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Article

Evaluation of heart rhythm coherence feedback training on physiological and psychological variables

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Abstract

HeartMath refers to a psychophysiological approach dedicated to helping people establish heart-based living and global coherence through heart rate variability training, especially through heart rhythm coherence feedback. This study investigated the influence of emWave2 heart rhythm coherence feedback learning on standardized measures of physiological coherence, sense of coherence, health, mindfulness, and spirituality perceptions, as experienced and evaluated by a small convenience sample of 10 participants. Six women and four men with a mean age of 44.8 years and an age range from 23 to 78 years completed at least five emWave2 biofeedback sessions, with a mean of 10 sessions and a range from 5 to 15 sessions. Quantitative findings indicated significant improvements on all standardized measures. Qualitative findings indicated meaningful experiences and positive evaluations of the workshop. Integrative findings are discussed in relation to previous and future research.

Keywords

Biofeedback, health, heart rhythm, mindfulness, physiological coherence, sense of coherence, spirituality

Biofeedback involves the use of instrumentation to monitor typically unconscious psychophysiological processes, which may be brought under voluntary control (Thompson & Thompson, 2003). Scientific studies have revealed many benefits of heart rhythm coherence feedback as researched at the California Institute of HeartMath (McCraty & Atkinson, 2003; McCraty, Atkinson, & Tomasino, 2001; McCraty, Atkinson, Tomasino, & Bradley, 2006; McCraty & Tomasino, 2004).

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For example, rigorous research has indicated that heart rhythm coherence, characterized by a heart rate (HR) variability pattern that approximates sinusoidal curve form, promotes general physiological coherence, health, and optimal performance. Physiological coherence is characterized by a heart rhythm pattern of elevated amplitude in low-frequency HR variability of around 0.1 Hz, associated with balanced harmony between sympathetic and parasympathetic divisions of the autonomic nervous system, which typically occurs at about 6 breaths/min. As distinct from meditation and respiratory sinus arrhythmia (RSA)-induced states of consciousness, heart rhythm coherence is experienced as a positive emotional state of relaxed alertness, which is consciously induced through focussing attention on the heart, intentionally breathing into the heart area and cultivating a positive emotion from this area of the body. Sportspersons describe this state as 'being in the zone' (McCraty et al., 2006; Murphy & White, 1995).

The physiological and psychological qualities of the heart, especially in relation to the breath, have been recognized in various wisdom and spiritual healing traditions for many centuries, for example, as Yogic middle chakra and Christian sacred heart (Edwards, 2013). The general systemic, holographic theory of McCraty et al. (2006) postulates that of all the bodily organs, the heart generates the most powerful, comprehensive, rhythmic electromagnetic field, whose information patterns network with various environmental energy fields. Through HR variability patterns, the heart orchestrates and synchronizes neurological, biochemical, and biophysical information of nerve impulses, neurotransmitters, hormones, pressure waves, and electromagnetic field interactions (Acharya, Joseph, Kannathal, Lim, & Suri, 2006). The heart also has the most extensive neural connection with the brain. Electroencephalographic rhythms, especially in the alpha activity band of 8–12 Hz, naturally synchronize with and entrain to heart rhythms (McCraty et al., 2006).

Motivation for this study was specifically provided through literature review of the Institute of HeartMath research library and personal communication with Rollin McCraty, Director of HeartMath Research. The study is an extension of previous research indicating the psychological effectiveness of heart and breath consciousness workshops (Edwards, 2012a, 2012b, 2013). The specific goal of this small-scale, pilot study was to evaluate the influence of heart rhythm–based physiological coherence training of at least five sessions on quantitative dependent variables of physiological coherence, as measured on an emWave2 apparatus, and standardized psychological measures of sense of coherence, general health, mindfulness, and spirituality, as well as participants' qualitative, evaluative experiences of the training. In view of the reported effectiveness of the independent, variable heart rhythm feedback training (McCraty & Tomasino, 2004), it was hypothesized that training would be associated with improvements in all dependent variables over time.

Method

Design

This small-scale study required a pre- and post-test, within-subjects outcome evaluative design. Integral psychological, mixed, quantitative, and qualitative methods were employed (Creswell & Plano-Clark, 2007; Terre Blanche, Durheim, & Painter, 2006; Wilber, 1997, 2000, 2007).

Participants

The participants were a small convenience sample of 10 adults, selected for their proximity to the researcher, commitment to participate in the research, and willingness to explore, describe,

explicate, and articulate their experience. While such qualitative research selection criteria have certain advantages in small-scale, pilot-type evaluative research as this study, they do present the methodological limitation of social desirability. This limitation can be addressed through further randomized controlled studies with larger samples. All participants were English-speaking. There were six women and four men, with a mean age of 44.8 years and an age range from 23 to 78 years.

Procedure

The study was introduced to participants with the above-mentioned emWave2 rationale of heart focus, heart breathing, and heart feeling. All were informed that research on heart rhythm coherence feedback training had indicated various physiological and psychological benefits, such as blood pressure reduction and sustained positive emotions. All understood that as participants, they would be assisting with quantitative evaluations of the effect of an emWave2 biofeedback apparatus on physiological coherence, and perceptions of sense of coherence, general health, mindfulness, and spirituality, as well as qualitative evaluations of their experiences of training. After pre-testing on all quantitative measures, participants completed at least five emWave2 biofeedback sessions, with a mean of 10 sessions and a range from 5 to 15 sessions. The duration of practice ranged from 4 to 101 days, with a mean of 33 days. At post-testing, all participants were retested on the quantitative measures and provided written descriptions of their experiences and evaluation of the training.

Ethics

All participants were informed of the nature of the research and provided written consent with regard to the use of the information for publication purposes. It was considered to be proper ethical procedure that participants were fully informed as to HeartMath research whatever experimenter effect this might possibly have on the outcome due to their enhanced positive expectancies. Participants were guaranteed nominal confidentiality and advised as to their right to withdraw from the research at any stage.

Measures

The emWave2 biofeedback apparatus was used in this study. When attached to a laptop computer, the instrument gives readings of HR variability, time elapsed, as well as low, medium, and high levels of physiological coherence as defined above. Feedback consisted of red-, blue-, and green-coloured bars with percentage indications and accompanying tones for low, medium, and high coherence levels, respectively. Further feedback was provided by a cumulative coherence graph with a demarcated area for coherence indicating the zone of optimal autonomic nervous system functioning. A feedback tone is provided when 100 coherence points accrue. The apparatus, approximately 2 × 3 inches in size, can be handheld or attached to a computer, for physiological coherence biofeedback purposes.

The adapted Sense of Coherence (SOC) measure consisted of a shortened 9-item version of Antonovsky's (1987) scale, with a Cronbach's alpha reliability coefficient of .79. Antonovsky's (1987) original scale has three subscales, which measure the degree to which participants perceive their world as manageable, meaningful, and predictable. The shortened version used in this study has been shown to demonstrate high internal reliability and concurrent validity when assessed against Antonovsky's original 29-item measure (Klepp, Mastekaasa, Sorensen, Sandanger, &

Kleiner, 2007). Participants reported their feelings in relation to items such as, 'Do you have the feeling that you don't really care about what goes on around you?' on nine 7-point Likert-type scale items anchored by the descriptors *very often* to *very seldom*.

The General Health Scale consisted of an adaptation of the General Health Questionnaire (GHQ-12; Goldberg & Williams, 1988), which is intended to screen for general psychiatric morbidity. Although it has not been standardized in South Africa, it has been widely used internationally and, as a result, translated into many languages and extensively validated in general and clinical populations worldwide. A recent study conducted in the United Kingdom indicated that reliability of this model was over-estimated by the reported Cronbach's alpha of .90 for the Likert scoring method and that a more realistic estimate of reliability was .73 (Hankins, 2008). The adapted version used in this study consisted of 12 items, 6 positively phrased and 6 negatively phrased, with a 4-point Likert scale ranging from 1 to 4, respectively requiring responses of *strongly agree*, *agree*, *disagree*, and *strongly disagree*.

The Mindfulness Inventory consisted of an adaptation of the 14-item Freiburg Mindfulness Inventory to include a present moment orientation (Wallach, Buchheld, Buttenmuller, Kleinknecht, & Schmidt, 2006).The 14-item scale is recommended for general, non-Buddhist mindfulness contexts. The responses to items were scored on a 4-point Likert rating system as *rarely, occasionally, fairly often*, and *almost always*. Scores range from 14 to 56. Factor analysis of test–retest versions of the original 30-item scale with a sample of 115 participants supported the view of mindfulness as a general construct of interrelated facets, with high internal consistency at both measurements (Cronbach's alpha coefficients of .93 and .94, respectively). This was supported in further validation research with a sample of 156 participants, indicating that the 14-item scale can be considered the core of the mindfulness construct, having a Pearson correlation coefficient of $r = .95$ with the 30-item scale, and a reliability coefficient of alpha = .86 (Wallach et al., 2006).

The Spirituality Scale consisted of a 12-item adaptation of Delaney's (2005) Spirituality Scale. This was standardized with a South African sample of 302 participants, and a short 12-item version (SS-12) of the scale was developed (Edwards, 2012c). Reliability analysis for the SS-12 as a whole indicated a very satisfactory total scale alpha coefficient of .82. Responses to items were scored on a 4-point Likert rating system graded from *strongly disagree* to *strongly agree*.

Although only the Spirituality Scale was previously standardized for South Africa, this is not necessarily a limitation in the context of the present small-scale study with its within-group, test–retest design.

Data analysis

Quantitative data were analysed using the Statistical Package for the Social Sciences (SPSS), with specific reference to non-parametric comparisons of means using Wilcoxon *Z* statistics. Physiological coherence data comparisons were made between the mean scores of the first and second half of the total number of sessions for each participant; so strictly speaking, this is a baseline–post-test comparison; however the pre-test–post-test comparison terminology is retained for convenience purposes. When the number of sessions was uneven, the median session was ignored. Psychometric comparisons were made between pre-test and post-test scores on the respective scales. Qualitative data in the form of participants' phenomenological descriptions and evaluations of the workshop were analysed into natural meaning units of experience and synthesized into collective experiences and evaluations. The conventional probability level of $p < .05$ was set for all statistical comparisons (Bryman & Cramer, 2008; Terre Blanche et al., 2006).

Table 1. Pre-test and post-test means and standard deviations (SD).

Measure	Pre-test	*SD*	Post-test	*SD*	Wilcoxon *Z*	*p*
LO	33.7	22.17	19.8	11.81	2.431	.015*
ME	20.1	9.16	18.4	9.40	1.127	.260
HI	45.4	27.80	62.0	18.84	2.501	.012**
Time	10.9	5.26	7.8	2.44	2.254	.024*
HR	68.8	11.55	65.7	10.13	1.127	.260
SOC	45.4	5.19	50.5	6.06	2.668	.008**
Health	33.7	3.59	38.5	3.54	2.809	.005**
MIND	39	6.24	44.1	3.96	2.255	.024*
Spirit	39	7.80	43.9	4.41	2.821	.005**

LO: low; ME: medium; HI: high; HR: heart rate; SOC: Sense of Coherence; MIND: Mindfulness.
Significant comparisons at the 5% and 1% level are designated with single and double asterisks, respectively.

Results and discussion

Quantitative physiological coherence and psychological findings

Table 1 refers to pre-test and post-test means and standard deviations (SD) for measures of low (LO), medium (ME), and high (HI) physiological coherence; HR; time taken (Time); SOC; and Health, Mindfulness (MIND), and Spirituality (Spirit) perceptions.

Table 1 indicates that the coherence training was associated with significant mean score decreases in low physiological coherence – $Z = 2.431$, $p = .015$ – and significant mean score increases in high physiological coherence – $Z = 2.501$, $p = .012$. This was associated with significant decreases in time taken – $Z = 2.254$, $p = .024$ – accompanied by non-significant decreases in medium coherence from a pre-test mean of 20.1 to a post-test mean of 18.4 and non-significant decreases in HR from a pre-test mean of 68.8 to a post-test mean of 65.7 beats/min. Thus, findings from the physiological coherence measures provide support for all research hypotheses except for medium coherence and HR. However, mean decreases are in the expected direction on the two dependent variables.

Concerning psychological perceptions, Table 1 indicates that coherence training was associated with significant increases in scores on measures of sense of coherence: $Z = 2.668$, $p = .008$; health: $Z = 2.809$, $p = .005$; mindfulness: $Z = 2.255$, $p = .024$; and spirituality: $Z = 2.821$, $p = .005$. Thus, findings from the psychological measures findings provide significant support for all research hypotheses for these dependent variables. These findings are amplified in greater depth in the following qualitative and integrative findings.

Qualitative, experiential, and evaluative findings

Qualitative descriptions and group summaries of the 10 participants follow, coded A to J, respectively. The specific, uniformly positive responses attested to the value of the training as experienced and evaluated by participants.

Experiential descriptions

A. After completing the heart based coherence training, I feel as if I have gained a deeper understanding of how to control my physiological behaviour (1) and how to understand correct timing when engaging with others in society (2). I cannot always have my own way but everyone will have an opportunity (3).

B. My experience of the program is different from any other meditation or contemplation that I have practiced over many years (1). It is essentially a relaxed yet focused experience similar to one I many years ago when preparing for and participating in sporting competitions (2). This is a way of controlling arousal levels so as not to be too worked up or too relaxed (3). This relaxed focused state is now typically referred to as 'being in the zone' (4). This is a flourishing, optimal state of consciousness, health, wellbeing, integrity, preparedness for and openness to each moment (5)

C. Initially I found it very difficult to get into the 'zone' (1). I became anxious wanting to succeed (2). I was not able to maintain concentration and became discouraged (3). Finally I was able to let go, breathe and just feel and listen to my heart and say a mantra (repetitive word or phrase) about Jesus (4). I am now getting into the zone (5).

D. I am writing this in the quiet space of 2:00am, the only time in my home I can find some quiet space for myself (1). My first experience of HeartMath was rewarding (2). It took place in my parents home, they were helping to look after the children (3). I quickly entered a coherent state and remained there for the 20 minutes (4). I thought it was too easy (5). The second session was interrupted by my father and daughter (6). I used it to prepare for an anxiety-provoking situation in which I was faced with the possibility of the suicide of a long-term patient (7). I noticed how in heart focus, I remained steady, and how I became more incoherent when I lost this focus (8). Later on, I could not achieve a coherent state after an intense interaction with others, and coinciding with feeling pulled away from myself through anxiety and possibly also need for approval from others (9).

E. I thoroughly enjoyed the heart and breath focused learning experience and peaceful feeling (10).

F. I originally found it quite easy to do. This was the first example of this (1). And then for the next and following on times more difficult (2). I was very sidetracked mentally and found focussing on what I should be doing rather difficult (3). I was more relaxed now and seemed to be able to get into it better (4).

G. My initial practice was undertaken in a slightly noisy environment. This had an impact on my coherence levels (1). It took me almost 20 minutes to get above the 100 level (2). However the distractions were also beneficial. During this initial practice, I learnt to really focus on the three steps of heart focus, heart breathing and heart feeling (3). As I continued to practice, I would firstly focus more on my breathing rhythm and then move onto the three steps (4). I was able to reach the 100 level each time normally in about 4/5 minutes (5). I found myself focusing mostly on the feeling of love (6). I experienced it growing like a ball of light. It seemed to get bigger and bigger (7). I was able to recreate this experience during most of the other occasions (8). I could feel the positive effect which the practice had on me. I felt more relaxed, revitalized and at peace (9).

H. I found the experience of the feedback to be very appropriate and was in conjunction with the mind set that I set for myself (1). By altering one's breathing pattern, and one's mind set, you can achieve a greater sense of peace, which shows in the feedback given by the programme (2). It was fascinating to see how the mind and heart can function together, and how your whole body output is transformed when you concentrate on making the two organs work together (3).

I. My experience of using the emWave2 programme has been great (1). It is easy to use, and it really puts into perspective how important it is for the heart and the brain to function coherently (2). It has helped with my day to day routine of waking up and going to bed, as I practice the breathing and getting myself into a peaceful place (3). The experience has had a positive effect on my daily outlook (4).

J. At first I could not notice a difference in myself when I was getting red, blue or green (1). I wanted to do well, so was focusing on that. I was trying to logically do what I thought I should to 'make it work' (2). I was too much in my head and following the formula I was given as guide (2). When I let all of that go, and stopped thinking and just being in my body and feeling, it all came together. I listened to, and followed, my heart (4).

Collective experiences. All participants describe learning involving consciousness transformations. A, B, and H assimilated the experience into established meditation, breath and/or arousal control methods. C, J, and G had to overcome initial struggles involving anxiety, achievement orientation, and distraction; D and F had to work harder after easy beginnings; and A, E, H, and I noted improved understanding and peaceful feelings. All participants experienced some focus on heart, breath, and positive emotion (A1, B2, C4, D8, E1, F3, G3, H1, I2, and J4). Other specific techniques included using a mantra (C4) and imagery (G7). Coherence, being in the zone, balance, and control were central themes (A1, B4, C5, D4, G1, H3, I2, and J4). Specific positive emotions included peace (E10, I3) and love (G6).

Evaluative descriptions of the programme

A. The program was positive and allowed me to gain a sense of control over my self and understand my environment (1).

B. My evaluation is that the emWave2 machine is a very useful and adaptable biofeedback resource for health, sport, exercise, performance and/or meditation contexts (1). It can be used for training body, mind and spirit, which will have many emotional, social and ecological spin-offs (2).

C. I feel it is valuable and feel encouraged to practice it regularly (1). It helps me to become centred, calm and focussed, not only during the sessions, but in daily situations (2). I recommend it highly as means to gaining health and peace (3).

D. I enjoyed the process of gradually and incrementally building up a greater coherence (1). I did this with increased focus and less attention paid to the feedback, which was distracting at times (3). I recognize the need to practice this as one would practice scales (4). I am sure I have a sense of tighter boundaries of self and ability to assert myself (4).

E. I have no doubt that the sessions were of health benefit, both physically and spiritual (1).

F. I find it a little too early to give this an accurate evaluation (1). I have been very stressed and side tracked because of me going away and getting my work in order (2). I should be a bit more focussed when I get back (3).

G. I thoroughly enjoyed the programme (1). The three components of heart focus, heart breathing and heart feeling are ideal for such practice (2). When I found it difficult to set aside the time to do the daily practice, I remembered the benefits of it and the positive feeling I felt afterwards (3). This was a great motivator for continued practice (4). I could feel the positive effects, even after a few minutes of practice (5). I would strongly recommend others partaking in such a programme (6). Regular practice could have great spiritual, health and well-being benefits (7).

H. I found it quite difficult to do the first time, even though I had experienced similar at a local clinic although the breathing technique he used was slightly different (2). On the first session I think I tuned into the deep dong sound, it was a little distracting (3). This was less distracting the next time and towards the end of the program I was able to tune out more to the chimes (4). I did feel calmer after a session, which was happening at a very busy time for me (5). I will definitely use the breathing in the future (6).

I. My experience of using the emWave2 programme has been great (1). It is easy to use (2), and it really puts into perspective how important it is for the heart and the brain to function coherently (3). It has helped with my day to day routine of waking up and going to bed, as I practice the breathing and getting myself into a peaceful place (4). The experience has had a positive effect on my daily outlook (5).

J. I think it will be a useful ‘skill’ in my busy life, to sit down and take stock every so often and centre myself again (1). It is interesting and engaging to have such direct feedback while doing the HeartMath (2). I would like to read more and practice to see the benefits (3).

Collective evaluation. Evaluations combined objective and subjective perceptions corresponding to the quantitative and qualitative data, respectively. Objectively, the emWave2 programme was judged to be a positive (A1, G3, and I5), valuable (C1), useful (B1, I2, and J1), and adaptable biofeedback resource (B1) and skill (J1) for health (B1, C3, E1, and G7), sport, exercise, performance, and/or meditation and daily life contexts (B1). Its particular value related to direct, incremental provision of psychophysiological coherence through biofeedback training (C1, D1, and H2) for human physical, emotional, mental, spiritual, health, social, and ecological improvements (A1, B2, C3, E1, and G7). It was highly recommended (C3 and G6). Subjectively, the programme was experienced to improve self-control (A1), self-boundaries (D4), environmental understanding (A1), centeredness (C2 and J1), calmness (C2 and H5), focus (C2, D3 and H4), peacefulness (C3 and I4) assertiveness (D4), positivity (G3), daily outlook (I5), and motivation to practise regularly (D4, G4, G7, H6, and J3).

Integrative evaluation

From an integral psychological perspective, emWave2 coherence training can be considered a contemporary, scientific, evidence-based form of heart and breath meditation, contemplation, and/or prayer that has been practised by various spiritual or wisdom traditions, such as ancestral reverence, Hinduism, Judaism, Buddhism, Taoism, Christianity, and Islam for many centuries (Benson, 1996; Edwards, 2012a, 2012b, 2013).

In this study, qualitative experiential and evaluative descriptions meaningfully endorsed the quantitative physiological and psychological findings with regard to the perceived value and effectiveness of the emWave2 heart rhythm biofeedback training on participants' physiological coherence, sense of coherence, health, mindfulness, and spirituality perceptions. Results echo established HR variability findings (Acharya et al., 2006). Similar findings have accrued in other breath and HR variability studies, especially with regard to improved health and spirituality (Edwards, 2012a, 2012b, 2013; Peng et al., 2004; Song & Lehrer, 2003). Findings generally support the claims of McCraty et al. (2006) with regard to the value of psychophysiological coherence training in promoting global, social, interpersonal, physical, mental, and spiritual health. Similar findings of psychophysiological health benefits have been observed in various other forms of biofeedback (Thompson & Thompson, 2003).

Integrative findings generally support various truth claims suggested by Wilber's integral theory (1997, 2000, 2007) towards the study findings being reliable, valid, dependable, credible, and transferable. The research hypotheses of improvements in physiological and psychological variables were supported. Similar international and local psychophysiological training and related programmes are recommended to promote health and well-being. Since this was a small-scale study, findings should be treated with caution. Further research is needed to generalize and/or transfer findings in different contexts with other participant samples and methods. Randomized controlled studies are recommended to control for possible experimenter effect of enhanced expectancies of fully informed participants as to HeartMath research findings. Such randomized controlled studies are also specifically needed for causal inferences to be made with regard to quantitative data.

Conclusion

The aim of the study was to evaluate the influence of heart rhythm–based physiological coherence training with a duration of at least five sessions as quantitatively measured on physiological and psychological measures and as qualitatively assessed in terms of participants' experiences and evaluations of the training. Quantitative findings indicated significant improvements

in physiological coherence, as well as sense of coherence, health, mindfulness, and spirituality perceptions. Qualitative findings indicated meaningful learning experiences and positive evaluations of the emWave2 coherence feedback for health, sport, exercise, performance, meditation, and daily life contexts. Further controlled research investigations are encouraged.

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Declaration of conflicting interests

Any opinion, finding, and conclusion or recommendation expressed in this material is that of the author, and the National Research Foundation (NRF) does not accept any liability in regard thereto.

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