Rollin McCraty's Comments on literature review article by Jan Houtveen et. al titled Questing the working mechanism of slow breathing and Heart Coherence Training.

I have made commented on the authors statements interspaced throughout the article below. My comments are in blue text and the original statements are in black text.

Slow Breathing and Heart Coherence Training are increasingly used in regular mental health care in the Netherlands to treat anxiety, depression and stress-related psychological and somatic complaints.

As part of these treatments, the therapist will elaborate on what a low heart rate variability or 'incoherent heart rhythm' (these terms will be explained later) looks like, and how this adversely affects health: "A long-lasting incoherent heart rhythm in the long-term has a negative effect on health and in the short term hinders you to perform optimally. [...] The ever-changing rhythms of the heart influence your feelings, your thinking, the way you give meaning to what you perceive, your learning abilities and your behavior. [...] When the heart is in disorder, it will involve the emotional brain" (quotes from the HeartMath Workbook 2004 and from the book The Instinct to Heal by David Servan-Schreiber 2003).

It is not clear which quotes are from the workbook or the book by Servan-Schreiber. I would caution against statements such as "A long-lasting incoherent heart rhythm in the long-term has a negative effect on health" and "When the heart is in disorder, it will involve the emotional brain" The first is not really supported by the research. It would be more accurate to say long term stress has negative effects of health and for the second, when we're emotionally upset (angry, etc.) it can cause increased disorder to be reflected in the heart rhythms (incoherence). These are not major issues but shared to fine tune the statements mentioned.

I think it also important to reiterate, that HeartMath (HM) is not positioned as a "treatment" for any clinical condition. That does not mean that it cannot be used by health care professionals in conjunction with other modalities or as a standalone process for helping clients learn to better self-regulate their stressful emotions, or to improve performance.

During the sessions and through home assignments the patient will practice techniques to breath slowly and/or reach a coherent heart rate, supported with biofeedback on respiration or variability of the heart rate. These courses are often combined with the 'known' treatment elements such as psychoeducation, emotional regulation and other cognitive behavioral techniques.

Several studies suggest that Slow Breathing and Heart Coherence Training do indeed have a positive effect on mental and physical health, including symptoms of depression, anxiety, post-traumatic stress disorder, medically unexplained syndromes, high blood pressure and lung function (e.g. Lehrer et al 2000; McCraty et al 2003; 2009). A marginal note would be that some remarks could be made on the methodology of a large part of these impact studies: the majority of the studies are pilot studies, and well conducted, randomized and controlled research (RCT) is still scarce. Nevertheless, we do not wish to question the therapeutic efficacy here.

We do, however, wish to question the role of heart rate variability in the working mechanism. For this, two conditions have to be met (in addition to an effect of the treatment): (1) there is a correlation between symptoms and low or suboptimal heart rate variability, and (2) the optimization of the heart rate variability specifically leads to a reduction of the symptoms.

I see a significant error in the logic of this statement. It is incorrect to assume that in terms of an improvement in physiological or psychological state that there first has to be a correlation between symptoms and low or suboptimal HRV. Take hypertension for example, a person with high blood pressure is typically unaware of any symptoms, and both slow breathing protocols and HM coherence techniques have been shown to reduce BP, with no change in experienced symptoms. This is also true for psychological states; often individuals are unaware of their mental and emotional states. The same issue exists for the second aspect of this assumption. For example there can be beneficial improvements in physiological functioning– such as increased reaction times, less tension, etc., that are not apparent as a reduction in symptoms

With that said, the primary focus of HM and coherence training is improved emotional self-regulation. We have discussed in research literature and books that HRV patterns tend to co-vary with emotional states and thus reflect emotional states.[1-5] This has been consistently and independently confirmed by other research groups with a recent study showing that HRV pattern analysis is nearly 75% accurate in determining emotional states.[6] We have also introduced the heart rhythm coherence hypothesis[1] which does suggest that the afferent input from the heart, lungs, facial expressions, etc., can modulate cognitive processes and emotions.

I think it would be helpful to begin by reviewing what we have suggested in the published scientific literature.

“One of the most important findings of our research, however, is that changes in the heart’s rhythmic patterns can also be intentionally generated. This shift in the heart’s rhythmic patterns is one of the physiological correlates of using the HeartMath positive emotion-based coherence-building techniques, which couple an intentional shift in attention to the physical area of the heart with the self-induction of a positive emotional state. We have found that this process rapidly initiates a distinct shift to increased

coherence in the heart's rhythms. This, in turn, results in a change in the pattern of afferent cardiac signals sent to the brain, which serves to reinforce the self-generated positive emotional shift, making it easier to sustain. Through the consistent use of the coherence-building techniques, the coupling between the psychophysiological coherence mode and positive emotion is further reinforced. This subsequently strengthens the ability of a positive feeling shift to initiate a beneficial physiological shift towards increased coherence, or a physiological shift to facilitate the experience of a positive emotion.

While the process of activating the psychophysiological coherence mode clearly leads to immediate benefits by helping to transform stress in the moment it is experienced, it can also contribute to long-term improvements in emotion regulation abilities and emotional well-being that ultimately affect many aspects of one's life. This is because each time individuals intentionally self-generate a state of psychophysiological coherence, the "new" coherent patterns—and "new" repertoires for responding to challenge—are reinforced in the neural architecture. With consistency of practice, these patterns become increasingly familiar to the brain. Thus, through a feed-forward process, these new, healthy patterns become established as a new baseline or reference, which the system then strives to maintain. It is in this way that HeartMath tools facilitate a re-patterning process, whereby the maladaptive patterns that underlie the experience of stress are progressively replaced by healthier physiological, emotional, cognitive, and behavioral patterns as the "automatic" or familiar way of being."[1] (page 41)

"In the course of conducting our studies, we had received numerous reports from individuals able to maintain the psychophysiological coherence mode that their performance in various activities had noticeably improved. These involved faculties and abilities requiring the processing of external sensory information (e.g., speed and accuracy, coordination, and synchronization, such as in sports and the performing arts) as well as processes requiring primarily internal focus (e.g., problem solving, decision making, creativity, and intuition, such as in business and intellectual activities). This led us to postulate that psychophysiological coherence and the associated macro-scale patterns of the temporal organization of the heart's rhythmic activity—heart rhythm patterns occurring over seconds to minutes—also have an important effect on cognitive processes and intentional behavior. Focusing on the nature of the organization of the heart's rhythmic activity, which reflects emotional state, we hypothesize that emotion-driven changes in global psychophysiological function, and the resulting change in the pattern of heart rhythm activity, are also directly related to the facilitation or inhibition of the brain processes involved in cognitive function. In specific terms, sustained positive emotions induce psychophysiological coherence, which, in turn, is reflected in increased heart rhythm coherence. Thus, the greater the degree of emotional stability and system-wide coherence, the greater the facilitation of cognitive and task performance. We call this hypothesis the heart rhythm coherence hypothesis.[1](page 42)

This primary stated focus of the article takes issue with the afferent aspects of the hypothesis. On this point, the article used a very narrow and selective approach of citing literature and never really addresses the hypothesis in any meaningful way, and certainly does not show that afferent inputs to the brain are not involved in modulating cognitive or emotional processes. To try and limit the argument for the case against this hypothesis to one of physiological process and to the conscious perception of symptoms is inappropriate and inaccurate. He also fails to cite the long history of research on this topic (or even mention it) that supports the role of afferent inputs including a well-articulated theory of the process by the person who many consider to be the father of modern cognitive neuroscience.

We performed a literature study to map out both the evidence for these two conditions and the alternative mechanisms; we will also elaborate on our own research.

Again, it was a selective and biased literature review and the hypothesis on the role of afferents in modulation of cognitive and emotional processes was not mentioned or cited. This is to say that we may not have to modify the hypothesis in the future as new research emerges.

First we will discuss some technical and physiological terms such as 'Heart Rate Variability', 'Heart Coherence', 'Resonant Breathing' and 'Heart-Brain Communication'.

RELEVANT TERMS AND ASSUMPTIONS

According to the founders of these forms of treatment both Slow Breathing and Heart Coherence Training are based on the optimization of the heart rate variability.

This is not accurate. As stated above, HM is based on emotional self-regulation. HRV is primarily used to facilitate skill acquisition (of the self-regulation techniques), and as the hypothesis stated in the above quote – the resulting change in the pattern of afferent cardiac signals sent to the brain, serves to reinforce the self-generated positive emotional shift, making it easier to sustain. There are examples of where the emotion is not reflected in either the HRV or afferent systems. This does not mean that they are not involved however. There are many factors which are beyond this discussion.

Heart rate variability is the mostly cyclic variation of the time between heartbeats. Heart rate variability, like sound, consists of waves of different frequencies: very low, low and high tones that may be audible simultaneously. The strength of the heart rate variability is usually indicated separately for different frequency waves:

- Very low frequency wave (VLF): a variability of under 0.04 Hz;

- Low frequency wave (LF): a variability around 0.1 Hz; a wave that corresponds to the variations in blood pressure;
- High frequency wave (HF): a variability between 0.15 and 0.4 Hz; a wave that corresponds to the frequency of breathing; this variation is also known as 'respiratory sinus arrhythmia' (RSA).

In research on the psychophysiological effects of stress, the LF component or LF-HF ratio is sometimes used as a non-invasive index of the sympathetic regulation of the heart, although this is controversial.

Indeed, this is controversial and I am one of a growing number of people suggesting that this is incorrect, at least in resting contexts.

The HF component is used as a non-invasive index of the parasympathetic (vagal) regulation of the heart. When someone starts to breath in a very low frequency (approximately 6 times per minute, twice as slowly as normal), the RSA and the blood pressure control component of the heart rate variability can get in sync with each other.

To clarify language and terms, it is important to distinguish between what is often referred to as “vagal tone” which is not well defined and I find to be a rather vague term (in essence it is a measure how well the vagal nerve is able to transmit neural signals through it) and vagal activity or activation levels of the efferent parasympathetic system. I actually avoid whenever possible terms like “regulation of the heart” and prefer statements like “vagal influence on the heart”.

This type of breathing is called 'Slow Breathing'. The breathing-related RSA component will subsequently shift to the lower frequency of blood pressure control and the LF heart rate variability could therefore increase considerably (Berntson et al 1993). Slow Breathing and Heart Coherence Training both focus on the above described synchronization.

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Agreed

Slow Breathing

In case of Slow Breathing, the specific treatment element consists of a very slow breathing method (about 6 times per minute) to increase the level of heart rate variability in the LF wave, or the strength of the lower tones. This is considered 'resonant breathing' and is a favorable condition of 'sympathetic-parasympathetic synchronization "(Lehrer et al 2000; McCraty et al 2003; Tiller et al 1996; Vaschillo et al 2006). For Slow Breathing it is stated that - through projections of blood pressure receptors to, for instance, the hypothalamus (the stress control center) and the limbic system (the emotional brain) - this will improve the autonomic regulation of the organs and the emotional stability (Lehrer et al 2000; Vaschillo et al 2006). The heart rate variability in the LF wave is then used as a marker associated with the mental (and physical) health.

The statement that "The heart rate variability in the LF wave is then used as a marker associated with the mental (and physical) health is somewhat problematic. It appears that this statement is being made by Leher et al, but I would say it a bit differently. It is true however that a number of studies have shown such associations, but one can have low HRV for a wide range of reasons so this is an over statement if not used in the proper context.

Heart Coherence Training

In Heart Coherence Training the coherence of the heart is especially important. Coherence is measured using the LF (VLF + HF) ratio or the relative LF heart rate variability (McCraty et al 2003; Tiller et al 1996). This is positively related to the heart rate variability in the LF wave and negatively with the heart rate variability in the other frequency waves (the relation between the lower and the other tones)."

This is basically accurate although the methods for assessing coherence were significantly updated.[1]

"For that matter, coherence is a somewhat strange name for this ratio. Coherence stands for the relation between beats, similar to correlation. However, the heart coherence consists of only one beat: the relative LF heart rate variability."

Although I think I understand what he is trying to say here, it is misleading to say that coherence consists of only one beat. Of course we are looking at the patterns embedded in the rhythm over many heartbeats, but the rhythm can become stable at one frequency.

If you try and use the term coherence in the context of one heartbeat, it would be a strange term but that is not the case and coherence is a perfect term as discussed elsewhere.[1, 2] In this context, and context is important when using these terms, a sine wave pattern is often used as an example of what is called- auto-coherence in signal

processing and physics. It is true that the frequency of this naturally occurring rhythm usually occurs in the LF region, but not in all cases.

Heart Coherence Training aims for a state of heart coherence (optimization of the ratio), through a combination of: creating an internal mental state of relaxation, a focus on positive emotions, the focus of attention on the area around the heart, the instruction to breath slowly, deeply and regularly, and biofeedback of the heart coherence with special equipment.

True enough, at least for some of the techniques (but not all). I would not say that a coherent state is always associated with a state of relaxation. Coherence is not necessarily a relaxed state. For example, with training in and practice with the self-regulation techniques, soldiers are able to shift into a coherent state with heart rates well over 100 BPM.

An increase of the heart coherence through the afferent nerve bundles from the heart to the brain (this is called 'Heart-Brain Communication') would have a positive effect on the mental and physical health (HeartMath 2004, Servan-Schreiber 2003).”

Basically correct however, I think the reference (this is called 'Heart-Brain Communication') is used out of context. In our publications we do refer to heart-brain communication, but this is used in a much broader context which includes the afferent pathways that are being referred to in this statement.

It is suggested that this higher state of coherence is associated with a shift in the autonomic balance towards more parasympathetic activity and increased synchronization or balance between sympathetic and parasympathetic regulation.

I may have used the term balance in some older publications, and when taken in the proper context, it does convey the idea that the increased parasympathetic activity is occurring, which is what is meant. The concept of improved neural system synchronization is the main concept.

The fact that the heart rate variability in the LF wave could theoretically also increase through a higher sympathetic regulation, which would actually be less favorable, has not been discussed.

This statement has several assumptions that require comment. I will not discuss this in depth here, as I am in the process of writing a manuscript that addresses this topic in depth. Firstly, the idea that the LF region reflects sympathetic activity is controversial. I would argue that in a normal resting state, the rhythms in the LF region (which is a complex region), primarily reflects baro-receptor activity involved in short-term blood pressure regulation. This reflex is entirely mediated by the parasympathetic system and

in a resting context (even when in a coherent state) has very little or nothing to do with sympathetic activity.

It is a different story in ambulatory HRV recordings where the efferent sympathetic system can modulate both the frequency and amplitude or the heart's rhythms in such a way that the frequency of the sympathetically induced change in the rhythm will overlap with the LF band. The idea of the LF/HF ratio having something to do with the ratio of sympathetic and parasympathetic activity came from cardiologists looking at 24-hour ambulatory recordings and it was later assumed by people doing short-term recordings that this interpretation would be the same in resting contexts. It is not.

Secondly, it is assumed that increased sympathetic activity is less favorable. This is an overly simplistic view and is clearly not always the case. In fact, in 24-hour HRV recordings, many individuals' with mental health issues have HRV indicators associated with low sympathetic activity while the indicators of parasympathetic activity are normal. Importantly, these indicators (VLF power) are most strongly associated with future adverse outcomes. In addition, a more relaxed state is not always appropriate or desirable; it depends on context and condition. This issue of the LF and sympathetic function has been discussed in several publications and mentioned in one of our early papers.[7] In essence the author is on one hand arguing that the LF region is not associated with sympathetic activity, then turning around and saying that it is and that it may not be good to increase LF power.

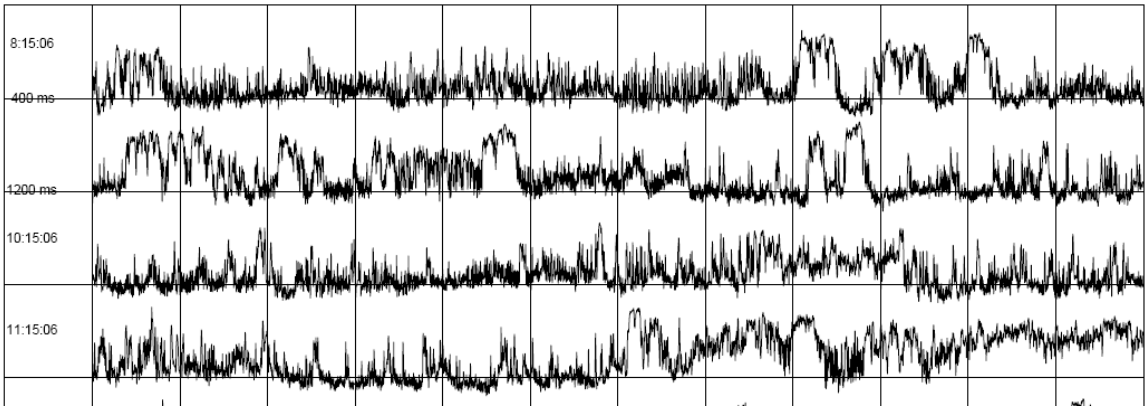
IS THERE A RELATION BETWEEN HEART RATE VARIABILITY AND MENTAL HEALTH?

The first condition for a particular mechanism for optimization of the heart rate variability is the need for a connection between the presence of psychological complaints and low or suboptimal heart rate variability.

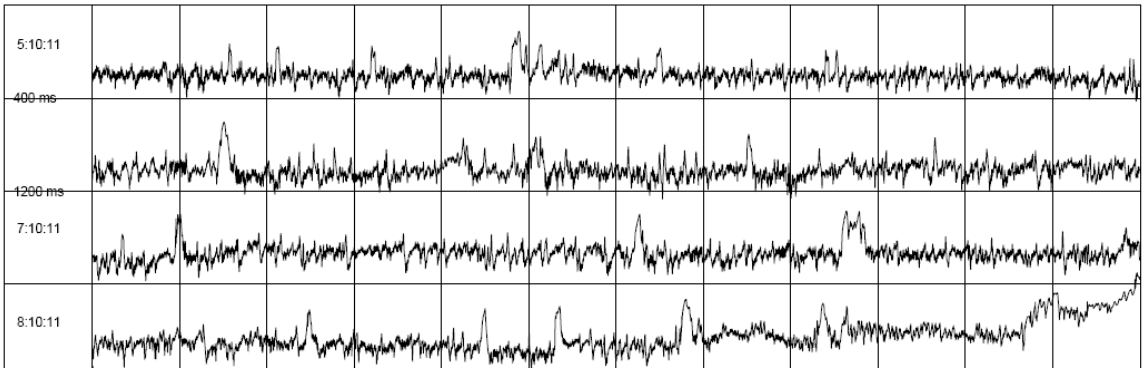
As discussed above, this is not necessarily correct to say there has to be connection between psychological complaints and HRV. Regardless, of the accuracy of this statement his statement, there is a connection between heart rhythms and cognitive and emotional processes that the author has failed to discuss or cite. For example, it was mentioned in an earlier comment that it has been independently confirmed that discrete emotional states can be determined from the HRV patterns. In other words, there is evidence of a connection between HRV and mental and emotional states. However, we have never attempted to say this was casual in the way the author is suggesting – it's just not that simple.

We see many young people with anxiety or other psychological complaints that are still resilient and have normal HRV levels. For example, we tend to see HRV patterns that are clearly associated with chronic anxiety (See example below). The overall HRV is normal and in many cases people with persistent anxiety have "high normal" levels of

age adjusted HRV. They have over active vagal systems (which is independent of what is called vagal tone). I think of this as vagal system chaos that is reflected in the HRV patterns. This could be thought of as suboptimal HRV to use the author term, and we do in fact see this on a regular basis in younger patients with a diagnosis of anxiety. The trend we see is that in old patients with a longer history of anxiety or child hood trauma, the amount of overall HRV becomes either "low normal" or below the normative ranges later in life. There can also be cases where a patient presenting with anxiety symptoms has normal rhythms most of the time (it is not chronic).



Example of HRV pattern above from a person with chronic anxiety



Example of HRV pattern from a normal healthy person the same age as in the example of the person with chronic anxiety.

This demand for coherence can be split up into an intrapersonal - or inner personal - comparison (differences between the states in one single person), and an interpersonal – or intermediary - comparison (differences between individuals).

Intrapersonal differences

We will start with the differences between different states of mind in one person. During a state of rest, the parasympathetic (vagal) regulation of various organs -

including the heart - increases and the sympathetic regulation decreases. During a stress situation, as part of the physiological 'fight-or-flight response', the opposite happens: the parasympathetic regulation decreases and the sympathetic regulation increases. With a fairly constant respiratory movement, the reduction of the RSA component of the heart rate variability will give a reasonably good impression of a stress-related decreased parasympathetic regulation of the heart.

Again I would not use the term "regulation of the heart" – but this is basically correct. Vagal activity or outflow is what we see as reflecting stress states – but it's not just changes in activation as discussed elsewhere.[1, 2]

The key question now is whether in an artificially slow breathing of 6 times per minute the increase in heart rate variability still represents an increased parasympathetic regulation of the heart. This question is relevant because an improvement of the balance between the sympathetic and parasympathetic nervous system - measured with a change in heart rate variability - can be outlined as an important mechanism of the above-mentioned treatment. The answer is: probably not.

On these points I both agree and disagree. The term regulation is problematic and I do not think the idea of balance in this context has any meaning. I would also agree that in short-term resting conditions that HRV is not a good indicator of ANS balance. A more appropriate question regarding ANS balance is: is the relative balance (sympathetic/parasympathetic) appropriate for the task or situation the person is engaged in? Is the nervous system able to respond and adapt to changing demands?

A much better indicator of the relative balance between sympathetic and parasympathetic activity is heart rate. For example, is the HR lower at night when trying to sleep, and is it able to quickly increase when climbing a flight of stairs, etc.?

The use of heart rate variability as a measure of an altered state of autonomic regulation of the heart appears to be controversial, specifically in case of a major change in the respiration (Berntson et al 1993, Ritz 2009). In a state of slow and deep breathing, the RSA can increase dramatically, regardless of the parasympathetic control of the heart (Berntson et al, 1993, see also Figure 1).

We can agree on this point. As mentioned earlier, the idea of vagal tone or how well the vagal nerve is transmitting impulses may not change, at least in the short-term. However, that is irrelevant, as vagal activity is clearly increased with both slow breathing and when in a coherent state as shown in their Figure 1 and many other examples. One of the reasons this is likely important is that slow breathing has been shown by several groups to increase baroreceptor function.[8, 9] Low baroreceptor function is clearly associated with a wide range of negative outcomes in health and has also been linked to depression.[10, 11] As I have pointed out elsewhere, the neurons involved in the baro-reflex system are most responsive to rate of change.[1] Thus by increasing the short term state

specific HRV as clearly occurs during slow breathing and coherence, there is increased potential to improve baroreceptor grain, and the activity of the afferent traffic to the brain. Improved baroreceptor system function is likely one of the mechanisms related to reductions in high blood pressure and BP medications that have been found in a number of studies using coherence training.[12-15]

Moreover, the sympathetic branch of the autonomous regulation of the heart - in contrast to what was originally thought – appears to be hardly reflected in the heart rate variability (Eckberg 1997 Goedhart and others 2008; Moak et al 2007).

On this point I have to disagree, at least with the way it is stated. Sympathetic activity clearly influences HRV. The two references for this statement which are in English do not actually come to this conclusion. They do challenge the idea of LF power reflecting sympathetic activity, which I agree with, especially in resting conditions. I would add that in resting conditions, even with intentional change to the breathing rhythm, that the vast majority of the HRV is mediated via vagal nerves, although is not necessarily all produced by efferent activity associated with RSA.

Deriving the state of autonomous balance from the heart rate variability is risky, and this will certainly go wrong if the respiratory frequency is severely manipulated. In other words, when, through Slow Breathing, the high (RSA) and the low (blood pressure) waves of heart rate variability coincide, the interpretation in terms of autonomous balance will be impossible.

Agreed. As discussed before, using HRV as an indicator of ANS balance is suspect. From my perspective, HRV is more appropriately used as an indicator or regulatory capacity.[16]

Interpersonal differences

The second question about coherence: are there interpersonal differences in low or suboptimal heart rate variability? With regard to physical health factors there are clear indications for differences between individuals: higher age, smoking, the use of coffee and medication, diabetes mellitus and heart diseases are indeed related with a lower heart rate variability (e.g. Hrushesky et al 1984; Tsuji et al 1996). The main question is whether people with psychological complaints such as depression, anxiety or functional somatic symptoms also suffer from abnormal heart rate variability. The finding that in individuals without psychological symptoms a state of stress is often associated with a state of lower heart rate variability does not mean that people with psychological problems show abnormal values.

This paragraph begins by asking about coherence, and interpersonal differences in HRV. All the remaining text is in the context of how much over all HRV an individual has. As is clearly stated in numerous publications, coherence is independent of the amount of HRV one has, or heart rate.[1, 2] This is a significant misunderstanding of coherence and its

potential role as a physiological level mechanism involved in physiological and or physiological benefits.

It is correct that not all individuals with psychological problems have low overall HRV.

Some researchers have indeed found lower values (in particular in the RSA component) in individuals with anxiety disorder (See e.g. Watkins et al 1998), depression (Rotten-Mount 2007), or with functional somatic complaints (Branch et al 2009).

There are many more examples of low HRV in various psychological conditions (PTSD, depression, behavior disorders, panic, etc.). It is not my intent here to provide a literature review, only to point out that a much richer literature exists than was cited which significantly weakens the perspective being presented in this section. The points being made in this section are not really relevant to the main argument regarding mechanisms anyway.

The group differences were small, however, and also the results of the various studies do not appear to be consistent. Our own group, for example, has not been able to show an unambiguous relation between the heart rate variability and a high score on questionnaires for functional somatic complaints, anxiety or depression (Houtveen et al 2003; Houtveen & Van Doornen 2007). Secondary analyses specifically focused on heart coherence show that these persons - compared to a control group - experience more negative emotions in their daily life, but they do not have a lower heart coherence (Houtveen et al 2011).

The above findings are not surprising, especially in the context described. For the coherence measure, although there are some untrained individuals who exhibit periods of coherence in a 24-hour recording, this is rather rare and we do not recommend using coherence as a measure in 24-hour recordings unless it is in a research context where participants have been trained in self-regulation techniques that are expected to increase coherence, and even in this context, we would only expect to see coherence when they are using a technique, or if they are in a resting state and have used the techniques over a long enough time period that the coherent state has become familiar and more automatic. An example for this was indeed found in a study of high school students.[17]

As discussed before, younger individuals with high stress, anxiety and other psychological challenges 24-hour HRV tend to be in normal values or even high normal. Depending on the length of the time, these challenges persist and the severity of them, we are seeing that as they get older, it can start to show up as low HRV values, and not necessarily the only indicators of parasympathetic activity.

The authors of two meta-analyses also come to the conclusion that, for the time being, the evidence for a relation between heart rate variability and mental health is far from convincing (Rottenberg 2007; Branch et al 2009).

What was not referenced here is several studies that show the opposite conclusion[18-24] (There are many more such references). In addition, the Rottenberg study only looked at short-term HRV and only at vagal measures. Although a number of studies do find low HRV indices to be associated with depression and other mental health conditions, many have found that it is the lower frequency measures, which is consistent with our observations.

The interpretation of individual differences in heart rate variability appears to include more pitfalls than the interpretation of differences between states of mind. For a start, the effect of breathing is also valid for the interpretation of RSA differences between individuals; the faster somebody's respiration, the lower the RSA component of the heart rate variability, but this does not necessarily reflect a difference in the vagal (parasympathetic) regulation of the heart.

Agreed, and this point has already been made. I fail to see the relevance of all the discussion in terms of the author's stated objective of the article.

In addition, a genetic component for RSA (up to 55%) has been demonstrated (Kupper et al 2004) that cannot directly be interpreted as individual differences in stress-related vagal activity.

Another disruptive factor is composed of individual differences in exercise behavior. In our own study, the initially found group difference in heart rate variability between people with high versus low levels of functional somatic complaints disappeared after corrections were made for exercise behavior (Houtveen & Van Doornen 2007). For that matter, there are indications that the relation between exercise and heart rate variability is not causally attributable to the exercise behavior itself, but rather to genetic differences that cause both a lower heart rate variability and less exercise behavior (de Geus & de Moor 2008).

Personally I am not convinced of the genetic differences argument. Here again none of the literature with opposing perspectives was cited. One must also take into account the growing literature on early life trauma, chronic stress and epigenetics which shows that psychological states can modify genetic expression. In fact one group of HRV researchers at Emory University has found an association between early childhood trauma and lower VLF power in 24-hor HRV recordings later in life (manuscript in preparation).

Finally, medication appears to be a disruptive factor. Although in the Dutch study on depression and anxiety (NESDA) lower resting values for heart rate variability were

found in people with anxiety or depression (Light et al 2008; 2009), these differences disappeared entirely or to a large extent after corrections were made for the use of antidepressants. A longitudinal follow-up study confirmed the large effect of antidepressants (in the present or in the past) on heart rate variability (Light et al 2010). Summarizing: a lower heart rate variability is probably related to the physical health, but other disruptive factors, such as sports, genetic factors and medication, are probably responsible for the assumed relation with mental health.

Of course HRV is related to physical health and reflects the influence of many factors on one's health. It is well know that HRV should be used as indicator of overall functional status, but does not reflect specific reasons for a depleted system. For example, a person can have low HRV due to physical challenge such as diabetes, or prolonged panic disorder, etc.

I also agree that physical exercise, etc. can improve mental health, and in fact, some of these factors actually support the hypothesis we have proposed, but I will not diverge into a discussion of that here.

If there is no connection, there can be no causality. Nevertheless, supporters of Slow Breathing and of Heart Coherence both claim that optimization of the heart rate variability has a specific beneficial effect on reducing various psychological and stress-related somatic complaints.

This statement is too simplistic and does not allow for the complexity of physiological systems or emotional experience. Causality as used in this context does not allow for a more subtle role that the afferent hypothesis suggests. This can be compared to the role of hormones and neurotransmitters in emotional experience. Do changes in hormones cause emotions, or occur because of them? Most would say both; they result from them and then act to re-enforce or sustain them or to tune the sensitivity and stability of neural systems involved in emotional experience and perception.

Furthermore, from my perspective he has woefully failed to show that there is not a connection. The literature cited was very one-sided and ignored an overwhelming number of studies that do show low HRV is associated with a wide range of mental conditions. But even if no mental health conditions were associated with overall low HRV (and there are examples of this), that has nothing to do with the potential mechanisms of slow breathing or HRV coherence having potential benefits. As stated earlier, the primary focus of HeartMath (coherence training) is self-regulation which is reflected in changes in the HRV pattern, not increased HRV (although increased HRV has been demonstrated). Also, there are clearly examples of people making emotional shifts where the HRV patterns do not change. We have never made the claim for causality in the way he has stated it above.

We do suggest that the afferents inputs to the brain are relevant to both cognitive function and emotional experience. HeartMath was by no means the first to suggest this, and it in fact has a very long history and a significant body of work supports this (none of which was mentioned or cited).

There is growing body of support for the cardiovascular afferent hypotheses, especially on improved cognitive functions.[1, 25, 26] One recent study (In press) that looked at the role of afferent influences on the brain activity during slow breathing, positive and negative emotional states using Heart-beat-evoked Potential analysis, found significant differences in all conditions – a finding which strongly supports the afferent hypotheses.

ARE THERE FEWER COMPLAINTS BY OPTIMIZING HEART RATE VARIABILITY?

Although the lack of a clear correlation between heart rate variability and mental health thus excludes causality, it will nevertheless be looked into separately.

Again, I do not see that in any meaningful way that this comment has been justified.

The second condition for a working mechanism states that specifically influencing (increasing or otherwise optimizing) the heart rate variability would have to lead to a decrease in symptoms. As we indicated before, breathing very slowly (about 6 times per minute) will allow the RSA and the blood pressure control component of heart rate variability to stay in line, which is associated with an increase in heart rate variability in the LF wave and an increase in Heart Coherence. Through communication of the blood vessels and the heart to the brain, this would have a positive effect on the autonomic stability and the functioning of the brain.

Controversial Views

This assumption is based, however, on contentious opinions. To begin with, several experiments with manipulation of the respiration showed that Slow Breathing has no direct effect on the - predominantly vagally regulated - heartbeat (Brown et al 1993; Houtveen et al 2005), nor on the sympathetic regulation of the heart (Houtveen et al 2005).

This is only true in the context of “vagal tone” which I have no disagreement with. However, as previously pointed out, deep breathing most certainly has effects on the vagal activity, HRV and HRV patterns. It is correct that in a resting condition that deep breathing would have little, if any impact on sympathetic outflow to the heart. However, in a context where a person is emotionally reacting and there has been an activation of the sympathetic system (anger, fear, etc.), deep breathing can indeed have effects on reducing sympathetic outflow.

The increase in the LF component of the heart rate variability and heart coherence by Slow Breathing therefore seems independent of a change in the autonomous regulation of the heart.

This is correct, but only in the very narrow perspective of "vagal tone." He is simply repeating the same thing over and over. The point that deep breathing and coherence both change the amount of vagal activity and modulation of the heart rhythm which in turn impacts the patterns of afferent activity that is sent to the brain is never discussed.

Furthermore, it is debatable whether an altered autonomic regulation of the heart has any effect on the autonomic regulation of other organs (cf. Ritz 2009).

Activity levels are clearly changed whether or not autonomic regulation (vagal tone) is. A simple literature search provides many references for this – although the statement is carefully worded in such a way that it twists the facts. It would be debatable if an increase in vagal tone has effects on other organs, although it likely does on other vagally innervated organs. It is very clear that a change in activity can affect other organ systems.

Finally, an increase in the vagal regulation is not necessarily healthy. In literature, vagal over activity is linked to SIDS, asthma and stomach ulcers (Ritz 2009).

This is true in some isolated examples, and I would add that in some chronic anxiety cases they have "vagal system chaos" which is not the same as increased vagal tone which may be a more important factor than is currently recognized. But the fact of the matter is that the vast majority of the literature in both physical and mental health is associated with poor vagal functioning.[27-49]

Here again he is arguing opposite perspectives. First he makes the case for slow breathing not increasing vagal tone (regulation) and then turns around to say that it's not a good thing to do.

Because no consistency or direct relationship was found in the literature between mental complaints and a decreased vagal regulation of the heart, it does not seem a good idea to stimulate vagal regulation of the heart and/or the other organs, because then it will increase to above normal. Fortunately, there are no indications either that Slow Breathing and Heart Coherence Training would lead to that.

What is the point of this paragraph?

Although the autonomic nervous system is probably not directly affected by Slow Breathing, the heart rate variability will increase strongly and the blood pressure variability will increase a little.

Not affected? I can only assume this is a typo.

This information can indeed reach the brain - through blood pressure receptors in the arterial system – and thus potentially influence the functioning of the brain (and the body). The fact that this afferent information could have a significant effect on anxiety, depression or emotional stability remains speculative.

Fair enough, but let's also acknowledge that there is sound theoretical underpinning for this concept and a rapidly growing body of literature that supports the hypothesis that changes in afferent activity and or patterns of activity, independent of changes in amount of activity from the heart, lungs, face, and even body postures indeed affect neural functions in a wide range of brain centers including the centers involved in emotional perception.

Randomized Controlled Trial

In order to elucidate this, we need robust RCTs. Finding differences between Slow Breathing or Heart Coherence Training and a wait-list condition or relaxation condition does not always prove that the effects are specifically attributable to changes in heart rate variability.

Although I agree that RCT would be great to do, I do not think they will ever be able to address the specific question regarding the potential role of the afferent systems having a significant mechanistic role. From my perspective, this requires laboratory based studies that actually incorporate measures of afferent activity and potential interactions between heart and brain activity during various emotional states and physiological conditions such as slow breathing and coherence. As mentioned above, one such recent study does support the afferent hypothesis. However, I agree that more research is clearly needed to confirm or disprove this aspect of the hypothesis.

A well-controlled study of a specific treatment element requires that patients in the control condition strongly believe that they are in the experimental treatment group (a plausible placebo; see Price et al 2008) and therefore a wait-list condition or relaxation condition is not sufficient. In a pilot study (Houtveen et al 2011), we have examined the immediate (i.e. instantaneous) effects of Slow Breathing in a subclinical population of students with a high score on depression. In this doubleblind RCT we compared the effects of three sessions of slow paced-breathing (with the respiration, 6 times per minute, following a curve on a computer) with a plausible placebo condition (paced breathing with normal breathing frequency). The LF heart rate variability and the index used for heart coherence increased, entirely as expected, only in the group with Slow Breathing.

As would be expected.

However, both conditions appeared to have a similar (positive) effect on instantaneous tension immediately after a session, but had no effect on the mood. A specific effect of Slow Breathing could therefore not be demonstrated.

This finding can just as easily be used in support of the afferent hypothesis. Even in the group that used paced breathing at normal rates, there will be a change in the stability (coherent pattern) of the afferent inputs from the lungs and heart to the brain. This finding is also consistent with other studies that used only slow breathing or resonant breathing as the intervention. A number of beneficial physiological changes have been shown with slow breathing only, but this does not appear to be as effective for improving mood or reducing anxiety, depression, etc. as is found with the inclusion of the activation of a positive emotion. The differences between simply using deep breathing and HM (coherence training) have been discussed elsewhere.[1]

However, in this pilot study we exclusively examined the short-term effects of only three sessions of a subclinical group. In a second pilot study, we followed two outpatient groups that were treated for 12 weeks with either a complete Heart Coherence Training or a mindfulness training (Houtveen et al 2011). Both trainings were found to have a significant treatment effect with a slightly greater effect for the mindfulness training. However, both the LF heart rate variability and the heart coherence increased solely due to Heart Coherence Training and not after the (more effective) mindfulness training.

Were there significant differences between the two groups? If not, it is not appropriate to say that one was more effective than the other.

So, a successful treatment does not necessarily coincide with higher heart coherence. In this pilot study, however, there was no randomization.

Agreed. There are lots of beneficial programs and techniques that do not necessarily lead to heart rhythm coherence. But keep in mind that both programs were intended to help participants become more aware of their emotions and ultimately to better self-regulate them.

Further research is therefore needed. For instance, a clinical RCT with plausible placebo with Heart Coherence Training, focused on the specific mechanism of Slow Breathing and Heart Coherence, with respect to the other elements (such as attentional control and recalled positive emotions).

We have only found one study in the literature on the effect of RSA biofeedback that slightly meets the requirement of an RCT with plausible placebo. Sherlin et al (2009) used 'Passive Biofeedback' as a control intervention, where participants did not have to influence anything, but were shown a curve on a screen, based on the heart rate. They were asked to let go of stressful thoughts in order to synchronize their thoughts with

their blood circulation. This was compared to the RSA with active biofeedback. Both the active and the passive biofeedback showed a treatment effect, with only a small difference in favor of the active RSA biofeedback.

Further research will be needed to show what the origin of this minor difference may be.

Agreed

INFLUENCE OF NON-SPECIFIC THERAPY FACTORS

Both Slow Breathing and Heart Coherence Training consist of a combination of: optimizing the heart rate variability (here referred to as 'the element'), general non-specific placebo elements, and elements that are also successfully used in evidence-based treatments such as cognitive behavioral therapy and mindfulness training. In other words, these treatments contain many non-specific therapy factors of which the effectiveness is undisputed, and are therefore scrounged off other evidence-based treatments. In our opinion, the treatment effects can also be explained with these elements.

This rather inflammatory statement indicates a clear and unfounded bias. I suspect many medial historians would take great issue with this statement. There are clearly elements of HeartMath techniques that are common to other approaches. Some of these actually have a very long history, and in fact considerably predate CBT. In can be easily be argued that improved self-regulation is the goal of CBT, and becoming more self-aware of our inner thoughts and emotions is key to the process. CBT certainly did not invent this concept and the western literature tends to trace this back to Descarte, and more recently in the 1880s to William James. However, these ideas have a much longer history in the Eastern traditions which Mindfulness is based on.

According to the PsychCentral website http://psychcentral.com/lib/2007/in-depth-cognitive-behavioral-therapy/all/1/ The roots of CBT began in the 1960s when Beck, a psychiatrist, observed that during his analytical sessions, his patients tended to have an internal dialogue going on in their minds, almost as if they were talking to themselves.

(I can only guess that he never was exposed to meditation, etc.)

“Beck realized that the link between thoughts and feelings was very important. He invented the term automatic thoughts to describe emotion-filled thoughts that might pop up in the mind. Beck found that people weren’t always fully aware of such thoughts, but could learn to identify and report them. If a person was feeling upset in some way, the thoughts were usually negative and neither realistic nor helpful. Beck found that identifying these thoughts was the key to the client understanding and

overcoming his or her difficulties. Beck called it cognitive therapy because of the importance it places on thinking. It's now known as cognitive-behavioral therapy (CBT) because the therapy employs behavioral techniques as well. The balance between the cognitive and the behavioral elements varies among the different therapies of this type, but all come under the umbrella term cognitive behavior therapy." "CBT pays close attention to the relationship between our problems, our behavior and our thoughts."

The same article also states: "How cognitive behavioral therapy works is complex. There are several possible theories about how it works, and clients often have their own views. Perhaps there is no one explanation. But CBT probably works in a number of ways at the same time. Some it shares with other therapies, some are specific to CBT."

We have never said or believed that emotions cannot be set in motion by thoughts or that self-regulating thought is not important. However, we as well as many others are suggesting that the cognitive models are incomplete, and that emotions are far more complex and that often they can and do occur independent of rational thought processes and that by focusing on shifting emotions first, that thoughts will usually follow suit.

Slow breathing has been used in many traditions for thousands of years, long before cognitive based therapies were ever conceived of. There are many scientific references to the benefits of slow breathing, especially for reduced BP, stress management, birthing, etc. The HeartMath system also has significant and growing number of independent studies supporting it effectiveness. In fact several of our programs are in the process of being listed on the US Det of Health and Human Services, National Registry of Evidence-based program and Practices.

This reminds me of a presentation at a recent conference where Dr. Bessel Vanderkolk (a very well-known researcher in PTSD, trauma, etc.) presented data from a large RCT of cognitive behavioral therapy. He pointed out that the data clearly showed it was not an effective treatment, but the authors concluded by saying it was! He also showed data from another study indicating that EMDR was much more effective but this data was being completely ignored by the main stream psychological community (actively denied and dismissed in fact). The clear implication was that the psychology community tends to ignore anything that is not consistent with their cognitive models and monopoly on insurance reimbursed approaches. He also stated that EMDR and HeartMath were two of the more effective approaches from his experience, and the combination was ideal for trauma. Sorry for the diversion, but the author's obvious bias reminded me of this. Now back to my thoughts on the above statement.

The field of positive psychology has rapidly grown in recent years, and new papers on the theoretical aspects of focusing on positive emotions (not just thoughts as CBT does) as well as outcome studies of increasing positive emotions are emerging from this community. The positive psychology movement was kicked off at the American

Psychological Association's Annual Convention in 2001. The idea that people could evoke positive emotions and that this this could be used as an effective approach to building resilience, undoing the effects of stress and negative emotions, treating psychological conditions, etc. was considered by many as revolutionary. It was and is still is met with skepticism by others in the mainstream psychology community.

I would not say that HeartMath invented these ideas either, but we did create intentionally simple techniques that do help people shift emotional states with the introduction of emotional regulation and positive emotion based re-focusing techniques in 1991, long before the positive psychology movement started.

The majority of people who have been trained in cognitive behavioral therapy approaches who take a HM training comment on how unique and different HM is.

We have also discussed how a physiological shift and the resulting change in the afferent inputs to the brain can be an important aspect of the self-regulation process. This is also not a completely new idea and also pre-dates CBT, which does not include this aspect in their models, ie, the body just carries the head around and has nothing to do with cognition or emotions. We also suggested that one's psychological and physiological base lines could be re-set which now has empirical support from a study of high schools students.[17] This idea was an extension of existing theory discussed elsewhere.[1, 50]

Formal Mindfulness trainings still do not instruct one to shift ones emotional state (just become aware of the inner feelings and observe) although HM ideas have now been incorporated into many programs that are being called Mindfulness.

I feel it is important to point out that the most unique element of the HeartMath approach, which has not been focused on in many of the training programs or scientific publications until more recently[2, 51-53] is improved access to our heart's intuition. This has always been one of the goals of using HM techniques although it has not been as overtly stated in our training programs until more recently. This is what we mean by the heart's intuitive intelligence. We are suggesting that the intuitive, energetic-heart is what people have associated with their "inner voice" throughout history. This is far more important than the physiological level communication that occurs between the heart and brain.

From our perspective, the energetic heart communicates a steady stream of intuitive information to the mind and brain, which in most cases, we only access small percentages of, because our mind overrides the frequency. As we learn to slow down our thoughts and emotions and attune to our deeper heart feelings, our natural intuitive connection can occur. Thus, we start to self-regulate from a deeper, more intelligent inner reference. This is area that we will be doing more research in coming years. In short, we are saying that everyone has a "larger self" or "higher self" and that

coherence (in the boarder use of the term, not just HRV patterns) increases ones access to our innate intuitive intelligence. Of course we expect this aspect of HM to draw criticism from those who believe there is no such thing as higher capacities, or that intuition is simply related to implicit learning process. Nonetheless, we are confident that in time, it will be verified, and we will stand by this perspective. One of the benefits of coherence training that we most often hear from people is the experience of increased intuitive guidance and synchronicities in life.

Mechanisms of the placebo

The mechanisms of the placebo are extensively described by Frank and Frank (1993) and Price (2008); non-specific therapy factors in breathing training are extensively described by Garssen et al (1992). Important factors include the expectation that a method will work and the desire for change. It is true that the use of innovative, impressive technology (such as the use of biofeedback devices) as well as an apparently sound scientifically physiological story will lead to higher expectations and thus a stronger outcome. The explanation that the symptoms would relate to a breathing that is too high or too fast, or a heart rate variability that is too low or not optimal, could have a corrective effect on possible dysfunctional beliefs (e.g. “I have a life-threatening condition ” or “I'm helpless ”) Correcting dysfunctional beliefs is a proven element of cognitive therapy in the treatment of mood and anxiety disorders and affects even the pathological process with physical disorders, such as heart and vascular diseases.

Combination with other techniques

In addition, Slow Breathing and Heart Coherence Training are usually combined with known techniques for emotional regulation or psychoeducation, to help participants better understand and gain control over their mental state. This will also increase the belief in their own abilities. All this can reduce the symptoms and complaint-related behavior such as avoidance. In conclusion, both Slow Breathing and Heart Coherence Training include elements of relaxation. All these factors have proven to be able to improve the mental and/or physical health (Frank & Frank 1993 Garssen et al, 1992; Price et al 2008).

Of course there are some common elements in any self-regulation approach. Relaxation skills are important, but it again it is incorrect to cast HM in a relaxation model, even though it is an effective method to calm and relax.[1, 2]

Role of the working memory?

In addition to the mentioned non-specific therapy factors, an entirely different mechanism would be conceivable through which Slow Breathing and biofeedback on Heart Coherence could be effective.

This mechanism comes from recent research on the mechanisms of Eye Movement Desensitization and Reprocessing (EMDR) and consists of a metered simultaneous tax on the working memory during the experience of a negative thought, feeling or image (van den Hout et al 2011). This study showed that a breathing exercise puts an equal tax on the working memory as the eye movements applied with EMDR. When replacing the eye movements during retrieval of a bad memory with an exercise in Slow Breathing, this had a similar effect on the reduction of vividness and the emotional tax of the memory. In other words, Slow Breathing and Biofeedback might very well work by taxing the working memory. Obviously, more research is needed into this interesting similarity between EMDR and the mechanisms behind interventions based on breathing and/or biofeedback.

I agree with the above statements and have similar views. The tax on working memory may be an additional mechanism, but may not be fundamental. In EMDR, the movement of the eyes in a rhythmic slow wave manor also creates a large, ordered (coherent) electrical brain rhythm which may also be involved in the mechanisms. It is also possible that changes in afferent inputs to the brain from the heart and lungs are involved in re-setting the brain (a term from EMDR) in a similar manor. This is all interesting speculation at this point.

I find it interesting that he is stating that slow breathing works as well as EMDR which is being shown to be more effective than CBT!

CONCLUSION

According to the available scientific literature, Slow Breathing and Heart Coherence Training probably do have a treatment effect. However, the two conditions for attributing this effect to the suggested operating mechanism are not or hardly being met.

As discussed above the argument for this conclusion has not been justified. The actual hypothesis relating to the potential role of afferents was not discussed in an accurate or meaningful manor and the literate used to support this conclusion omitted numerous publications that support it. I am not claiming that we have it all correct and that our hypothesis will not have to be updated in the future, but this article has not stated anything to suggest that it is incorrect.

For a start, it has not convincingly been demonstrated that an abnormal heart rate variability is a reliable marker for a worsened mental health.

No one that I know of has ever claimed this, although many studies are showing the low HRV is associated with poor physical and mental health.

As far as a connection is perceived, it is probably accidental or apparent (spurious) - it can be explained by confounding factors such as exercise behavior, genetic factors and medication use.

This is not true. – He ignored the substantial literature on this topic that suggests exactly the opposite conclusion.

We therefore conclude that Heart Rate Variability and Heart Coherence are not useful as a physiological marker of the mental health.

I would agree that HRV should not be used as a maker of mental health. But again no one that I know of has ever suggested it should be.

The first condition to be able to speak of a specific mechanism does not find sufficient empirical support. For the second condition for causality, scientific evidence is also problematic. Slow Breathing and Heart Coherence Training also have (besides a treatment effect) an effect on the heart rate variability. It is, however, highly doubtful whether this change represents a change in the autonomic balance, and whether this change is specifically responsible for the treatment effect.

Discussed above and will not be repeated here.

This leads to the following question: how did the treatment effects occur? There are several nonspecific psychological mechanisms conceivable that can explain the effects of Slow Breathing and Heart Coherence Training with much less assumptions. According to the epistemological principle of Ockham's Razor , the simplest explanation with the fewest assumptions is preferred.

Not necessarily! There are countless examples of this not being the case. But I agree that there are likely multiple mechanisms involved in both slow breathing and more in HM approaches. HM has never suggested the afferent hypothesis was the primary mechanism in the system's effectiveness.

How should we now view this training? With positive treatment results it is easy to think: “if it helps, it will do”, after all, the training sessions also contain active therapy factors. But it is not that simple.

For a start, in the communication with a client there is the ethical duty not to lie about alleged mechanisms, and therefore not to use contentious terms such as 'heart-brain communication'.

The bias and judgment this author has is made clear again in the above statement. Of course, it is inappropriate to knowingly lie to a client. As stated in the literate on CBT, the mechanisms are not clear, so are psychologists lying to their clients? There is a lot of supporting evidence for the afferent hypothesis, but more importantly the overall HM model and I will even go so far as to suggest it's just as strong as the cognitive models when viewed from a non-biased perspective. Certainly there have been more studies conducted with CBT, but that's only because it's been around a lot longer and had a small army of psychologists that have to do dissertation studies.

To say that heart-brain communication is a contentious term is silly and uninformed. The term dates back many years in the scientific literature and there are many publications on this topic.

It should be noted, however, that it is also important to give a good and credible rationale for the therapy, because this will strengthen non-specific therapy factors.

Furthermore, as long as we have no control on the specific working mechanisms of this training, it is unclear for whom they will or will not be suited. Therefore, there is also hardly any chance for improvement.

This statement does not make sense! And even if were stated in a way that did, the same can be said of CBT and many other medical treatments!

Finally, offering one therapy will be at the expense of another. We are afraid that diffuse groups of people with mental and/or somatic symptoms will be offered Slow Breathing or Heart Coherence Training, while they might be better off with a treatment according to the rules aimed at active therapy factors and tailored to their specific complaints.

I think this statement reveals the real motive for this article.

From my perspective this article should never have been published, and that it would not have been had been reviewed in a non-biased peer review process. Its primary focus was on one specific element of a hypothesis, and the logic used to suggest the hypothesis is incorrect and has significant flaws. It is full of irrelevant discussions and never accurately states the hypothesis it is attempting to disprove. It also fails to discuss the long history of this hypothesis or cite any of the literature supporting the specific aspect of the hypothesis it is stated as discussing. The author also provides a misleading perspective on what slow breathing and HeartMath are based on. A hypothesis is a hypothesis after all.

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