections", "Social Relationships", "Social Relationship", "Partner Communication", "Partner Communications", "Husband-Wife Communication", "Husband Wife Communication", interrelational, inter-relational, family, families, "family relationship", Familial, "Family relationships", "familial relationship", "familial relationships", parent, "parent child", "parent-child", "parent-child relationship", "parent child relationship", "parent-child relationships", "parent child relationships", Parental, Parenting, Friend, Companions, Companion, Friendship, Friendships, Acquaintances, "Family Members", "Family Member", Stepfamily, Stepfamilies, Step-family, Step-families, "Reconstituted Families", "Reconstituted Family", "blended family", "blended families", Filiation, "Kinship Networks", "Kinship Network", "Extended Family", "Extended Families", "nuclear family", "nuclear families", "significant other", "significant others", caregiver, caregivers

Table 2

Summary of Included Studies (n = 23)

Study	Outcome	BPSS Health Dimension	Biofeedback Modality	Relational Unit	Sample Size
Allen & McKeen, 1991	Pediatric migraine	Physical	EMG, Temperature	Parents and children	n = 21 children
Avila Mireles et al., 2017	Physiological skill acquisition through peer contact	Physical, Social	EMG, Haptic	Unspecified	n = 30 participants
Barnes et al., 1984	Vaginismus	Physical	EMG	Married couples	n = 5 couples
Blain-Moraes et al., 2013	Interacting with persons with profound multiple disabilities (PMD)	Psychological, Physical, Social	BVP, EDA, Respiration, Temperature	Caregivers and dependents	n = 3 dependents; 10 caregivers
Borgeat et al., 1980	Headaches	Physical	EMG	Therapist and patients	n = 16 participants
Borgeat et al., 1984	Headaches	Physical	EDA, EEG, EMG	Therapist and patients	n = 16 participants
Bregman & McAllister, 1983	Skin temperature control	Physical	Temperature	Experimenter and subjects	n = 53 participants
Burke & Andrasik, 1989	Pediatric migraine	Physical	Temperature	Parents and children	n = 9 children
Burton et al., 2018	Regulating stress related to medical procedures	Psychological, Social	HR	Caregivers, medical personnel, and children	n = 30 children; 29 caregivers; 30 clinicians
Cheung et al., 2016	Identifying anxiety in persons with disabilities	Psychological, Physical, Social	BVP, EDA, Respiration, Temperature	Strangers	n = 16 participants

Dikker et al., 2021	Brain activity synchrony and social behaviors	Social	EEG	Unspecified	n = 1798 participants
Frederiks et al., 2015	Interacting with persons with Prader-Willi syndrome	Psychological, Physical, Social	EDA	Parents and children	n = 3 children
Frederiks et al., 2019	Joint attention behaviors with persons with visual and/or intellectual disabilities	Psychological, Physical, Social	EDA	Caregivers and clients	n = 4 dyads
Hamberger & Lohr, 1981	Muscle activity of the frontalis muscle	Physical	EMG	Trainers and subjects	n = 30 participants
Kerr et al., 2022	Regulating stress during conversation on distressing topics	Psychological, Social	Functional magnetic resonance imaging (fMRI)	Mothers and daughters	n = 6 dyads
Konvalinka et al., 2023	Joint action through interpersonal coordination	Social	Respiration	Strangers	Experiment 1 n = 24 participants Experiment 2 n = 24 participants
Malec et al., 1978	Muscle activity, Self-disclosure	Physical, Social	EMG	Experimenters and subjects	n = 96 participants
Müller et al., 2021	Action coordination, Interpersonal synchrony	Social	EEG	Strangers	n = 25 dyads
Muñoz-González et al., 2022	Sense of unity and enjoyment of experience through virtual reality platform	Social	EEG	Unspecified	n = 20 participants
Nash et al., 2008	Spasticity due to cerebral palsy	Physical	EMG	Children and families	n = 3 children

Patron et al., 2020	Respiratory sinus arrythmia, Competitiveness	Physical, Social	BP, BVP, EDA, HRV, Respiration	Competitors	n = 30 managers
Putri et al., 2022	Brain activity and competitive gaming	Physical, Social	EEG	Competitors	n = 10 dyads
Woodberry et al., 2020	Stress management, Criticism & conflict behaviors	Psychological, Social	HR	Youth and parents	n = 10 dyads

Note. BP- Blood Pressure; BVP- Blood Volume Pulse; EDA- Electrodermal Activity; EEG- Electroencephalography; EMG-Electromyography; HR- Heart Rate; HRV- Heart Rate Variability

Table 3

Risk of Bias Assessments

Study	Assessment Tool	Overall Rating
Allen & McKeen, 1991	ROB 2	High Risk
Avila Mireles et al., 2017	ROB 2	High Risk
Barnes et al., 1984	ROBINS-I	Moderate Risk
Borgeat et al., 1980	ROB 2	High Risk
Borgeat et al., 1984	ROB 2	High Risk
Bregman & McAllister, 1983	ROB 2	High Risk
Burke & Andrasik, 1989	ROB 2	High Risk
Burton et al., 2018	ROBINS-I	Serious Risk
Cheung et al., 2016	ROBINS-I	Moderate Risk
Dikker et al., 2021	ROBINS-I	Low Risk
Frederiks et al., 2015	ROBINS-I	Low Risk
Frederiks et al., 2019	ROB 2	High Risk
Hamberger & Lohr, 1981	ROB 2	High Risk
Kerr et al., 2022	ROBINS-I	Low Risk
Konvalinka et al., 2023	ROBINS-I	Low Risk
Malec et al., 1978	ROB 2	High Risk
Müller et al., 2021	ROBINS-I	Moderate Risk
Muñoz-González et al., 2022	ROBINS-I	Low Risk
Nash et al., 2008	ROBINS-I	Serious Risk
Patron et al., 2020	ROB 2	High Risk
Putri et al., 2022	ROBINS-I	Low Risk
Woodberry et al., 2020	ROBINS-I	Moderate Risk

CHAPTER 4: METHODOLOGY

Biofeedback can be used to alleviate symptoms of chronic disease, manage stress, optimize performance, and promote healthy physical functioning (Frank et al., 2010). Although biofeedback interventions are growing in popularity, the research regarding biofeedback is limited in scope in a crucial way. Biofeedback interventions are mostly studied as individual interventions (Frank et al., 2010; Schwartz et al., 2016). Unfortunately, the research on social support and relational interventions within biofeedback is underdeveloped and more exploration is needed regarding its potential applications. The biopsychosocial-spiritual (BPSS) health framework (Engel, 1977; Wright et al., 1996) posits that health should be viewed holistically and psychological, biological, social, and spiritual dimensions of health are all interconnected. The social dimension is a crucial piece in BPSS health that must be assessed and considered when developing health interventions. Furthermore, biofeedback practitioners may not be fully utilizing the social resources individuals possess that can provide encouragement, logistic support, and motivate change. Social support is a key component in psychophysiological regulation and, thus, should be incorporated into biofeedback interventions (Cohen & Wills, 1985; Konvalinka et al., 2023; Palumbo et al., 2017).

It is well-established that autonomic physiological processes impact and are impacted by social interactions (Kleinbub, 2017; Palumbo et al., 2017). Research has found that couples demonstrate physiological synchrony in respiration, skin conductance, and cardiac activity (Palumbo et al., 2017). Couples demonstrated synchrony in heart rate and respiration when connected through eye contact, touch, and even when sitting relaxed next to each other (Ferrer & Helm, 2013; Helm et al., 2012; McAssey et al., 2013). Therefore, it follows that incorporating social support into biofeedback interventions may have an impact on patients' physiology.

For the purpose of this paper, the authors define any biofeedback interventions which incorporate a relational component into the intervention as relational biofeedback. Relational biofeedback interventions apply the knowledge of interpersonal autonomic physiology to develop an active intervention that allows people to observe and exert control over their physiological processes in real-time within their relational contexts. This study specifically seeks to explore relational biofeedback with romantic partners. Of the relational biofeedback literature available, heart rate variability biofeedback (HRVB) within romantic partners has been proposed by several theoretical papers (Ehrenreich, 2018; Levit-Binnun et al., 2010). Therefore, this relational biofeedback modality may be a critical foundation in establishing efficacy and exploring applications of relational biofeedback among romantic partners. The purpose of this study is to evaluate the impact of a romantic partners' presence on outcomes during HRVB training.

Research Question and Hypotheses

Our aim is to establish whether partner presence impacts the participant experience and ability to increase heart rate variability (HRV). Additionally, we are interested in whether relationship satisfaction and participant perceived biopsychosocial-spiritual health moderates the relationship between partner presence and training outcomes. To that end, the following research questions were developed.

RQ1. Does the presence of a romantic partner affect the participant's qualitatively reported experience during HRVB training?

RQ2. Does the presence of a romantic partner impact the participant's ability to increase HRV through biofeedback training?

RQ3. Does perceived BPSS health moderate the relationship between partner presence and the ability to increase HRV?

RQ4. Does relationship satisfaction moderate the relationship between partner presence and the ability to increase HRV?

Using the current literature on interpersonal physiology and relational biofeedback, the following hypotheses were generated.

H1. The presence of a romantic partner will enhance the participant experience with biofeedback. Participating in an intervention and interacting with a clinician can evoke a stress response (Borgeat et al., 1984; Shaffer, 2020). Having a support person present may help attenuate the stress experienced within the unfamiliar environment. Furthermore, the partner is able to provide encouragement during the training.

H2. The presence of a romantic partner will enhance the participant's ability to increase HRV. People regulate physiologically through their relationships (Ferrer & Helm, 2013; Pietromonaco & Collins, 2017). Romantic partners may co-regulate and display synchrony in physiological processes. Specifically, contact with a romantic partner has been shown to synchronize cardiac activity and decrease physiological activation (Marzoratti & Evans, 2022; Palumbo et al., 2017). Having the romantic partner present will provide the participant with another resource to improve ANS regulation and, as a result, increase HRV.

H3. The relationship between partner presence and HRVB outcomes will be weaker for participants with poor self-perceived or partner-perceived BPSS health as measured by the Patient Health Index. Participants with poorer perceived BPSS health (Engel, 1977; Wright et al., 1996) may possess fewer resources that are helpful in increasing HRV and making overall health change, including biological (e.g., health behaviors, healthy cardiac activity), psychological (e.g., stress tolerance, self-efficacy), social (e.g., positive social connections, secure relationships), and spiritual (e.g., mindfulness, acceptance) resources.

H4. The relationship between partner presence and HRVB outcomes will be stronger for participants with higher levels of self-reported or partner-reported relationship satisfaction. Previous research has found that relationship satisfaction impacts physiological synchrony between partners (Chen et al., 2021; Helm et al., 2012; Levenson & Gottman, 1985; Thomsen & Gilbert, 1998). Furthermore, the social support serves as a buffer to stress when it is perceived as a positive relationship (Cohen & Wills, 1985; Pietromonaco & Collins, 2017; Uchino et al., 2012). Therefore, higher relationship satisfaction would indicate the partner is more likely to serve as a resource for the participant rather than an additional stressor, which would interfere with the participant's ability to regulate and increase HRV.

Study Design

To test the previously stated hypotheses, a between-subjects, mixed-methods study was conducted. This study utilizes an explanatory sequential design that collects quantitative data, followed by qualitative data to provide context and capture the participants' experience. Data was collected using questionnaires with Likert-type scales, a semi-structured interview, and physiological data. The study aimed to collect both the objective and subjective experience of participants undergoing a biofeedback intervention.

Participants

The target sample size was determined through consultation between researchers regarding feasibility and funding, as well as the exploratory nature of the study which will result in both quantitative and qualitative data. The researchers also considered the number of interviews to aim for to reach a point of saturation in the qualitative data. The target sample size was collectively determined to be 20 couples (40 total individuals) in romantic relationships. Inclusion criteria included (a) ability to attend a biofeedback session in-person, (b) currently in a romantic relationship with each other, (c) 18 years of age or older, and (d) both partners are able to read, write, and speak English fluently. Participants were excluded from analysis if they had any artificial cardiac devices (i.e., pacemaker) that may interfere with their ability or safety when performing an HRV intervention.

Procedure

The study received approval from the Institutional Review Board of East Carolina University prior to data collection (Appendix A). Participants were recruited through flyers posted in public spaces (e.g., libraries, coffee shops, classrooms) and through social media (e.g., Facebook, Instagram). Additionally, the principal investigator (PI) reached out to local institutions which provide services for couples (e.g., relational counseling, support groups). Moreover, participants were solicited through classroom instruction by various university instructors. A snowball sampling procedure was used (Creswell & Creswell, 2022). A brief description of the study was provided with contact information to express interest in the study. A graduate assistant followed up by phone to provide additional information about the study, complete a pre-screener (Appendix B), and set up a time for the couple to attend the session. At this time, one partner was randomly assigned as the primary participant (PP) who will complete the biofeedback session. The other partner was designated as the support person (SP) and did not have biofeedback data collected. The PI used a random number generator to assign the participant role. To compensate the couple for their time participating in the study, participants each received a $10 gift card.

Couples were also randomly assigned to either the partner present or partner absent condition using a random number generator. To begin the scheduled session, the PI orally reviewed the informed consent document with both partners. The partners had an opportunity to ask questions and then sign the informed consent document. Paper copies of the informed consent documents were kept in locked cabinets in the office of a member of the research team. Access to these documents were limited to members of the research team. The informed consent documents were not be connected with the data collected. Both partners then completed demographic questionnaires, assessments of relationship satisfaction, and BPSS health measures. Questionnaires were completed electronically through REDCap (Harris et al., 2019) on an iPad provided to the participants. REDCap is a secure, web-based platform that is compliant with the U.S. Health Insurance Portability and Accountability Act of 1996 (HIPAA; Harris et al., 2019). Thus, it is an ideal platform to collect and store participants' responses. To further protect participant health information, questionnaires were de-identified and assigned a couple number.

At this time, the partner designated as the PP was hooked up to the Body Health Analyzer (Binacor, 2019) instrumentation to monitor HRV. For couples in condition 1, both partners were present during the biofeedback intervention. The SP was informed of their role as a support for the PP and invited to touch, encourage, and/or coach the PP to their level of comfort. For couples in condition 2, the SP was asked to wait in a separate room while the PP participated in biofeedback. The biofeedback intervention is a non-intrusive, safe, and painless intervention (Frank et al., 2010; Shaffer, 2020). However, the PI provided a list of local medical and mental resources to participants in case they experienced discomfort during the intervention.

For both conditions, the PP participated in an intervention using the Body Health Analyzer breathwork training (Binacor, 2019). This is a common HRVB technique that teaches participants resonance breathing, which involves breathing at a slow pace (usually 4-7 breathes per minutes) to maximize RSA (Shaffer & Ginsberg, 2017; Yasuma & Hayano, 2004). RSA increases when heart and respiration rates are synchronized and is an indicator of healthy heart functioning. Breathing at resonance frequency increases HRV, improves mood, and decreases stress (Chaitanya et al., 2022). First, HRV was monitored during a five-minute baseline task in which the PP sat normally while their HRV is measured. Then, the training protocol facilitated by the PI used visual feedback to coach the PP to pace breathing to maximize RSA. Following the intervention, the PP completed a five-minute practice period during used the newly acquired skills to increase HRV. After completion of the biofeedback intervention, both partners completed a semi-structured interview with the PI about the experience (Appendix C). Participants' answers were audio recorded with an iPad designated for research purposes. The audio files were de-identified, transcribed, and deleted.

Measures

The measures utilized in this study captured both quantitative and qualitative data. Participants were asked to complete self-report measures to assess the following: (a) demographics, (b) relationship satisfaction, and (c) BPSS health. Additionally, physiological data was collected from the PP on HRV. Finally, participants participated in a semi-structured interview to gather qualitative data regarding the participant experience.

Demographic Questionnaire

We collected the following demographic information via survey: age, race/ethnicity, average household income, highest level of education, sexual orientation, gender, length of time in current relationship, relationship status (i.e., committed relationship- not cohabitating, committed relationship- cohabitating, married, separated/divorced, other), and number of children. Additionally, this questionnaire assessed whether the PP experiences chronic medical (e.g., hypertension, cardiovascular disease) and mental (e.g., anxiety disorder, depressive disorder) health conditions, takes antihypertensive medications, or uses artificial cardiac devices (i.e., pacemaker).

Relationship Satisfaction

Relationship satisfaction was measured using the Couples Satisfaction Index (CSI-32; Appendix D; Funk & Rogge, 2007). The questionnaire is made up of thirty-two items that participants rate on a Likert scale. Some items are reverse coded so that higher scores indicate higher levels of satisfaction in the relationship. Scores range from 0-161 with the cutoff score indicating distress within the couple being 104.5. The CSI-32 possesses suitable construct validity and convergent validity with other measures of relationship satisfaction (Atkins & Baucom, 2016; Funk & Rogge, 2007). Furthermore, the measure can be applied to various types of couples (e.g., dating, married; Atkins & Baucom, 2016). Chronbach's alpha of reliability was originally found to be .98, indicating excellent reliability (Funk & Rogge, 2007). A later meta-analysis found the Chronbach's alpha to be .94 (Graham et al., 2011). The CSI-32 is a highly validated and reliable measure of satisfaction within a relationship.

Biopsychosocial-spiritual Health

BPSS health was measured using an adaptation of the Patient Health Index (PHI; Appendix D; Office of Patient Centered Care and Cultural Transformation, 2019). The PHI was developed by the Office of Patient Centered Care and Cultural Transformation within the U.S. Department of Veterans Affairs (VA) to assess patients' current perceptions of their health. Patients complete global questions about their physical well-being, mental well-being, and day-to-day life by rating it on a scale from 1 (miserable) to 5 (great). Patients then rate themselves on a scale from 1 (low) to 5 (high) in 9 areas of self-care: Moving the Body; Recharge; Food and Drink; Personal Development; Family, Friends, and Co-Workers; Spirit and Soul; Surroundings; Power of the Mind; and Professional Care. The participants' ratings of their current perceived health in each of these areas will be aggregated to obtain an overall score. Scores range from 12 – 60, with higher scores indicating perception of better health. While the VA uses this measure as a clinical tool to assess holistic health, it is being used to assess BPSS health for this study due to its holistic nature, attention to each dimension of health, and patient-centered focus rather than disease-focused (Howe et al., 2017). To this author's knowledge, no formal assessments have been developed to directly measure BPSS health. The adapted PHI best aligns with the theoretical foundation of the BPSS framework (Engel, 1977; Wright et al., 1996) by assessing biological (e.g., moving the body, food and drink), psychological (e.g., power of the mind), social (e.g., family, friends, and co-workers), and spiritual (e.g., spirit and soul) dimensions of health.

Heart Rate Variability

The Body Health Analyzer was used for HRVB for this study (Binacor, 2019). The system included a photoplethysmograph (PPG) sensor placed on the index finger and an online interface that allows users to view visual and auditory feedback. Participants completed two five-minute periods monitoring their HRV, before and after completing a breathwork intervention. To calculate changes in HRV, the Standard Deviation of Normal-Normal interval (SDNN) was calculated in milliseconds at the pre-intervention (Time 1) and post-intervention (Time 2) period. The SDNN is a time-domain HRV measure and is considered a gold standard metric (Shaffer & Ginsberg, 2017). The metric calculates the standard deviation of the interbeat intervals between normal sinus beats. Five-minute recording periods are standard practice for short-term recordings within research (Shaffer & Ginsberg, 2017). The change in the SDNN from pre-intervention to post-intervention was calculated (Time 2 – Time 1). Higher difference scores indicate participants demonstrated greater HRV after the intervention, indicating better psychophysiological functioning.

Participant Experience

To explore the participants' experience with either individual or relational biofeedback, a semi-structured interview was conducted by the PI. Semi-structured interviews involve using standard prompts for all participants, but allowing participants to elaborate through the use of additional open-ended questions (Creswell & Creswell, 2022; Creswell & Poth, 2018). Interview questions are provided in Appendix C.

Data Analysis Plan

To test the first of the previously stated hypotheses, a qualitative descriptive research design was used. Qualitative descriptive research is a common method of qualitative research in healthcare (Doyle et al., 2020). It is used to explore straightforward descriptions of experiences, particularly when little is known about the topic (Doyle et al., 2020; Kim et al., 2017). Due to the focus on the participant experience and the early, exploratory nature of this study to better understand relational biofeedback, qualitative descriptive research is appropriate.

Prior to analysis, participants' answers to the semi-structured interview questions were audio recorded, transcribed, and de-identified. Thematic analysis is one of the most common data analysis techniques in qualitative descriptive research (Doyle et al., 2020). The thematic analysis procedure was guided by the six-step guidelines developed by Kiger and Varpio (2020). These steps involved (1) coders becoming familiar with the data, (2) developing initial codes, (3) identifying themes, (4) reviewing themes, (5) defining and naming themes, and (6) reporting results. The PI and a graduate assistant independently reviewed and coded the transcripts. Throughout the process, the PI and graduate assistant engaged in reflexivity discussions together. Reflexivity is crucial to exploring how biases, values, and backgrounds may influence the interpretation of data (Creswell & Creswell, 2022; Creswell & Poth, 2018). The PI and graduate assistant kept journals documenting their thoughts and reactions during the interview and analysis. They also engaged in ongoing discussions around bias and researcher subjectivity. For example, both coders were White females in graduate programs. They discussed how to minimize bias in their interpretation of the data based on their social identities and experience within their own relationships.

Codes were developed inductively from the data. The codes were then reviewed and collapsed into themes. The PI and graduate assistant then met to agree upon, define, and name themes. When discrepancies arose, the PI and graduate assistant reached a consensus through consultation with each other. A third party was available to resolve discrepancies if the PI and graduate assistant were unable to reach an agreement. This third party served as the advisor for the project and a member of the research team.

To test the remaining hypotheses, linear regression models were used. Calculations were completed using R statistical software (R Core Team, 2023). Prior to regression analysis, univariate descriptive statistics and bivariate correlations were examined. Additionally, t-tests and chi-square analyses were used to analyze whether there are significant differences between the groups based on demographic variables. If so, the demographic variables were controlled for in the regression models. The group condition (i.e., partner presence, partner absence) acted as the predictor variable and the change in the SDNN of HRV from pre-intervention to post-intervention (Time 2 – Time 1) served as a dependent variable. The total score on the PP CSI-32, SP CSI-32, PP PHI, and SP PHI were included as moderator variables in the models. Moderation is present when the relationship between the independent and dependent variable changes at different levels of the moderator variable (Memon et al., 2019). For example, previous research has established that physiological synchrony was either beneficial or detrimental to an individual's physical and mental health depending on relationship quality and satisfaction (Chen et al., 2021; Helm et al., 2014; Levenson & Gottman, 1985; Thomsen & Gilbert, 1998). Therefore, we will test to determine if the relationship between partner presence or absence and ability to increase HRV changes based on the self-reported relationship satisfaction of both partners (PP CSI-32, SP CSI-32).

In the following chapter, the results of this study will be reported and discussed. Additionally, the strengths and limitations of the proposed study will be evaluated. Finally, the authors will discuss the importance of both the quantitative and qualitative findings, as well as how they can be applied for researchers and clinicians interested in relational biofeedback.

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CHAPTER 5: THE IMPACT OF A ROMANTIC PARTNER ON A PATIENT'S EXPERIENCE OF HEART RATE VARIABILITY BIOFEEDBACK

Introduction

With rising rates of chronic disease (Ansah & Chiu, 2022), there is a growing need for effective clinical practices to treat health conditions and alleviate symptoms. Biofeedback is one such clinical practice. Biofeedback is an umbrella term that includes a variety of modalities including electromyography, electrodermal activity, cardiovascular, and respiration biofeedback (Frank et al., 2010). The commonality between all biofeedback interventions is the use of physiological monitoring to provide real-time feedback to promote improved self-regulation and increase control over physiological responses. Biofeedback interventions can target many physiological processes, such as respiration, cardiovascular activity, muscle tension, brain activity, sweat gland activity, and temperature (McKee, 2008; Schwartz et al., 2016). These practices have been found to be effective in improving symptomology of over 30 physical and mental health conditions (McKee, 2008; Tan et al., 2016). It may also be used for general stress management and to optimize physical performance (Frank et al., 2010). The versatility of biofeedback interventions makes it a useful practice in a variety of healthcare systems and in the clinical work of various healthcare professionals.

Biofeedback continues to grow in popularity in several disciplines, such as rehabilitation sciences, medicine, nursing, and mental health (Frank et al., 2010; McKee, 2008). Clinicians and researchers continue to explore how to most effectively implement biofeedback interventions to facilitate long-term change and the alleviation of symptoms in their clientele (McKee, 2008; Schwartz et al., 2016; Shaffer, 2020). The purpose of this study is to investigate whether a crucial addition in clinical protocol may influence the outcomes of a biofeedback intervention to determine whether it is a beneficial practice to incorporate into future clinical work.

To date, most biofeedback interventions have been individual and research typically focuses primarily on biofeedback interventions' impact on individual physiology (Frank et al., 2010; Schwartz et al., 2016). However, individual interventions may not capture a critical part of the patients' experience. Individuals seldom operate in isolation as they exist within a variety of micro and macro social networks (Bronfenbrenner, 1979). Prior research has established that social interactions have an impact on self-regulation, stress management, and autonomic physiology, which are key concepts within biofeedback (Kleinbub, 2017; Palumbo et al., 2017). Consequently, utilizing social support as a resource within biofeedback, a practice which the present researchers are terming "relational biofeedback", may be an impactful addition to the typical clinical processes.

Relational Biofeedback

The present researchers define relational biofeedback as any biofeedback intervention that leverages relational dynamics as a resource within clinical biofeedback practices to assist the patient in making the desired change. It is meant to be a broad term that envelops many opportunities for relational dynamics and social support to be incorporated into the intervention. Prior studies have theorized about types of relational biofeedback techniques that may be useful, although terminology is inconsistent. Kassel and LeMay (2015) present a growing body of research regarding how interpersonal biofeedback (i.e., two romantic partners simultaneously receive feedback) may be used to aid in couples' therapeutic treatment. This builds upon the work of Levenson and Gottman (1983, 1985) who examined the use of biofeedback in couple's therapy can help couples identify their partner's physiological arousal and respond to each other in more compassionate ways. Similarly, dyadic biofeedback has been proposed, although empirical support has not been established (Levit-Binnun et al., 2010). However, it is not always possible, realistic, nor helpful for multiple parties to be monitored and receive feedback simultaneously, especially if the intervention is targeting a particular health condition of an individual. This does not suggest that relational biofeedback cannot occur or that it is not beneficial to utilize the individual's social support system. The mere presence of another person may also have an impact on an individual participating in biofeedback (Ehrenreich, 2018; Gottman & Gottman, 2008; Kassel & LeMay, 2015).

Positively perceived social support has been found to buffer the experience of stress (Pietromonaco & Collins, 2017). Biofeedback interventions often target the stress response and assist patients in down-regulating their sympathetic nervous system (stress response) activity and up-regulating their parasympathetic nervous system (relaxation response) activity (Frank et al., 2010; Shaffer, 2020). Using social support persons to help an individual learn how to regulate their stress response may be a beneficial practice. Additionally, research in the field of interpersonal autonomic physiology has also found that individuals respond physiologically within relationships. Social interactions can influence an individual's cardiovascular, immune, and neuroendocrine systems (Kleinbub, 2017; Palumbo et al., 2017). For example, researchers have discovered synchrony in heart rate and respiration between romantic partners when connected through eye contact, touch, or physical proximity (Ferrer & Helm, 2013; Helm et al., 2012; McAssey et al., 2013). To note, the influence between social support and physiological processes can be either positive or negative based on the quality of the relationship and perception of support (Coutinho et al., 2017; Heaphy & Dutton, 2008).

Based on the patient's presenting problem, clinical goals, or available resources, there are a variety of ways in which biofeedback clinicians may choose to practice relational biofeedback. For example, Ehrenreich (2018) suggested the use of skin conductance and heart rate biofeedback with dyads. Kassel and LeMay (2015) also advocated for the use of neurofeedback in couple's therapy. However, it is beyond the scope of this paper to investigate how social support may be incorporated into all biofeedback modalities. See Chapter 3 for a systematic review of relational biofeedback interventions to better understand the various ways relational units have been incorporated into biofeedback. For this purposes of this study, the researchers will focus on a commonly utilized and evidence-based biofeedback modality – heart rate variability biofeedback (HRVB).

Heart Rate Variability Biofeedback

HRVB targets heart rate variability (HRV), which is a marker of autonomic nervous system functioning (Lehrer, 2013). HRV measures the minute changes in times between successive heartbeats. High variation in time between heartbeats indicates healthier functioning and a nervous system that is able to adapt to the demands of the environment. Conversely, lower HRV indicates the autonomic nervous system is out of balance and is associated with a greater risk of physical dysfunction and mental distress (Gibbons, 2019; Lehrer, 2013). HRVB uses exercises to assist patients in learning how to increase their HRV. Beneficial results have been found even after one session (Lin et al., 2019; Prinsloo et al., 2013). One commonly utilized exercise with HRVB is that of teaching the patient to breathe at resonance frequency (Yasuma & Hayano, 2004). Resonance frequency (typically around 4-7 breathes per minute) is conducive to optimal cardiovascular functioning and maximizes HRV. Respiration and cardiovascular activity are linked. Thus, by regulating breathing rates, the patient can improve cardiovascular functioning and increase HRV (Lehrer, 2013; Yasuma & Hayano, 2004).

HRVB was chosen for this study given that it is a well-established modality for a variety of medical and mental health conditions, as well as for general stress management (Chaitanya et al., 2022; Fournié et al., 2021). Thus, it can be used widely with a diverse group of people, including a healthy, non-clinical sample. Furthermore, previous research has found synchrony in cardiac activity among couples (Ferrer & Helm, 2013; Helm et al., 2012; McAssey et al., 2013). Since couples are the targeted population for this study, it is appropriate to use a modality that has evidence to support that the physiological processes may be impacted by the relationship.

Biopsychosocial-Spiritual Framework

Not only is this study guided by prior research, it is also grounded in the biopsychosocial-spiritual (BPSS) framework (Engel, 1977; Wright et al., 1996). The BPSS framework emerged from the biopsychosocial model proposed by Engel (1977) to better understand how biological (i.e., organ systems, biochemical processes), psychological (e.g., cognitions, emotions, personality, behaviors), and social (e.g., support system, cultural identity) aspects of a person's experience are inextricably linked. Each dimension mutually influences the others to impact overall health and well-being. Wright and colleagues (1996) later incorporated the spiritual component to better capture the how purpose, beliefs, morals, and meaning play into holistic health. When accounting for the BPSS framework, it becomes clear that it is not enough to teach a biofeedback patient to make changes to their physiology (biological health), give them skills to manage stress (psychological health), or facilitate meditation and/or mindfulness practices (spiritual health) to promote physiological regulation. Despite accounting for each of these critical domains of health, biofeedback clinicians often fail to address a crucial dimension of their patient's experience – social health. Without attending to this dimension, a clinician risks neglecting a potentially invaluable health resource (Cohen & Wills, 1985; Uchino et al., 2018). Additionally, they may jeopardize the generalization of skills to real-world contexts by ignoring how social interactions impact a patient physiologically outside of clinical settings. For this reason, a research study was conducted to evaluate the influence of incorporating a support person, particularly a romantic partner, into a biofeedback intervention.

Method

A mixed-methods study was developed to explore how the presence or absence of a romantic partner may impact a patient's experience with biofeedback. To that end, the following research questions guided the study: (a) Does the presence of a romantic partner influence the participant's qualitatively reported experience during HRVB training? (b) Does the presence of a romantic partner impact the participant's ability to increase HRV through biofeedback training? (c) Does perceived BPSS health moderate the relationship between partner presence and the ability to increase HRV? (d) Does relationship satisfaction moderate the relationship between partner presence and the ability to increase HRV?

Through review of previous literature (Chen et al., 2021; Ferrer & Helm, 2013; Palumbo et al., 2017; Pietromonaco & Collins, 2017), the following hypotheses were generated: (a) the presence of a romantic partner will enhance the participant experience with biofeedback; (b) the presence of a romantic partner will enhance the participant's ability to increase HRV; (c) the relationship between partner presence and HRVB outcomes will be weaker for participants with poor self-perceived or partner-perceived BPSS health; (d) the relationship between partner presence and HRVB outcomes will be stronger for participants with higher levels of self-reported or partner-reported relationship satisfaction.

Procedures

All study procedures were approved by the university Institutional Review Board. Participants were recruited through flyers posted in public spaces and distributed electronically (Appendix F). Emails were sent to facilities providing services to couples (i.e., family therapy clinics) requesting they share information about the study. University instructors also shared information about the study with their students. Once someone expressed interest in the study, a graduate assistant contacted them to screen for eligibility and schedule a time for the couple to participate.

The study began with the PI, a Board Certified Biofeedback clinician (BCB; first author), reviewing informed consent documents with both partners. The couple then completed electronic questionnaires separately to gather demographic information and assess for relationship satisfaction and health status via a RedCap (Harris et al., 2019) survey.

Couples were randomly assigned to either the “present” or “absent” condition. In the present condition, the partners were together throughout the intervention. In the absent condition, the partners were separated from each other during the biofeedback intervention. One partner from each couple was designated as the primary participant (PP), who participated in the biofeedback intervention. The other partner was designated as the support person (SP). A random number generator was used to randomly assign each partner to a role and assign each couple to one of the two conditions prior to their participation.

In both conditions, a photoplethysmography (PPG) was placed on the PPs’ index finger. The PP sat quietly for a 5-minute baseline period. Using biofeedback literature from Lehrer (2013; 2020), the PI then educated the PP on HRV and its connection to physical and mental health. The PI explained that the purpose of the breathing intervention is to assist in increasing heart rate variability, which is optimal for health and well-being (Lehrer, 2013). The PI coached the PP on proper breathing technique as needed. The PP then practiced breathing at resonance frequency by following a pacer and receiving visual feedback on their heart rate. The pacer provided visual prompts to the patient to inhale or exhale at a set pace. The PP completed a minimum of two rounds of breathing practice, with the option for additional practice until the PP reported they felt comfortable with the breathing exercise. The PP finished the biofeedback session with a 5-minute period during which they were encouraged to use the breathing technique without the pacer in order to demonstrate their ability to regulate breathing and improve HRV.

For couples in the present condition, the SP was present in the room with the PP during the biofeedback session. However, the SP was not connected to the biofeedback software and served solely as a support for the PP. The SP was instructed to support the PP in any way they deemed appropriate as their partner was learning and practicing this new breathing technique. Some SPs offered physical touch (e.g., rubbing their back, holding hands), verbal encouragement, or advice. Some SPs chose not to interact with PPs and sat quietly next to them. One SP chose to practice the breathing technique with the PP and help the PP pace their breathing. The PI did not direct the SPs' interaction with the PP in order to encourage comfortable and authentic interactions between the partners. For couples in the absent condition, the PP participated in the same biofeedback session, but without the SP. The SP was escorted to another room in the research lab, where they could not see or hear the PP's study activities.

The study concluded with a recorded, semi-structured interview regarding the couple's experience during the biofeedback session and their beliefs regarding whether the presence or absence of a partner impacts this experience. The couple had the opportunity to ask questions regarding their participation in the study and each participant was provided with a $10 gift card as compensation for their participation.

Measures

Demographic information was gathered on individual and relational characteristics, including age, sexual orientation, gender, race, relationship status, length of relationship, number of children, highest degree of education, and income. Participants also answered open-ended questions regarding diagnosed physical and mental health conditions and medications. Certain health conditions and medications could impact cardiac activity (Lehrer, 2013; Shaffer, 2020) and, thus, merited review prior to interpreting the participants' HRV performance.

To assess for relationship satisfaction, both partners completed the Couples Satisfaction Index (CSI-32), a 32-item measure with higher scores indicating greater relationship satisfaction (Funk & Rogge, 2007). Partners were asked to use a 6-point Likert scale to rate items describing their relationship (e.g., "Our relationship is strong," "I feel a strong connection to my partner"), their agreement with their partner on key concepts (e.g., "amount of time spent together," "making major decisions"), and how they would generally describe their relationship (e.g., bad vs. good, lonely vs. friendly). Select items were reverse-scored. The potential sum of the items ranged from 0-161, with higher scores indicating greater satisfaction. The scale demonstrated strong reliability with this sample ($\alpha = .94$).

To assess for BPSS health, both partners completed an adapted version of the Personal Health Inventory (PHI; Office of Patient Centered Care and Cultural Transformation, 2019) in relation to the primary participants' health. Both the PP's self-reported BPSS health and the partner-reported BPSS health were included as variables and measured using the adapted version of the PHI. The adapted PHI is a 12-item, self-report measure with higher scores indicating better perceived health. Participants used a 5-point Likert scale to rate physical well-being, mental/emotional well-being, and day to day life, with 1 indicating "miserable" and 5 indicating "great." The remaining questions had the participants rate the primary participant on several areas of self-care (e.g., spirit and soul, moving the body, professional care) from 1 "low" to 5 "high." The scale demonstrated acceptable reliability for self-reported BPSS health (α = .67) and partner-reported BPSS health (α = .72). The entire self-report survey consisted of 106 total items. See Appendix D for the full participant survey.

To measure heart rate variability changes in HRV, participants were monitored during 5-minute periods before and after a breathing intervention using the Body Health Analyzer software (Binacor, 2019). The standard deviation of normal to normal rhythms (SDNN) was calculated from the pre- and post-intervention periods. The SDNN is a gold metric measurement for HRV and measures the average variation between normal sinus rhythms in milliseconds (Shaffer & Ginsberg, 2017). The difference between the SDNN in the pre- and post-intervention periods was calculated to measure change in performance. Higher positive numbers indicate more improvement in HRV. Negative number indicate poorer HRV outcomes following the breathing intervention.

Finally, the participants' experience was assessed using a semi-structured qualitative interview. Participants were asked questions about their experience with biofeedback, their experience with being together or separated during the biofeedback session, and their opinions about the benefits or drawbacks of having a support person present. See Appendix D for the interview questions.

Participants

The sample consisted of 12 couples who met the following inclusion criteria: (a) 18 years of age or older, (b) able to read, write, and speak in English, (c) currently in a romantic relationship with each other, and (d) able to attend an in-person appointment. Participants were excluded if they had any artificial cardiac devices (i.e., pacemaker). Despite recruitment attempts to assess diverse participants and relationships, all couples were in heterosexual relationships and identified as monogamous. The partners primarily identified their sexual orientation as heterosexual (79.17%), with 12.5% identifying as bisexual and 8.33% as pansexual. The average length of relationship was 4.26 (*SD* = 5.27) years and 2 of the couples had children together. Most couples were dating but not cohabitating (45.83%), 37.5% were dating and cohabitating, and 16.67% were married. The average household income was $70,478.26 (*SD* = $50,528.9).

Of the PPs, 75% identified as White or Caucasian and 25% identified as Black or African American. The average age of PPs was 23.5 (*SD* = 6.22) years old. Half identified as male, 41.67% as female, and 8.33% as non-binary. See Tables 1-2 for a summary of sample demographics. Of the mental health conditions listed, anxiety was the most common and present in 30% of the PPs, followed by depression present in 25%. Two of the PPs reported respiratory conditions, such as asthma. No PPs reported cardiovascular conditions, taking anti-hypertensive medications, or having an artificial cardiac device (e.g., pacemaker). One PP had previous experience with biofeedback.

Data Analysis

To answer the first research question, qualitative data was gathered through semi-structured interviews. Interviews were transcribed and de-identified prior to analysis. The researchers used thematic analysis (Doyle et al., 2020) using the guidelines of Kiger and Varpio (2020). The PI and a graduate assistant independently coded the data. The data reached a point of saturation in that no new codes were identified in the final interviews. The PI and graduate assistant collectively reviewed the codes to collapse into themes. Once themes were named and defined, the data was coded a final time using the mutually agreed upon themes. While the sample size was limited, the data reached a point of saturation as evidenced by repeating themes and no new themes introduced by the final participants. See the results section for a thorough description of the qualitative themes.

A linear regression analysis was used to answer the remaining three research questions using self-report survey data. The data was cleaned and analyzed using R statistical software (R Core Team, 2023). Items on the CSI-32 and PHI were summed to create composite scores. Data was also screened for missingness and normality prior to analysis. No significant skew or kurtosis was detected. Missing survey data was present in 4 cases and was managed using mean substitution, which is an appropriate method to manage low-levels of missing item data (Fox-Wasylyshyn & El-Masri, 2005). Two moderator variables (primary participant reported relationship satisfaction and support person reported relationship satisfaction) were found to have a low outlier. The outliers were within two standard deviations of the mean and determined to be appropriate representations of the participant experiences. As they were true outliers and only present in one case each, the research team decided to retain said outliers in the analyses. The outliers were truncated using the next lowest value in the variable (Osborne & Overbay, 2014). Demographic variables were analyzed to determine if there were significant differences between participants in the two conditions based on age, income, gender, sexual orientation, race, relationship status, or length of relationship using *t*-tests for continuous variables and chi-square analyses for categorical variables (Howell, 2013). No significant differences were found, indicating they did not need to be controlled in the models.

Prior to regression analyses, correlations were analyzed between the continuous moderator variables and difference in HRV SDNN. Linear regression models were created with the difference in HRV SDNN being regressed on the condition of partner presence vs. absence. Interaction terms were then added to explore whether the total scores on the CSI-32 and PHI for both the PP and SP had a moderating effect on this relationship. Results of these models are discussed below.

Results

Of the 18 people who expressed interest in the study, 12 met the inclusion criteria and proceeded to participate. Of the 12 couples that participated, 6 were randomly assigned to the present condition and 6 were assigned to the absent condition. The following qualitative, descriptive, and inferential analyses should be interpreted in relation to each other to better understand the participant experience and obtain a thorough picture of the influence a support person may have during a biofeedback intervention.

Partner Presence and Participant Experience

To answer the first research question, a semi-structured interview was conducted with each couple about their experience with the biofeedback intervention and their opinion about the benefits and disadvantages of having a partner present during a biofeedback intervention. Couples in both conditions were more likely to use positive words (i.e., “relaxing,” “enjoyable”) to describe their experience than negative words (i.e., “stressful). Couples in both conditions endorsed more codes related to the benefits of having a partner present than the disadvantages. Both the benefits and disadvantages of having a partner present, as identified by the participating couples, are detailed below. See Table 3 for a list of themes and definitions.

Benefits

All couples were able to identify some benefits of having a partner present. However, the partners who were actually together during the intervention described advantages more frequently. The participants reflected on how their partner had a positive influence on their comfort, enjoyment, and ability to perform during the biofeedback intervention.

Security. Interestingly, all couples stated that having a partner present during the intervention provided a sense of security or safety. This was especially important considering the novelty of the intervention. To note, participants were in a new environment with a clinician they had just met and were completing a task with which they were unfamiliar. A sense of security may play a crucial role in helping individuals effectively engage with the biofeedback intervention and be able to regulate stress.

Couples in the present condition recognized the security that came with having their partner present. One couple discussed how the experience would be uncomfortable if they had not been together. “But if you just realize that you’re safe and someone’s here with you, and you are not with a complete stranger, then it’s fine” (Couple 10). For partners that were separated during the intervention, they also acknowledged how it would have been more comforting to have their partner with them rather than in a separate room. “I mean, just knowing that someone is there for, especially in a new area, makes it more comfortable, um, especially for an anxious person like me” (Couple 3).

Assistance. Seven couples discussed how a partner may provide assistance to someone completing a biofeedback intervention. Some couples recognized that a partner’s presence may assist the person in completing the breathing intervention task and regulating stress to increase HRV. One partner described how they tried to help the other during the breathing intervention.

"…you started like uh speeding up so I was trying to slow you back down" (Couple 4). Their partner found this to be helpful to pace their breathing. Another participant, whose partner was absent during the intervention, described how it may have been different if they were together. "I think I would have been able to take deeper breaths. I think it would have just been, like, more grounding" (Couple 9). Other couples reported the support provided by the partner (i.e., physical touch, encouragement) can be helpful in completing the exercise.

Enjoyment. Four couples described how being together makes the experience more fun or enjoyable. The couples described the sense of enjoyment was increased by simply having someone with whom to share the experience. When elaborating on why the partner's presence makes it more enjoyable, Couple 3 simply, but impactfully, replied "…we both just like each other's company."

Providing Context. A final benefit of having a partner present was reported by 3 couples. These couples believed that having a partner present provides more information to the clinician about someone's health and lifestyle. Having multiple perspectives may be beneficial for a clinician to better understand the individual's real-world experience and how to use biofeedback interventions most effectively to create long-term change. One couple described how having a partner present is also more reflective of real life outside of clinical settings. "And also, I'm with her all the time, so it's more realistic, because in the real world, I'm not just with a stranger, I'm with her all the time, so it's more of what you see in everyday life" (Couple 6).

Disadvantages

While the participants primarily discussed benefits of having a partner present during a biofeedback intervention, all couples also identified at least one disadvantage. The participants recognized how a partner being present may make it more difficult to engage in the intervention, or to do so authentically. Couples in each condition identified disadvantages at equal rates.

Distraction. The most commonly identified disadvantage was distraction. Eight couples expressed concern that the partner could serve as a distraction to the person trying to complete the intervention. This could occur in a variety of ways, such as through discussions, laughing together, or making the individual think about their partner rather than focus on the intervention. When asked about potential drawbacks of having a partner present, the primary participant of Couple 4 immediately stated to their partner, "You were making me laugh!" Similarly, Couple 5 described how their partner may make it more challenging to pace their breathing during HRVB. “Um, if I looked over or if I laughed or something, it would throw my breathing off.”

Self-Presentation. Another disadvantage identified was self-presentation, meaning the participants felt that a partner observing the intervention may put additional pressure on the participant. The individual may try to impress their partner and, as a result, be less honest with themselves and the clinician about their ability to perform the exercise. Six couples endorsed this theme. One couple in the present condition stated that it had not been a concern for them, but they expected other couples may find it a challenge. “…but I can see how it can be like kind of like more pressure, like people watching you while you’re doing it” (Couple 8).

Distressing Presence. Finally, one couple recognized that partners may not always be supportive. This could be due to the partner’s unwillingness or inability to provide support in a way that was helpful to the individual completing the intervention. This could create additional distress for the individual because the absence of support is more keenly felt. This was endorsed by a couple in the present condition in which the primary participant felt the support person was too quiet during the intervention and did not provide appropriate encouragement.

Partner Presence and Heart Rate Variability

The average change in the SDNN of HRV for all primary participants was 28.77 milliseconds. This indicates that, on average, HRV increased following the breathing intervention. This is consistent with previous literature demonstrating that breathing at resonance frequency increases HRV (Shaffer & Ginsberg, 2017), which is the goal of HRVB and signifies healthier cardiac functioning (Lehrer, 2013). See Table 4 for descriptive statistics of variables. A correlation matrix was developed with the continuous variables included in the regression analysis (Table 5). The only significant correlation present was between the CSI-32 scores of the PP and SP ($r(12) = .85$, $p < .05$). Unexpectedly, the correlation between the PP and SP PHI scores was not significant ($r(12) = -.23$, $p = .47$), indicating there is no association between how a participant perceives their holistic health and how it is perceived by their partner. No moderator variables were significantly correlated with the dependent variable.

To answer the second research question, a linear regression was used to regress the difference in SDNN of HRV on the randomized condition variable (partner presence vs. absence). The model was not significant ($b = -2.36$, $SE = 16.94$, $p = .89$, *95%CI* [-40.09, 35.38]), indicating there was no significant difference in the change in HRV based on whether or not the participant's partner was present during the biofeedback intervention.

To answer the third research question, interaction terms were created (condition * CSI-32 score) to test whether participant- or partner-reported relationship satisfaction, as measured by the CSI-32, moderated the relationship between partner presence and change in HRV. Neither the participant-reported ($b = 1.65$, $SE = 2.37$, p = ..51, *95%CI* [-3.83, 7.12]) or partner-reported relationship satisfaction ($b = -.39$, $SE = 1.45$, $p = .74$, *95%CI* [-3.04, 2.26]) showed significant moderation.

To answer the fourth research question, additional interaction terms were created (condition * PHI score) to test whether participant- or partner-perceived BPSS health, as measured by the PHI, moderated the relationship between partner presence and change in HRV. Neither the participant's perception of their holistic health (b = -.01, SE = 3.98, p = .99, *95%CI* [--9.2, 9.17]) or partner's perception of the PP's holistic health (b = -.44, SE = 3.9, p = .91, *95%CI* [-9.43, 8.54]) showed significant moderation. See Table 6 for summary results of regression analyses. Non-significant quantitative findings are not surprising given the small sample size in the current study.

Discussion

The results of this study show that, while there may not have been a quantifiable change in HRV based on partner presence, there was clearly an impact on how participants experienced the intervention. The participants overwhelmingly viewed having a partner present during the HRVB intervention as more beneficial than disadvantageous. The participants used words such as "enjoyable," "fun," and "interesting" to describe having a partner present during an intervention. Although partner presence does not appear to improve physiological outcomes (i.e., having a greater increase in HRV), it also did not have a negative impact. Therefore, including a romantic partner may improve the patient experience without being detrimental to their performance. Taking into account prior studies on the impact of patient satisfaction on retention rates and clinician satisfaction and morale (Bhanu, 2010; Leebov & Scott, 1993), future research should explore how improving patient experience through the inclusion of social support persons in biofeedback interventions may impact service outcomes for biofeedback practitioners.

Another benefit that participants identified focused on an important concept for biofeedback clinicians. The participants described how incorporating a partner provides more context for the biofeedback training. Not only does having an additional person provide information give the clinician a better picture of the patients' real-world context, but it also allows the patient to practice in an environment that is more reflective of their natural environment. Generalization of skills is crucial for effective biofeedback interventions (Shaffer, 2020). While patients may learn skills in clinical settings, they are encouraged to practice at home to create lasting change. This may include the clinician providing exercises to complete at home and/or the use of portable, wearable biofeedback devices. To bridge the gap between clinic and home, a partner may bring a familiar, more natural feel to the clinic and allow the patient to practice with a familiar person. Having their partner be aware of and involved in the process may also increase likelihood of completing the assigned exercises at home.

Despite the benefits reported, it must be noted that there are potential disadvantages to having a partner present during a biofeedback intervention. As described by the participants, the partner can serve as a distraction or cause additional stress to the individual, which is counterproductive. Additionally, the researchers recognize there may be logistical challenges in include an additional person (e.g., scheduling, informed consent). These challenges are common for professionals working with multiple parties in healthcare or therapeutic settings. There are legal, ethical, and logistical considerations that practitioners must be mindful of when having more than one person in the room (American Psychological Association, n.d.). However, several of these disadvantages can be attenuated with appropriate guidance from the biofeedback clinician. Suggestions for effectively incorporating social support into biofeedback interventions are detailed in Chapter 6.

While no significant difference in change in HRV was shown between participants who had a partner present versus those who did not, these results are inconsistent with previous research. Studies in interpersonal autonomic physiology found that having a support person present typically reduces stress and improves physiological regulation (Cariolato et al., 2020; Kleinbub, 2017), both of which are a crucial part of increasing HRV (Chaitanya et al., 2022; Fournié et al., 2021). Furthermore, the participants themselves described how having their partner present either was or would have been relaxing and comforting when completing the exercise.

From the perspective of the BPSS framework (Engel, 1977; Wright et al., 1996), the presence of a social support person has an impact on other dimensions of health. The findings of this study found that the social connection did impact participants' psychological health, either positively by increasing their sense of safety and comfort or negatively by serving as a distressing presence, depending on how the support was received by the primary participant. However, the influence on the participants' biological dimension of health was not detected since no change was seen in HRV based on social connections. It was also hypothesized that participants with higher perceived BPSS health would have more psychological, social, and spiritual resources to self-regulate (Palumbo et al., 2017; Pietromonaco & Collins, 2017), which would improve their ability to uptrain HRV. Therefore, BPSS health was included as a moderator variable, but no such effect was found.

Another discrepancy in the literature relates to the influence of relationship satisfaction. As discussed previously, the relationship between perceived social support and autonomic physiology has been shown to change based on the quality of the relationship (Chen et al., 2021; Levenson & Gottman, 1983, 1985; Thomsen & Gilbert, 1998). The perception of the social support and how it is received by the individual is crucial to the effect that it has on their physiology (Heaphy & Dutton, 2008). For this reason, relationship satisfaction was explored as a moderator variable. However, the inclusion of this variable into the model did not produce significant results.

One explanation is that our population consisted primarily of younger, healthy adults. The average age of PPs was 23.5 years old. Additionally, a majority of PPs reported no major medical or mental health conditions that would impact their cardiovascular functioning (small percentage reported anxiety or asthma). Therefore, there may not have been as large of an increase following the intervention with a healthy sample than with a clinical sample. If participants started with higher HRVs, there may not have been much room for improvement. On the other hand, the average SDNN of HRV of the PPs prior to the intervention was 64.02 milliseconds. According to Shaffer and Ginsberg (2017), this is within the "compromised health" range, which is classified as neither healthy nor unhealthy. Alternatively, the inconsistent results could also be due, in part, to the limitations of the present study.

Strengths and Limitations

The study sought to explore the impact of having a romantic partner present during a HRVB intervention had on an individual's performance and experience during the intervention. While previous research has theorized about dyadic or relational biofeedback (Gottman & Gottman, 2008; Kassel & LeMay, 2015; Levit-Binnun et al., 2010; Oren et al., 2018), this is the first study that attempts to compare how the presence or absence of a partner influences an individual's experience in biofeedback. Using a mixed-method design allows the researchers to monitor both physiological changes for the individual, as well as their qualitatively reported experience. The exploratory nature of this study allowed researchers to begin delving into a previously under-researched topic.

However, the study also has limitations that readers must take into consideration when interpreting the above results. The most notable limitation is the small sample size. Due to challenges with recruitment of couples for an in-person research study, only 12 couples completed the full study. This makes it challenging to generalize results. In particular, the quantitative results are biased by a small sample size. This may also be the reason the quantitative analyses failed to reach significance. The small sample size makes it challenging for statistical analyses to detect a true effect, if one does exist.

Furthermore, the sample consisted solely of heterosexual couples, which is not a representative sample. Despite the study being advertised to all couples, only heterosexual couples responded and volunteered to participate. Umberson and colleagues (2015) found this is not an uncommon occurrence. Same-sex couples are less likely to participate in research studies, partially due to concerns about discrimination, uncertainty about confidentiality, or fears that findings will not be presented without bias or stigmatizing. Unfortunately, this contributes to the LGBTQIA+ population being underrepresented in research. Despite the lack of this key demographic in the present study, it is of note that the sample contained racial, gender, and economic diversity that is more closely aligned with the larger population (United States Census Bureau, 2020).

Additionally, the study did not capture how the partner provided support and whether the type of support behaviors influenced the primary participants. Observationally, the PI made note of different types of supportive behaviors exhibited by couples in the present condition. Types of support behaviors included holding hands, placing a hand on the partner’s leg, rubbing their back, eye contact, smiling, and words of encouragement. Some couples did not interact at all and were merely present together during the intervention. Different types of social interactions and their connection to interpersonal synchrony has been explored by the literature, including touch (Chatel-Goldman et al., 2014; Goldstein et al., 2017) and eye contact (Ferrer & Helm, 2013). Despite these observations, the study did not code the types of behaviors or include it as a variable. Future studies may benefit from the inclusion of a variable regarding the methods of providing support.

Finally, some readers may question the use of a single-session biofeedback intervention to accurately reflect how a partner may affect clinical biofeedback practices, which may consist of several sessions over a period of time. However, single-session HRVB is frequently used in research and has been found to be effective in increasing HRV (Lin et al., 2020; Prinsloo et al., 2013). Participants for this study, on average, also demonstrated an increase in HRV after the single intervention. Yet, the researchers recognize a single session may not be typical for all clinicians' experience. It is also important to note that this study used HRVB with a romantic partner present. Results may vary based on biofeedback modality used and the type of relational unit present. Future research can expand on this topic, which will be discussed further below.

Conclusion

Biofeedback is a growing field that can be used to alleviate symptoms of disease and illness, improve physiological functioning, and regulate stress (Frank et al., 2010; Schwartz et al., 2016). HRVB, in particular, is a promising modality with a strong evidence-base (Fournié et al., 2021). As the field grows, it is important to explore best practices for biofeedback clinicians and determine how to improve patient outcomes. The present study is a first step in evaluating how the presence of a romantic partner and provision of social support for an individual during a biofeedback intervention influences their outcomes and experience with the intervention. Previous research suggest that social support plays a critical role in self-regulation and influences physiological processes (Kleinbub, 2017; Palumbo et al., 2017), although quantifiable differences in physiology based on presence of a partner were not detected in this study. However, the presence of a romantic partner had an impact on how participants qualitatively experienced the intervention and, therefore, how they engage clinically. Future research must build upon this initial step to better ascertain how relational dynamics influences clinical biofeedback.

The next chapter will discuss the clinical and research implications of the findings of this study. In particular, it will provide important considerations for clinicians interested in incorporating social support for their patients into clinical practice. Additionally, it will provide future directions to continue expanding research in the field of interpersonal autonomic physiology and the application to biofeedback practices.

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Table 1

Demographic Variables of All Participants (N = 24)

Demographic Variable	n (%)
Race	
White/Caucasian	17 (70.83%)
Black/African American	6 (25%)
Asian	1 (4.17%)
Gender	
Male	12 (50%)
Female	11 (45.83%)
Non-binary	1 (4.17%)
Sexual Orientation	
Heterosexual/Straight	19 (79.17%)
Bisexual	3 (12.5%)
Pansexual	2 (8.33%)
Highest Education	
Some High School	2 (8.33%)
High School Diploma	3 (12.5%)
Some College	7 (29.17%)
Associate's Degree	1 (4.17%)
Bachelor's Degree	8 (33.33%)
Graduate Degree	3 (12.5%)
Relationship Status	
Committed Relationship- Not Cohabitating	11 (45.83%)
Committed Relationship- Cohabitating	9 (37.5%)
Married	4 (16.67%)

Table 2

Demographic Variables of Primary Participants (N = 12)

Demographic Variable	n (%)
Race	
White/Caucasian	9 (75%)
Black/African American	3 (25%)
Gender	
Male	6 (50%)
Female	5 (41.67%)
Non-binary	1 (8.33%)
Sexual Orientation	
Heterosexual/Straight	9 (75%)
Bisexual	2 (16.67%)
Pansexual	1 (8.33%)
Highest Education	
Some High School	1 (8.33%)
High School Diploma	2 (16.67%)
Some College	2 (16.67%)
Associate’s Degree	1 (8.33%)
Bachelor’s Degree	5 (41.67%)
Graduate Degree	1 (8.33%)
Relationship Status	
Committed Relationship- Not Cohabitating	5 (41.67%)
Committed Relationship- Cohabitating	5 (41.67%)
Married	2 (16.67%)

Table 3

Qualitative Themes and Definitions

Themes	Definitions	Number of Times Endorsed (Present Condition)	Number of Times Endorsed (Absent Condition)
Benefits of Partner Presence			
Security	When the presence of a partner decreases stress and provides a more calming, comforting environment, especially in an unfamiliar environment	6	6
Assistance	The ability to provide the participant with support and help through pacing, encouragement, physical touch, etc.	4	3
Enjoyment	Having an improved, more enjoyable experience by one or both parties when together	2	2
Context	Partner presence allowing for additional perspectives and better aligning with real-world experience	2	1
Disadvantages of Partner Presence			
Self-Presentation	When the presence and observation by a partner creates additional pressure on participant; impacts ability to be honest	2	4
Distraction	When the presence of a partner draws the participant's attention away from the intervention through looks, interactions, or discussions	5	3
Distressing Presence	Increased dissatisfaction with experience by participant when their partner is unsupportive or uncertain about how to provide support	1	0

Table 4

Descriptive Statistics of Variables by Condition (N = 12)

Variable	***M (SD)***
Difference in HRV SDNN	
Partner Present	29.06 (32.65)
Partner Absent	26.71 (25.6)
Combined	27.88 (27.99)
CSI-32 Primary Participant	
Partner Present	145.4 (6.19)
Partner Absent	139.54 (24.55)
Combined	142.47 (17.34)
CSI-32 Support Person	
Partner Present	143.1 (13.85)
Partner Absent	138.6 (26.48)
Combined	140.85 (20.29)
PHI Primary Participant	
Partner Present	46.67 (5.13)
Partner Absent	48.5 (5.24)
Combined	47.58 (5.04)
PHI Support Person	
Partner Present	44.83 (5.23)
Partner Absent	48.83 (5.08)
Combined	46.83 (5.47)

Note. M = mean; *SD* = standard deviation; CSI-32 = Couples Satisfaction Index; PHI = Patient Health Index; HRV = Heart Rate Variability; SDNN = Standard Deviation of Normal to Normal Rhythms

Table 5

Correlations Between Continuous Variables

	Change in HRV SDNN	PP CSI-32	SP CSI-32	PP PHI	SP PHI
Change in HRV SDNN	1.00	*	*	*	*
PP CSI-32	-.01	1.00	*	*	*
SP CSI-32	.25	.85**	1.00	*	*
PP PHI	-.10	-.05	-.33	1.00	*
SP PHI	-.12	-.11	.21	-.23	1.00

Note. PP = Primary Participant; SP = Support Person; CSI-32 = Couples Satisfaction Index; PHI = Patient Health Index; HRV = Heart Rate Variability; SDNN = Standard Deviation of Normal to Normal Rhythms; ** = Significance at $p < .05$

Table 6

Effects of Partner Presence on Change in Heart Rate Variability

Model	Predictor (IV)	*b*	*SE* (*b*)	*t-value*	*p*-value
DV- *Change in HRV SDNN* IV- *Condition*	Condition	-2.36	16.94	-.14	.89
DV- *Change in HRV SDNN* IV- *Condition* Moderator- *PP Perceived Relationship Satisfaction*	Condition PP CSI-32 Interaction	-241.248 -3.23 1.65	344.73 4.64 2.37	-.7 -.69 .69	.5 .5 .5
DV- *Change in HRV SDNN* IV- *Condition* Moderator- *SP Perceived Relationship Satisfaction*	Condition SP CSI-32 Interaction	54.86 1.04 -.39	164.4 2.11 1.15	.33 .5 -.34	.75 .63 .74
DV- *Change in HRV SDNN* IV- *Condition* Moderator- *PP Perceived BPSS Health*	Condition PP PHI Interaction	-.73 -.51 -.01	190.47 6.34 3.98	-.01 -.08 -.01	.99 .94 .99
DV- *Change in HRV SDNN* IV- *Condition* Moderator- *SP Perceived Relationship Satisfaction*	Condition SP PHI Interaction	21.03 .03 -.44	184.21 5.99 3.9	.11 .01 -.11	.91 .99 .91

Note. PP = Primary Participant; SP = Support Person; CSI-32 = Couples Satisfaction Index; PHI = Patient Health Index; HRV = Heart Rate Variability; SDNN = Standard Deviation of Normal to Normal Rhythms; DV = Dependent Variable; IV = Independent Variable; Condition was coded 1 = Present, 2 = Absent

CHAPTER 6: RECOMMENDATIONS AND CONSIDERATIONS FOR UTILIZING SOCIAL SUPPORT DURING BIOFEEDBACK INTERVENTIONS

The final chapter of this dissertation provides a synopsis of the previous chapters and a summary of the findings. There is also a discussion for how these findings can be applied to clinical practice. Recommendations are made for biofeedback clinicians interested in incorporating social support persons into their work with patients. These recommendations are for any biofeedback clinician with the appropriate training and certification to conduct biofeedback interventions, no matter their professional setting (i.e., hospitals, mental health practices, rehabilitation centers). For questions about appropriate training, readers are encouraged to visit the website of the Biofeedback Certification International Alliance (BCIA). Next, implications for research and future directions will be discussed.

While professionals in a variety of disciplines are encouraged to make use of these recommendations, the chapter will conclude with a particular emphasis on the role Medical Family Therapists (MedFTs) may play in the development and application of relational biofeedback. MedFTs often act as bridges between the worlds of physical and mental health and have a strong emphasis on social systems (Trudeau-Hern et al., 2014). Thus, they are well-situated to promote this holistic health intervention and expand it into a variety of healthcare systems.

Dissertation in Review

In the first chapter, the topic of biofeedback and, in particular, relational biofeedback was introduced. Biofeedback is a health intervention that trains people to regulate their physiological responses using real-time feedback mechanisms (Frank et al., 2010; Schwartz et al., 2016). Various modalities of biofeedback have been used to manage symptoms of several physical and mental health conditions (Kondo et al., 2019; McKee, 2008; Tan et al., 2016). Relational biofeedback is a term coined in this dissertation to encompass biofeedback exercises that utilize more than one person in the intervention. Since the literature has differed on the terminology and application of social networks in biofeedback (Ehrenreich, 2018; Kassel & LeMay, 2015; Levit-Binnun et al., 2010), relational biofeedback was used as a more inclusive term.

The second chapter provided additional information on interpersonal psychophysiology to support the relevance and potential benefits of relational biofeedback interventions. Biofeedback interventions often target the body's stress response to assist patients in regulating the stress response and promoting a relaxation state, which is better for health and well-being (McKee, 2008; Schwartz et al., 2016; Shaffer, 2020). Previous research has established that contact with support persons has a psychological and physiological impact (Kleinbub, 2017; Palumbo et al., 2017; Pietromonaco & Collins, 2017). Psychologically, social support can attenuate stressors and serve as a buffer for the stress response (Cohen & Wills, 1985). Physiologically, it has been established that contact with social support has an impact on cardiovascular, immune, and endocrine systems (Coutinho et al., 2021; Heaphy & Dutton, 2008; Kleinbub, 2017). People regulate and synchronize physiological processes in relation to those around them (Coutinho et al., 2021; Karvonen et al., 2016; Marzoratti & Evans, 2022). However, the impact of social systems can be positive or negative, depending on how the support is perceived (Chen et al., 2021; Heaphy & Dutton, 2008). Overall, it is clear that social support plays an important role in physiological regulation, which is the ultimate goal of biofeedback interventions. Thus, including another person and making biofeedback interventions relational could be beneficial to the training process.

The previously stated findings should be interpreted in the context of the biopsychosocial-spiritual (BPSS) framework (Engel, 1977; Wright et al., 1996), which serves as the theoretical foundation of this dissertation. The BPSS framework is a holistic approach that acknowledges the interplay between biological, psychological, social, and spiritual dimensions of health (Engel, 1977; Wright et al., 1996). Illness or dysfunction in one dimension of health influences well-being in other dimensions. Conversely, when efforts are made to improve health in one dimension, it can have a subsequent impact on other dimensions. Using this framework, it can be seen how increasing social support (i.e., social dimension) within biofeedback interventions impacts how they perform psychologically and physiologically.

While there is great potential for relational biofeedback, it has been largely under-researched. Biofeedback interventions are mostly individual interventions (Frank et al., 2010; Schwartz et al., 2016). To that end, chapter three consists of a systematic review that sought to identify how social support persons have been incorporated into biofeedback interventions to target different dimensions of health. The systematic review looked broadly at all biofeedback modalities and methods of utilizing social support. Findings of this chapter are detailed further below. Overall, it was determined that there is a wide variety in how relational biofeedback has been used and what it is called. Therefore, there is a need to explore relational biofeedback with specific modalities, presenting problems, and populations.

Consequently, an original research study was proposed. Chapter 4 details the methodology of the study. The researchers decided to use heart rate variability biofeedback, which is a commonly used modality for several health conditions, as well as general stress management (Fournié et al., 2021). Therefore, it was determined to be appropriate for a non-clinical sample and a good first step to grow the literature on relational biofeedback.

Additionally, the study focused on romantic partners due to the wealth of literature on interpersonal psychophysiology among romantic partners (Ferrer & Helm, 2013; Helm et al., 2012, 2014). The purpose of this study was to explore the impact of the presence of a romantic partner during a HRVB intervention, even without the partner participating directly in the exercise. The researchers evaluated whether the partner's presence impacted training outcomes and the participants' experience with the intervention. The full findings of this mixed-methods study is described in chapter 5. These findings are summarized below.

Key Findings from Chapter Three

The systematic review in chapter 3 identified 23 articles that met inclusion criteria. All of the included articles had to demonstrate some attempt to include an additional person into biofeedback interventions. Most of the studies used biofeedback interventions to target physical health, such as headaches (Allen & McKeen, 1991; Borgeat et al., 1980, 1984) and vaginismus (Barnes et al., 1984). Psychological health, including stress (Burton et al., 2018; Kerr et al., 2022) and anxiety (Cheung et al., 2016), and social health, such as conflict behaviors (Woodberry et al., 2020) and interpersonal coordination (Müller et al., 2021), was also targeted. No studies targeted spiritual health. Within the included studies, a variety of biofeedback modalities were used, including skin conductance, blood volume pulse, respiration, electromyography, and neurofeedback. These interventions were used with parent-child dyads (Allen & McKeen, 1991; Burke & Andrasik, 1989; Frederiks et al., 2015, 2019; Kerr et al., 2022; Nash et al., 2008; Woodberry et al., 2020), therapist-client dyads (Borgeat et al., 1980, 1984), romantic partners (Barnes et al., 1984), competitors (Patron et al., 2020; Putri et al., 2022), and strangers (Cheung et al., 2016; Müller et al., 2021). While all studies incorporated an additional person, the way they included that person varied. Some studies had multiple people receive feedback on their physiology simultaneously (Dikker et al., 2021; Konvalinka et al., 2023; Muñoz-González et al., 2022). Other studies used biofeedback to facilitate communication and understanding of an individual by others (Blain-Moraes et al., 2013; Frederiks et al., 2015, 2019; Kerr et al., 2022). Further studies used social support persons to facilitate at-home practice of biofeedback (Burke & Andrasik, 1989; Nash et al., 2008).

These findings are significant for several reasons. First, they provide support from the literature that adding a relational component to biofeedback interventions is feasible and useful. The results demonstrate there are a variety of ways that social connections can be beneficial to biofeedback training (e.g., providing encouragement, facilitating practice outside of clinical settings; Burke & Andrasik, 1989; Nash et al., 2008) and, conversely, biofeedback can be used to strength social ties (e.g., increase understanding of others' internal states; Blain-Moraes et al., 2013; Kerr et al., 2022). Although a relatively small number of studies were identified, the systematic review highlights that there are attempts made to utilize social support as a resource within biofeedback.

However, the results also highlight glaring gaps in the literature. Primarily, the studies rarely evaluate whether the relational component makes a difference in training outcomes. Most of the outcome metrics focus on the alleviation of symptoms as part of the overall treatment protocol, but do not evaluate the relational component specifically or compare it to individual interventions. Therefore, the effects of relational biofeedback remain unsupported in the literature. Additionally, it underscores the lack of standardization for relational biofeedback, as each study shows clinicians using different terminology and procedures. Of course, this versatility in how social support persons can contribute to biofeedback training can be beneficial because it allows clinicians to tailor their treatment to the needs of their clientele. Unfortunately, clinicians interested in relational biofeedback may have a difficult time finding empirical evidence and guidelines. The inconsistent terminology alone makes it challenging to locate empirical studies on the practice. For this reason, more research must focus specifically on the practice of relational biofeedback interventions.

Key Findings from Chapter Five

The findings of chapter 5 take a single step in developing the literature in relational biofeedback. The study sought to compare individual to relational HRVB by determining if HRVB outcomes were different based on whether the person completing the intervention was alone or with a partner. Couples were recruited to participate in the study and one partner from each couple completed a HRVB intervention. The other partner was either present or absent during the intervention. The study evaluated physiological outcomes and the participants' reported experience based on which condition they were in. No difference in HRV was found based on whether the intervention was completed individually or with their partner present. Results also showed that this relationship did not change even when accounting for relationship satisfaction and BPSS health as moderating variables.

Qualitatively, participants described both benefits and disadvantages of having a partner present during a biofeedback intervention. Overwhelmingly, participants preferred to have a partner present. Reported benefits of doing HRVB and incorporating a romantic partner included a sense of security, increased enjoyment of the experience, the ability to give assistance to the individual completing the intervention, and providing more context for the application of biofeedback. On the other hand, the disadvantages of incorporating a romantic partner included pressure to present oneself well, distraction, and the potential for their presence to cause distress.

These findings are significant because, to the authors' knowledge, it was the first study to attempt to directly compare individual to relational biofeedback interventions. The study represented the first step in exploring how the mere presence of another person may impact patient outcomes. While no differences were found in the physiological outcomes, the quantitative results of the study were limited by the small sample size. The qualitative findings also provide useful information on how to maximize the benefits of relational biofeedback and minimize potential challenges and liabilities.

Clinical Recommendations

Using the results from the previous chapters, several recommendations can be made for biofeedback clinicians who see the value of including social support systems into their work with patients. First, the clinician may encourage patients to bring a support person with them when participating in biofeedback treatments. During initial contact, clinicians can invite the patient to bring someone they perceive as supportive. This may require flexibility in scheduling around multiple people's schedules, but demonstrates early on that the treatment space is welcoming to both the patient and their family and friends. While this may seem like a simple step, patients may not be aware this is an option and the clinician's invitation serves as permission, if they believe that would be helpful.

This could be particularly impactful during the first visit. One of the primary themes that emerged from the interviews in chapter 5 was the theme of security. Participants described how having someone with them in a new environment made them more comfortable. Patients may find it intimidating to perform novel tasks in new clinical settings with unfamiliar practitioners. It is well documented that healthcare settings can be anxiety inducing in some patients (Legg et al., 2015). The well-known "white coat syndrome" refers to the increase in blood pressure many patients experience in clinical settings as a result of increased stress (Pioli et al., 2018). Therefore, increasing their sense of comfort and safety is crucial to physiological regulation.

Once a support person is present, it is important for clinicians to provide proper instruction to all parties. Support persons may desire to be supportive, but uncertain about what they can and should do. This could impact the training process in three ways. First, a support person may interfere with the training process through distraction. Several participants in the study in chapter 5 identified this as a potential challenge. Many partners expressed concern about distracting the other from the exercise and, thus, "ruining" the intervention. Second, the support person may interfere with equipment. For example, a person trying to be encouraging may provide physical touch and then unintentionally move sensors placed on the patient's body. Finally, the support person may not be sure how to support the patient, which can lead to a noticeable lack of support that is distressing to the patient. This theme (distressing presence) emerged in the interviews in the previous chapter. Most of these issues can be prevented through appropriate education early in the training process. The clinician should explain the protocol, equipment, and purpose of the exercises to all patients (Shaffer, 2020). One participant in the above-mentioned study suggested providing the patient and support person adequate time to discuss with each other about the upcoming intervention, what would be helpful, and what would be distracting. These brief steps can prevent or attenuate many potential challenges.

It may occur that the presence of a social support person actually becomes detrimental to the patients' success in biofeedback training. In the results of chapter 5, it was noted that a support person did not impact an individual's change in HRV, either positively or negatively. However, the qualitative theme of a "distressing presence" emerged from one couple. A support person may be a distressing presence as a result of a high conflict relationship. As mentioned previously, social support is only beneficial if it is perceived as positively supportive by the person receiving it (Chen et al., 2021; Heaphy & Dutton, 2008; Lakey & Orehek, 2011). This potential challenge should not serve as a hindrance to biofeedback clinicians interested in including support persons into their work with patients. Should this occur, clinicians can make efforts to continue with individual sessions going forward and address this occurrence with the patient, if appropriate and conducive to the clinician-patient relationship.

Finally, clinicians are encouraged to incorporate support people in treatment planning, with the patient's consent. More and more frequently, healthcare practitioners of all kinds are encouraged to include the family (however a patient defines it) into treatment (Doody et al., 2017; Prior & Campbell, 2018). McDaniel and colleagues (1992) have endorsed the importance of promoting communion within healthcare settings. The authors note that a sense of connectedness is a crucial psychosocial factor in a patient's experience of disease and illness. Biofeedback clinicians should be no different. Family and friends can provide additional information about the patients' real-world context that could be useful for the clinician. This theme of "context" emerged from the interviews in the previous chapter. Participants stated their partner knew them well enough that they could provide valuable information on their health and lifestyle. For example, they may be able to identify triggers, stressors, and health behaviors which the patient has not recognized. This information could be useful when considering the practice and application of biofeedback skills.

Additionally, participants in the study explained the presence of a partner was more representative of their real-world experience. So, the inclusion of a support person may aid in the generalization of skills outside of clinical settings. As identified in some of the articles in the systematic review in chapter 3, family members can be helpful in facilitating at-home practice.

They can provide assistance, accountability, and encouragement for the patient. Biofeedback clinicians should utilize this resource to create a comprehensive, realistic treatment plan to help their patient practice new skills and meet their health goals.

It should be noted that these recommendations are based on biofeedback interventions being done with one person and utilizing their social support system for assistance. Some literature has suggested multiple parties complete biofeedback interventions simultaneously (Ehrenreich, 2018; Kassel & LeMay, 2015; Muñoz-González et al., 2022). While this is an exciting prospect and another application of relational biofeedback, there is not enough empirical evidence to make specific recommendations for clinicians at this time. The next section will address future directions for research that can continue to grow the literature on relational biofeedback.

Research Implications

This dissertation has focused primarily on the concept of relational biofeedback as an umbrella term which encompasses a variety of biofeedback practices. This is to advocate for the consideration and inclusion of social support within biofeedback and applied psychophysiology, which is frequently overlooked. This broad term is also used due to the inconsistent terminology in the literature, such as dyadic biofeedback (Levit-Binnun et al., 2010) or interpersonal biofeedback (Kassel & LeMay, 2015). Since this concept is underdeveloped, this dissertation attempts to take the first step in increasing awareness and consideration of this idea within the professional biofeedback community. However, the authors recognize there are many ways which relational biofeedback may be interpreted and applied. Therefore, there are many directions future research may take to explore how to best utilize relational biofeedback.

First, researchers can explore different modalities of relational biofeedback for various presenting problems. The study conducted in chapter 5 used HRVB, since it is a common and frequently used modality (Lehrer, 2013). The systematic review in chapter 3 identified a few studies that have used social support persons with neurofeedback (Müller et al., 2021; Muñoz-González et al., 2022; Putri et al., 2022), electromyography (Malec et al., 1978; Nash et al., 2008), temperature (Burke & Andrasik, 1989; Cheung et al., 2016), respiration (Cheung et al., 2016; Konvalinka et al., 2023), cardiovascular (Woodberry et al., 2020), electrical dermal activity (Frederiks et al., 2015, 2019), and haptic biofeedback (Avila Mireles et al., 2017). Additionally, the present study was not conducted on a clinical sample and, thus, used biofeedback for general stress reduction and improved autonomic nervous system functioning. However, there is evidence to support the potential efficacy of biofeedback for over 30 health conditions (McKee, 2008; Tan et al., 2016), such as anxiety (Russoniello et al., 2013; Sarkar et al., 1999; Tolin et al., 2020), depression (Caldwell & Steffen, 2018; Lin et al., 2019), chronic pain (Arena & Tankersley, 2018), insomnia (Melo et al., 2019), migraine (Mullally et al., 2009), or trauma and stress disorders (Russoniello et al., 2013; Yu et al., 2018).. The next step would be to incorporate a relational component into biofeedback interventions for these health conditions. Researchers can explore how the inclusion of social support persons into each of the mentioned modalities and with different presenting problems may impact patient outcomes.

Additionally, research results detailed in the previous chapter are based on a biofeedback intervention conducted with romantic partners. Relational biofeedback could also be used with a variety of relational units, including parent-child, families, friends, or co-workers (Ehrenreich, 2018; Levit-Binnun et al., 2010). The systematic review even identified studies where strangers participated in a biofeedback intervention together (Konvalinka et al., 2023; Müller et al., 2021).

Not only could research capture different relational units, but also different types of supportive behaviors. For example, researchers could explore the impact of physical touch, verbal encouragement, or eye contact. There is an abundance of opportunities to explore how various relational units may impact biofeedback outcomes, as well as how biofeedback can be used to increase the BPSS health of family, friend, and community systems.

The primary limitation of the original research study in chapter 5 is the small sample size. The challenge of recruiting relational units in research can be seen in past biofeedback research. The systematic review above identifies 23 studies that had some type of relational component in their biofeedback intervention. Of these included studies, most of them had small sample sizes, with the smallest consisting of only 3 children-caregiver units (Blain-Moraes et al., 2013; Frederiks et al., 2015; Nash et al., 2008). While relational research is a challenge, it also presents an opportunity for future research. Conducting studies with a larger sample would better detect any effects present and be more generalizable.

Finally, the authors encourage future research to delineate different types of relational biofeedback. In the research study, only one participant completed the biofeedback intervention with a support person present. There are a few studies identified in the systematic review that also had one person complete the intervention with another assisting (Allen & McKeen, 1991; Burke & Andrasik, 1989). This is a type of relational biofeedback and has several benefits, as described previously. But, relational biofeedback is not limited to this method. Some studies have made efforts to have multiple persons complete biofeedback interventions together (Müller et al., 2021). Theoretical papers have suggested how this could particularly be useful in couple's therapy (Ehrenreich, 2018; Gottman & Gottman, 2008; Kassel & LeMay, 2015; Levit-Binnun et al., 2010). Additional research is needed to understand the effects of this method of relational biofeedback. Due to the limited literature, this dissertation introduced the broad concept of relational biofeedback, but future directions can provide more focus on particular ways clinicians may utilize patients' relational context.

The Role of MedFTs

Medical Family Therapy (MedFT) emerged from the field of Marriage and Family Therapy in the United States during the 1980s in response to the increasing fragmentation in healthcare systems and the growing rates of mental and physical health comorbidities (Tyndall et al., 2014). The BPSS framework (Engel, 1977; Wright et al., 1996) is foundational in MedFT because of its acknowledgement on the interplay in different dimensions of health and encouragement to provide holistic healthcare to patients (Tyndall et al., 2014). MedFTs are frequently active in integrated healthcare sites and are employed as clinicians, educators, and academics in both medical and mental health settings (Marlowe et al., 2014; Trudeau-Hern et al., 2014). Additionally, since MedFT grew out of marriage and family therapy, practitioners are often trained in systems theory and usually have advanced experience working clinically with relational systems (i.e., couples, families; Trudeau-Hern et al., 2014; Tyndall et al., 2014).

MedFTs who are interested in biofeedback may already appreciate how biofeedback interventions make use of the mutual influence of a patients' psychological and physiological state (Frank et al., 2010; Schwartz et al., 2016). Several practices common in biofeedback interventions are also commonly used in mental health treatment, from which MedFTs most often originate. For example, meditation, mindfulness, progressive muscle relaxation, deep breathing practices, and grounding exercises are common techniques used to promote self-regulation in biofeedback (Schwartz et al., 2016; Shaffer, 2020). Several of these practices (e.g., meditation, mindfulness) also tap into a spiritual component, which the BPSS framework recognizes has an impact on biological and psychological systems (Engel, 1977; Wright et al., 1996). In addition to the readily apparent intersections among the tenets of biofeedback with those of MedFT, the inclusion of the social dimension is especially helpful when working from a MedFT perspective. Given that they are trained to work in relational contexts and value the influence of systems on patient health, it seems to be a natural progression to broaden the intervention to include more members of the patient's family and friends.

Currently, there are MedFTs employed in hospitals, primary care clinics, rehabilitation centers, and mental health clinics (Tyndall et al., 2014). Each of these sites may benefit from biofeedback interventions due to the strong evidence on how it can improve symptoms of physical and mental health conditions, improve performance, and decrease stress (McKee, 2008; Tan et al., 2016). MedFTs frequently make efforts to integrate holistic health practices into healthcare settings (Marlowe et al., 2014), and can use these professional skills to introduce this intervention to patients, colleagues, and larger systems. Where biofeedback is already present, MedFTs may advocate for inclusion of the patient's social support system into the training and provide guidance to clinicians who are uncertain about how to work with multiple parties. MedFTs can use their training, skills, and influence to be strong advocates for the growth and expansion of relational biofeedback in clinical practice and through interdisciplinary research.

Integration of Relational Biofeedback

For MedFTs interested in advancing this idea, they may wonder how to go about integrating relational biofeedback into their work. Peek's Four World View of healthcare (Lamson et al., 2022; Peek, 2008) can be a useful framework from which to understand how to integrate relational biofeedback practices into different healthcare systems. Peek identified four worlds of healthcare that are dependent on each other and must be addressed simultaneously to make change in healthcare systems (Peek, 2008). The clinical world focuses on what practitioners do with patients. MedFTs can learn to provide clinical biofeedback services by completing the appropriate training and undergoing the certification process through BCIA. While there is no specific training for relational biofeedback, MedFTs may find it useful to lean on their systems training when considering how to work with multiple parties clinically.

Operationally, it is crucial to understand how this practice can be integrated into the environment and workflow of the system (Peek, 2008). Fortunately, biofeedback interventions can be relatively brief and still effective (Frank et al., 2010; Schwartz et al., 2016). While some practitioners may use 60-90 minute sessions, others complete the intervention in 20-30 minute sessions. This allows for more versatility depending on the needs and resources of the healthcare system. Additionally, biofeedback interventions only require enough space for equipment, patient, and practitioners (Shaffer, 2020). For relational biofeedback there should be adequate space for all parties. Most standard office spaces in non-distracting environments would be appropriate.

Financially, healthcare systems must evaluate the cost and return on investment (Peek, 2008). There is an initial startup cost for relational biofeedback interventions because practitioners must obtain the appropriate equipment and software (Shaffer, 2020). Following this initial investment, maintenance of the program can be relatively inexpensive. Additionally, there are billable CPT codes for biofeedback interventions (see CPT codes 90875, 90876, 90901, 90911, 90912, 90913; Centers for Medicare & Medicaid Services, 2020). These codes can typically be billed in addition to any therapeutic services or medical services provided, as long as they do not overlap. There is no specific code for relational biofeedback, but practitioners can bill for the same services. Readers are encouraged to refer to specific payers, as well as regulations in their state and professional setting to determine appropriate billing procedures.

Finally, there is the "hidden" training/education world which focuses on how professionals within the healthcare setting are trained to implement the change (Peek, 2008). This is an underdeveloped area as there is little literature and guidelines on relational biofeedback. In this area, MedFTs can be beneficial in the development of empirical evidence and training procedures for other professionals through their involvement in research.

Conclusion

In conclusion, this dissertation has made efforts to establish and advocate for relational biofeedback. Through a systematic review and an original research study, this work has investigated the application, potential benefits, and challenges of incorporating social support persons into biofeedback interventions. The findings emphasize the feasibility and potential advantages of relational biofeedback, but also highlight the need for further empirical support and standardization. Clinicians interested in integrating social support systems into their biofeedback practice can start by fostering a welcoming environment for support persons, offering proper education and guidance, and incorporating support systems into treatment planning. Researchers can also contribute to the development of the field by advancing research on how relational biofeedback can be used through different modalities, methods, and relational units. While this dissertation serves as a call to action for all professionals interested in biofeedback, MedFTs are especially well-positioned to champion the expansion and integration of relational biofeedback interventions into various healthcare settings. Relational biofeedback represents a promising frontier in biofeedback and applied psychophysiology and has the potential to provide a more personalized approach to health and well-being.

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APPENDIX A: IRB APPROVAL LETTER

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
Willis Building · Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · **rede.ecu.edu/umcirb/**

Notification of Initial Approval: Expedited

From: Biomedical IRB
To: Adrian Knauss
CC: Jake Jensen
Date: 12/20/2023
Re: UMCIRB 23-002367
Relational Biofeedback Study

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) occurred on 12/19/2023. The research study is eligible for review under expedited category # 4,6,7. The Chairperson (or designee) deemed this study no more than minimal risk.

As the Principal Investigator you are explicitly responsible for the conduct of all aspects of this study and must adhere to all reporting requirements for the study. Your responsibilities include but are not limited to:

1. Ensuring changes to the approved research (including the UMCIRB approved consent document) are initiated only after UMCIRB review and approval except when necessary to eliminate an apparent immediate hazard to the participant. All changes (e.g. a change in procedure, number of participants, personnel, study locations, new recruitment materials, study instruments, etc.) must be prospectively reviewed and approved by the UMCIRB before they are implemented;

2. Where informed consent has not been waived by the UMCIRB, ensuring that only valid versions of the UMCIRB approved, date-stamped informed consent document(s) are used for obtaining informed consent (consent documents with the IRB approval date stamp are found under the Documents tab in the ePIRATE study workspace);

3. Promptly reporting to the UMCIRB all unanticipated problems involving risks to participants and others;

4. Submission of a final report application to the UMICRB prior to the expected end date provided in the IRB application in order to document human research activity has ended and to provide a timepoint in which to base document retention; and

5. Submission of an amendment to extend the expected end date if the study is not expected to be completed by that date. The amendment should be submitted 30 days prior to the UMCIRB approved expected end date or as soon as the Investigator is aware that the study will not be completed by that date.

The approval includes the following items:

Name	Description
Data Collection- Interview Questions	Data Collection Sheet
Data Collection- Participant Survey	Data Collection Sheet
Dissertation Proposal	Study Protocol or Grant Application
Email Script	Recruitment Documents/Scripts
Informed Consent	Consent Forms
Interview Script	Interview/Focus Group Scripts/Questions
Local Resources	Additional Items
Participant Screener	Additional Items
Participant Survey.docx	Surveys and Questionnaires
Protocol	Study Protocol or Grant Application
Recruitment Flyer	Recruitment Documents/Scripts

For research studies where a waiver or alteration of HIPAA Authorization has been approved, the IRB states that each of the waiver criteria in 45 CFR 164.512(i)(1)(i)(A) and (2)(i) through (v) have been met. Additionally, the elements of PHI to be collected as described in items 1 and 2 of the Application for Waiver of Authorization have been determined to be the minimal necessary for the specified research.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

APPENDIX B: PRE-SCREENER

We are conducting a study about how key relationships impact our health. We are looking for couples who are willing to participate in a study for 1-1.5 hours. For your participation, you can enter a drawing for one of three gift cards. All information collected will remain anonymous. Is this something you and your partner would be interested in completing?

For the purposes of this study, one partner will be identified as the primary participant and the other as the support person. The primary participant will be asked to complete more questions and tasks, including being hooked up to a small medical device. But nothing will be invasive, dangerous, or painful.

To determine if you are eligible, I have a few questions to review with you. It will only take a couple minutes to go through the questions.

Are you and your partner both comfortable with reading and writing English?
YES _______ NO _________

Are you and your partner both able to attend an in-person appointment that will last about 1-1.5 hours?
YES _______ NO _________

Are you and your partner both at least 18 years of age or older?
YES _______ NO _________

If all yes:
Thank you for reviewing that information with me. You are eligible for this study. We can schedule a time that would work for you both. If you are unable to make this time, we ask you contact us at least 24 hours prior.
Partner 1 Name _________________________ Partner 2 Name _________________________
Phone Number _________________________ Phone Number _________________________
May we contact you via phone if there are any changes to your appointment? ______________
Appointment Date __________________ Time ____________________

If any are no:
Thank you for reviewing that information with me. Unfortunately, you are not eligible for this study. We appreciate your interest and hope you will continue to reach out to other research studies in the future.

For Researcher Use
Randomly assign participants PP Initials ________ SP Initials ________
Randomly assign condition Condition 1- Present ________ Condition 2- Absent _______

APPENDIX C: INTERVIEW SCRIPT

Thank you for participating in the biofeedback session. I now have some questions for both of you regarding your experience so far. Please answer to the best of your ability and feel free to expand if necessary. I will be using this iPad to record audio of this interview. These audio recordings are to help us remember what you said. We will remove all identifying information and keep all records confidential. You can stop at any time if you do not wish to answer a question.

Condition 1: Partner Present

1. Please describe your experience participating in biofeedback.
2. What influence, if any, did your partner’s presence during the biofeedback session have on your experience?
3. What do you believe are the benefits, if any, of having a partner present when practicing biofeedback?
4. What do you believe are the disadvantages, if any, of having a partner present when practicing biofeedback?

Condition 2: Partner Absent

1. Please describe your experience participating in biofeedback.
2. What influence, if any, did your partner’s absence during the biofeedback session have on your experience?
3. What do you believe are the benefits, if any, of having a partner present when practicing biofeedback?
4. What do you believe are the disadvantages, if any, of having a partner present when practicing biofeedback?

APPENDIX D: PARTICIPANT SURVEY

Researcher:

Couple ID # _________

Participant Role?
1, PP
2, SP

Condition
1, Present
2, Absent

Demographics

We would like to ask a few questions about yourself. Please answer to the best of your ability. You may choose not to answer questions that make you uncomfortable.

How old are you?

How would you describe your Race and/or Ethnicity?

What is your average household income?

What is the highest level of education you have completed?
1, Some High School
2, High School Diploma
3, Some College
4, Associate's Degree
5, Bachelor's Degree
6, Graduate Degree
7, Career/Technical Certification or Training Program

How would you describe your sexual orientation?

What gender do you identify with?

How long have you been in a romantic relationship with the partner you brought with you today?
____________ years ___________ months

What is your current relationship status?
1, Committed Relationship- Not Cohabitating
2, Committed Relationship- Cohabitating
3, Married
4, Separated/Divorced
5, Other ____________________________________

How many children do you have?

How many children do you have with the partner you brought with you today?

Are you currently in a romantic relationship with other persons?

1, Yes
2, No

How would you best describe your relationship?

1, Monogamous (only in a relationship with each other)
2, Open to include other persons in the relationship
3, Polyamorous (in a relationship with more than one person)
4, Undecided
5, Other ___________________

Are you currently in couple's counseling or therapy with your partner?

1, Yes
2, No

Health

The questions below will ask about your physical and mental health. This information will be de-identified (not connected to your name or other identifying information) and will be kept confidential. You may choose not to answer questions that make you uncomfortable.

What medical conditions have you been diagnosed with by a physician, nurse practitioner, or other medical professional?

What mental health conditions have you been diagnosed with by a physician, psychiatrist, nurse practitioner, counselor, or other health professional?

What prescription medications are you currently taking?

What supplements or over-the-counter medication do you take regularly?

Do you currently have a pacemaker or other artificial cardiac device?

1, Yes
2, No

Have you every participated in biofeedback before?

1, Yes
2, No

Do you have previous experience with breathing exercises, such as paced breathing?

1, Yes
2, No

How would you rate your overall stress level at this time on a scale from 1 (none) to 10 (extremely high)?

(If participant is designated as the primary participant)
Primary Participant Personal Health Inventory

The following questions will ask about your perception of your whole health. This includes your physical, mental/emotional, social, and spiritual well-being.

Rate where you feel you are on the scales below from 1-5, with 1 being miserable and 5 being great.

Physical Well-Being	1 Miserable	2	3	4	5 Great
Mental Emotional Well-Being	1 Miserable	2	3	4	5 Great
Life: How is it to live your day-to -day life?	1 Miserable	2	3	4	5 Great

For each area below, consider how you perceive your health at this point in time. Write in a number between 1 (low) and 5 (high) that best represents where you are. You do not need to be a “5” in any of the areas.

Area of Self Care	Where I am Now (1-5)
Moving the Body: Our physical, mental, and emotional health are impacted by the amount and kind of movement we do. Moving the body can take many forms such as dancing, walking, gardening, yoga, and exercise.	
Recharge: Our bodies and minds must rest and recharge in order to optimize our health. Getting a good night’s rest as well as recharging our mental and physical energy throughout the day are vital to well-being. Taking short breaks or doing something you enjoy or feels good for moments throughout the day are examples of ways to refresh.	
Food and Drink: What we eat and drink can have a huge effect on how we experience life, both physically and mentally. Energy, mood, weight, how long we live, and overall health are all impacted by what and how we choose to eat and drink.	
Personal Development: Our health is impacted by how we choose to spend our time. Aligning our work and personal activities with what really matters to us, or what brings us joy, can have a big effect on our health and outlook on life.	
Family, Friends, and Co-Workers: Our relationships, including those with pets, have as significant an effect on our physical and emotional health as any other factor associated with well-being. Spending more time in relationships that ‘fuel’ us and less in relationships that ‘drain’ us is one potential option. Improving our relationship skills or creating new relationships through community activities are other options to consider.	
Spirit and Soul: Connecting with something greater than ourselves may provide a sense of meaning and purpose, peace, or comfort. Connecting and aligning spiritually is very individual and may take the form of religious affiliation, connection to nature, or engaging in things like music or art.	
Surroundings: Our surroundings, both at work and where we live, indoors and out, can affect our health and outlook on life. Changes within our control	

such as organizing, decluttering, adding a plant or artwork can improve mood and health.	
Power of the Mind: Our thoughts are powerful and can affect our physical, mental, and emotional health. Changing our mindset can aid in healing and coping. Breathing techniques, guided imagery, Tai Chi, yoga, or gratitude can buffer the impact of stress and other emotions.	
Professional Care: “Prevention and Clinical Care” Staying up to date on prevention and understanding your health concerns, care options, treatment plan, and their role in your health.	

(If participant is designated as the support person)

<u>Support Person Personal Health Inventory</u>

The following questions will ask about your perception of your partner’s whole health. This includes their physical, mental/emotional, social, and spiritual well-being.

Rate where you feel you are on the scales below from 1-5, with 1 being miserable and 5 being great.

Physical Well-Being	1 Miserable	2	3	4	5 Great
Mental Emotional Well-Being	1 Miserable	2	3	4	5 Great
Life: How is it to live your day-to -day life?	1 Miserable	2	3	4	5 Great

For each area below, consider how you perceive your partner’s health at this point in time. Write in a number between 1 (low) and 5 (high) that best represents where you believe they are. You do not need to have a “5” in any of the areas.

Area of Self Care	Where I am Now (1-5)
Moving the Body: Our physical, mental, and emotional health are impacted by the amount and kind of movement we do. Moving the body can take many forms such as dancing, walking, gardening, yoga, and exercise.	
Recharge: Our bodies and minds must rest and recharge in order to optimize our health. Getting a good night’s rest as well as recharging our mental and physical energy throughout the day are vital to well-being. Taking short breaks or doing something you enjoy or feels good for moments throughout the day are examples of ways to refresh.	
Food and Drink: What we eat and drink can have a huge effect on how we experience life, both physically and mentally. Energy, mood, weight, how long we live, and overall health are all impacted by what and how we choose to eat and drink.	
Personal Development: Our health is impacted by how we choose to spend our time. Aligning our work and personal activities with what really matters to us, or what brings us joy, can have a big effect on our health and outlook on life.	
Family, Friends, and Co-Workers: Our relationships, including those with pets, have as significant an effect on our physical and emotional health as any other factor associated with well-being. Spending more time in relationships that ‘fuel’ us and less in relationships that ‘drain’ us is one	

potential option. Improving our relationship skills or creating new relationships through community activities are other options to consider.	
Spirit and Soul: Connecting with something greater than ourselves may provide a sense of meaning and purpose, peace, or comfort. Connecting and aligning spiritually is very individual and may take the form of religious affiliation, connection to nature, or engaging in things like music or art.	
Surroundings: Our surroundings, both at work and where we live, indoors and out, can affect our health and outlook on life. Changes within our control such as organizing, decluttering, adding a plant or artwork can improve mood and health.	
Power of the Mind: Our thoughts are powerful and can affect our physical, mental, and emotional health. Changing our mindset can aid in healing and coping. Breathing techniques, guided imagery, Tai Chi, yoga, or gratitude can buffer the impact of stress and other emotions.	
Professional Care: "Prevention and Clinical Care" Staying up to date on prevention and understanding your health concerns, care options, treatment plan, and their role in your health.	

Relationship Satisfaction

The following questions will ask about your relationship with your partner (the person you brought with you today). Select one answer for each question that best represents your experience with your current partner. Both you and your partner's answers will be kept confidential.

1. Please indicate the degree of happiness, all things considered, of your relationship.

0, Extremely Unhappy	1, Fairly Unhappy	2, A Little Unhappy	3, Happy	4, Very Happy	5, Extremely Happy	6, Perfect

Most people have disagreements in their relationships. Please indicate below the approximate extent of agreement or disagreement between you and your partner for each item on the following list.

	5, Always Agree	4, Almost Always Agree	3, Occasionally Disagree	2, Frequently Disagree	1, Almost Always Disagree	0, Always Disagree
2. Amount of time spent together						
3. Making major decisions						
4. Demonstrations of affection						

	All the Time	Most of the Time	More Often than Not	Occasionally	Rarely	Never
5. In general, how often do you think that things between you and your partner are going well?	5	4	3	2	1	0
6. How often do you wish you hadn't gotten into this relationship?	0	1	2	3	4	5

	Not at all True	A little True	Somewhat True	Mostly True	Almost Completely True	Completely True
7. I still feel a strong connection with my partner	0	1	2	3	4	5
8. If I had my life to live over, I would marry (or live with/date) the same person	0	1	2	3	4	5
9. Our relationship is strong	0	1	2	3	4	5
10. I sometimes wonder if there is someone else out there for me	5	4	3	2	1	0
11. My relationship with my partner makes me happy	0	1	2	3	4	5
12. I have a warm and comfortable relationship with my partner	0	1	2	3	4	5
13. I can't imagine ending my relationship with my partner	0	1	2	3	4	5
14. I feel that I can confide in my partner about virtually anything	0	1	2	3	4	5

15. I have had second thoughts about this relationship recently	5	4	3	2	1	0
16. For me, my partner is the perfect romantic partner	0	1	2	3	4	5
17. I really feel like part of a team with my partner	0	1	2	3	4	5
18. I cannot imagine another person making me as happy as my partner does	0	1	2	3	4	5

	0, Not at All	1, A little	2, Somewhat	3, Mostly	4, Almost Completely	5, Completely
19. How rewarding is your relationship with your partner?						
20. How well does your partner meet your needs?						
21. To what extent has your relationship met your original expectations?						
22. In general, how satisfied are you with your relationship?						

	Worse than all others (extremely bad)					Better than all others (extremely good)
23. How good is your relationship compared to most?	0	1	2	3	4	5

	Never	Less than once a month	Once or twice a month	Once or twice a week	Once a day	More often

24. Do you enjoy your partner's company?	0	1	2	3	4	5
25. How often do you and your partner have fun together?	0	1	2	3	4	5

For each of the following items, select the answer that best describes how you feel about your relationship. Base your responses on your first impressions and immediate feelings about the item.

26.	INTERESTING	5	4	3	2	1	0	BORING
27.	BAD	0	1	2	3	4	5	GOOD
28.	FULL	5	4	3	2	1	0	EMPTY
29.	LONELY	0	1	2	3	4	5	FRIENDLY
30.	STURDY	5	4	3	2	1	0	FRAGILE
31.	DISCOURAGING	0	1	2	3	4	5	HOPEFUL
32.	ENJOYABLE	5	4	3	2	1	0	MISERABLE

Please select an answer that best represents your experiences in your current relationship with your partner.

	Never True	Rarely True	Sometimes True	Usually True	Always True
1. I am rarely available to my partner.	1	2	3	4	5
2. It is hard for my partner to get my attention.	1	2	3	4	5
3. I listen when my partner shares their deepest feelings.	5	4	3	2	1
4. I am confident I reach out to my partner.	5	4	3	2	1
5. It is hard for me to confide in my partner.	1	2	3	4	5
6. I struggle to feel close and engaged in our relationship.	1	2	3	4	5

7. My partner is rarely available to me.	1	2	3	4	5
8. It is hard for me to get my partner's attention.	1	2	3	4	5
9. My partner listens when I share my deepest feelings.	5	4	3	2	1
10. I am confident my partner reaches out to me.	5	4	3	2	1
11. It is hard for my partner to confide in me.	1	2	3	4	5
12. My partner struggles to feel close and engaged in our relationship.	1	2	3	4	5

APPENDIX E: RECRUITMENT FLYER