Research & Publications

Peter Gruenewald
The Quiet Heart. Putting Stress in its Place. Floris Books, 2007.

McCraty R, Atkinson M, Lipsenthal L & Arguelles l. New hope for correctional officers: an innovative program for reducing stress and health risks. Applied Psychophysiological Biofeedback. 2009 Dec;34(4):251-72. doi: 10.1007/s10484-009-9087-0. Epub 2009 May 23.

Zucker TL, Samuelson KW, Muench F, Greenberg MA, Gervitz RN The effects of respiratory sinus arrhythmia biofeedback on heart rate variability and posttraumatic stress disorder symptoms: a pilot study. 2009 Applied Psychophysiological Biofeedback Jun;34(2):135-43. doi: 10.1007/s10484-009-9085-2. Epub 2009 Apr 25.

Lemaire JB, Wallace JE, Lewin AM, de Grood J, Schaefer JP. The effect of a biofeedback-based stress management tool on physician stress: a randomized controlled clinical trial. Open Med. 2011;5(4):e154-63. Epub 2011 Oct 4.

A Gruzelier JH, Thompson T, Redding E, Brandt R, Steffert T: Application of alpha/theta neurofeedback and heart rate variability training to young contemporary dancers: state anxiety and creativity. Int J Psychophysiol. 2014 Jul;93(1):105-11. doi: 10.1016/j.ijpsycho.2013.05.004. Epub 2013 May 15.

Owens, J., Marsh, G.R.: Binaural Auditory Beats Affect Vigilance Performance and Mood. In: Physiology & Behavior, 63 (2), p.249-252, 1998.

Various Authors: Binaural beat technology in humans: a pilot study to assess neuropsychologic, physiologic, and electroencephalographic effects. In: Journal of alternative and complementary medicine 13 (2), p.199-206, 2007.

Wahbeh, H., Calabrese, C., Zwickey, H.: Binaural beat technology in humans: a pilot study to assess psychologic and physiologic effects. In: Journal of alternative and complementary medicine 13 (1), p.25-32, 2007.

Various Authors: Use of binaural beat tapes for treatment of anxiety: a pilot study of tape preference and outcomes. In: Alternative therapies in health and medicine, 7 (1), p.58-63, 2001.

Binaural beat induced theta EEG activity and hypnotic susceptibility: contradictory results and technical considerations. In: The American journal of clinical hypnosis, 45 (4), p.295-309, 2003.

Brady, B., Stevens, L.: Binaural-beat induced theta EEG activity and hypnotic susceptibility. In: The American journal of clinical hypnosis, 43 (1), p.53-69, 2000. Harris, B.: Thresholds of the mind. - USA: Centerpointe Research Institute, 2007.

Traumatology, Vol. 12, No. 1 (March, 2006) EMDR and Low Frequency Stimulation of the Brain. Tasha Rasolkhani-Kalhorn1 and Melvin L. Harper2.

Owens, J., Marsh, G.R.: Binaural Auditory Beats Affect Vigilance Performance and Mood. In: Physiology & Behavior, 63 (2), p.249-252, 1998.

Various Authors: Binaural beat technology in humans: a pilot study to assess neuropsychologic, physiologic, and electroencephalographic effects. In: Journal of alternative and complementary medicine 13 (2), p.199-206, 2007.

Wahbeh, H., Calabrese, C., Zwickey, H.: Binaural beat technology in humans: a pilot study to assess psychologic and physiologic effects. In: Journal of alternative and complementary medicine 13 (1), p.25-32, 2007.

Various Authors: Use of binaural beat tapes for treatment of anxiety: a pilot study of tape preference and outcomes. In: Alternative therapies in health and medicine, 7 (1), p.58-63, 2001. Binaural beat induced theta EEG activity and hypnotic susceptibility: contradictory results and technical considerations. In: The American

journal of clinical hypnosis, 45 (4), p.295-309, 2003. Brady, B., Stevens, L.: Binaural-beat induced theta EEG activity and hypnotic susceptibility. In: The American journal of clinical hypnosis, 43 (1), p.53-69, 2000. Harris, B.: Thresholds of the mind. - USA: Centerpointe Research Institute, 2007.

Biomedical Research 29 (5) 242-250, 2008. Shr-Da Wu, Pei-Chen Lo, Department of Electrical and Control Engineering, National Chiao Tung University. Inward-attention meditation increases parasympathetic activity: a study based on heart rate variability. From the Abstract: "Phenomenon of the heart rate variability (HRV) during various meditation techniques has been reported. However, most of these techniques emphasized the skill of slow breathing (< 0.15 Hz). This paper reports our study on HRV during meditation, which emphasizes inward attention. Inward attention has been an important approach for the Zen-meditation practitioners to enter into transcendental consciousness. Two groups of subjects were investigated, 10 experimental subjects with Zen-meditation experience and 10 control subjects without any meditation experience. We analyzed HRV both in time and frequency domains. The results revealed both common and different effects on HRV between inward-attention meditation and normal rest. The major difference of effects between two groups were the decrease of LF/HF ratio and LF norm as well as the increase of HF norm, which suggested the benefit of a sympathovagal balance toward parasympathetic activity. Moreover, we observed regular oscillating rhythms of the heart rate when the LF/HF ratio was small under meditation. According to previous studies, regular oscillations of heart rate signal usually appeared in the low-frequency band of HRV under slow breathing. Our findings showed that such regular oscillations could also appear in the high-frequency band of HRV but with smaller amplitude."

International Journal of Cardiology, Volume 130, Issue 3, 28 Nov. 2008, Pages 481–484. Sukanya Phongsuphap, Yongyuth Pongsupap, Pakorn Chandanamattha, Chidchanok Lursinsap. Department of Computer Science, Faculty of Science, Mahidol University, Bangkok. Health Care Reform Project, National Health Security Office, Nonthaburi, Thailand. Department of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok
Department of Mathematics, Faculty of Science, Chulalongkorn University, Bangkok. Changes in heart rate variability during concentration meditation. From the Abstract: "This study aims at investigating changes in heart rate variability (HRV) measured during meditation. The statistical and spectral measures of HRV from the RR intervals were analyzed. Results indicate that meditation may have different effects on health depending on frequency of the resonant peak that each meditator can achieve. The possible effects may concern resetting baroreflex sensitivity, increasing the parasympathetic tone, and improving efficiency of gas exchange in the lung."

Gian Mauro Manzoni, Francesco Pagnini, Gianluca Castelnuovo and Enrico Molinari. Relaxation training for anxiety: a ten-years systematic review with meta-analysis. BMC Psychiatry. 2008. 8:41. Conclusion: "The results show consistent and significant efficacy of relaxation training in reducing anxiety. This meta-analysis extends the existing literature through facilitation of a better understanding of the variability and clinical significance of anxiety improvement subsequent to relaxation training."

Ruth Wells, Tim Outhred, James A. J. Heathers, Daniel S. Quintana, Andrew H. Kemp. Matter Over Mind: A Randomised-Controlled Trial of Single-Session Biofeedback Training on Performance Anxiety and Heart Rate Variability in Musicians. PLOS ONE 7(10): e46597. "These findings indicate that a single session of slow breathing, regardless of biofeedback, is sufficient for controlling physiological arousal in anticipation of psychosocial stress associated with music performance and that slow breathing is particularly helpful for musicians with high levels of anxiety. Future research is needed to further examine the effects of HRV BF as a low-cost, non-pharmacological treatment for music performance anxiety."

Kevin Vaughan, Michael S. Armstrong, Ruth Gold, Nicholas O'Connor, William Jenneke, Nicholas Tarrier. A trial of eye movement desensitization compared to image habituation training and applied muscle relaxation in post-traumatic stress disorder. Journal of Behavior Therapy and Experimental Psychiatry, Volume 25, Issue 4, Pages 283-291.

Terri L. Zucker, Kristin W. Samuelson, Frederick Muench, Melanie A. Greenberg, Richard N. Gevirtz
The Effects of Respiratory Sinus Arrhythmia Biofeedback on Heart Rate Variability and Posttraumatic Stress Disorder Symptoms: A Pilot Study. ppl Psychophysiol Biofeedback (2009) 34: 135.

Adaptive Resilience

Research & Publications

Reynolds, W. M., & Coats, K. I. (1986). A comparison of cognitive-behavioral therapy and relaxation training for the treatment of depression in adolescents. *Journal of Consulting and Clinical Psychology, 54*(5), 653-660.
The cognitive-behavioral and relaxation training groups were superior to the wait-list control group in the reduction of depressive symptoms at both posttest and 5-wk follow-up assessments. There was no significant difference between active treatments in their effectiveness for reducing depression. Ss in the cognitive-behavioral and relaxation training conditions went from moderate levels of depression at pretest to nondepressed levels at posttest, and they maintained these levels at follow-up. Improvements in anxiety and academic self-concept were also demonstrated by the active treatments. Findings demonstrate that these short-term group-administered therapies are effective in significantly decreasing depression in adolescents.

George E. Murphy, Robert M. Carney, Mary Ann Knesevich, Richard D. Wetzel, Pamela Whitworth
Cognitive Behavior Therapy, Relaxation Training, and Tricyclic Antidepressant Medication in the Treatment of Depression. Psychological Reports. Volume: 77 issue: 2, page(s): 403-420 Issue published: October 1, 1995
"Outcomes of seven treatment trials comparing cognitive behavioral therapy to treatment with tricyclic antidepressant medication in major depressive disorder have been quite similar to one another. This led us to question whether treatment outcome in time-limited studies reflected a unique effect of cognitive behavioral therapy … For both cognitive behavioral therapy and relaxation training, outcome of depression was superior to that of tricyclic antidepressant medication by endpoint analysis."

P. Cuijpers, Ph.D., Professor of Clinical Psychology, Department of Clinical Psychology, VU University Amsterdam, Van der Boechorststraat 1, 1081 BT Amsterdam, The Netherlands. Is guided self-help as effective as face-to-face psychotherapy for depression and anxiety disorders? A systematic review and meta-analysis of comparative outcome studies. Psychological Medicine, Volume 40, Issue 12, December 2012, pp. 1943-1957
"It seems safe to conclude that guided self-help and face-to-face treatments can have comparable effects. It is time to start thinking about implementation in routine care."

Robert Freedman, James D. Papsdorf. Biofeedback and progressive relaxation treatment of sleep-onset insomnia. Biofeedback and Self-regulation (1976) 1: 253

Taylor, Shelley E.; Klein, Laura Cousino; Lewis, Brian P.; Gruenewald, Tara L.; Gurung, Regan A. R.; Updegraff, John A., Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. *From the Abstract: "The human stress response has been characterized, both physiologically and behaviorally, as "fight-or-flight." Although fight-or-flight may characterize the primary physiological responses to stress for both males and females, we propose that, behaviorally, females' responses are more marked by a pattern of "tend-and-befriend." Tending involves nurturant activities designed to protect the self and offspring that promote safety and reduce distress; befriending is the creation and maintenance of social networks that may aid in this process. The biobehavioral mechanism that underlies the tend-and-befriend pattern appears to draw on the attachment-caregiving system, and neuroendocrine evidence from animal and human studies suggests that oxytocin, in conjunction with female reproductive hormones and endogenous opioid peptide mechanisms, may be at its core. This previously unexplored stress regulatory system has manifold implications for the study of stress."*

Studies by Fredrickson et al., 2003; Tugade et al., 2004; Ong et al., 2006; Bonanno et al., 2007

Soc Sci Med. 1997 Oct;45(8):1207-21. Folkman S. Positive psychological states and coping with severe stress. Center for AIDS Prevention Studies, University of California at San Francisco, USA. *From the Abstract: "Providing care to a spouse or partner who is dying and then losing that person are among the most stressful of human experiences. A longitudinal study of the caregiving partners of men with AIDS showed that in addition to intense negative psychological states, these men also experienced positive psychological states throughout caregiving and bereavement. The co-occurrence of positive and negative psychological states in the midst of enduring and profoundly stressful circumstances has important implications for our understanding of the coping process. Coping theory had traditionally focused on the management of distress. This article describes coping processes that are associated with positive psychological states in the context of intense distress and discusses the theoretical implications of positive psychological states in the coping process."*

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Am Psychol. 2000 Jun;55(6):647-54. Folkman S, Moskowitz JT. Center for AIDS Prevention Studies, University of California, San Francisco, USA. Positive affect and the other side of coping. *From the Abstract: "Although research on coping over the past 30 years has produced convergent evidence about the functions of coping and the factors that influence it, psychologists still have a great deal to learn about how coping mechanisms affect diverse outcomes. One of the reasons more progress has not been made is the almost exclusive focus on negative outcomes in the stress process. Coping theory and research need to consider positive outcomes as well. The authors focus on one such outcome, positive affect, and review findings about the co-occurrence of positive affect with negative affect during chronic stress, the adaptive functions of positive affect during chronic stress, and a special class of meaning-based coping processes that support positive affect during chronic stress."*

Rev Gen Psychol. 1998 Sep;2(3):300-319. Fredrickson BL. University of Michigan. What Good Are Positive Emotions? *From the Abstract: "This article opens by noting that positive emotions do not fit existing models of emotions. Consequently, a new model is advanced to describe the form and function of a subset of positive emotions, including joy, interest, contentment, and love. This new model posits that these positive emotions serve to broaden an individual's momentary thought-action repertoire, which in turn has the effect of building that individual's physical, intellectual, and social resources. Empirical evidence to support this broaden-and-build model of positive emotions is reviewed, and implications for emotion regulation and health promotion are discussed."*

J Am Geriatr Soc. 2000 May;48(5):473-8. Ostir GV, Markides KS, Black SA, Goodwin JS. Department of Preventive Medicine and Community Health, University of Texas Medical Branch, Galveston 77555-0460, USA.
Emotional well-being predicts subsequent functional independence and survival. From the Abstract: "Our results support the concept that positive affect, or emotional well-being, is different from the absence of depression or negative affect. Positive affect seems to protect individuals against physical declines in old age."

J Pers Soc Psychol. 2004 February; 86(2): 320–333. Michele M. Tugade and Barbara L. Fredrickson
Resilient Individuals Use Positive Emotions to Bounce Back From Negative Emotional Experiences. *From the Abstract: "The broaden-and-build theory (Fredrickson, 1998, 2001) predicts that positive emotions are useful in several ways. The present research expanded this theory into the realm of coping, suggesting that positive emotions guide present coping behavior. By examining psychological resilience from subjective, cognitive, and physiological angles, the present investigation provides greater insight into the reasons why resilient individuals are able to effectively cope with stressful experiences, whereas others facing similar conditions do not fare as well. Resilient individuals may recognize the benefits that positive emotions have on negative emotion regulation. As proposed by the broaden-and-build theory (Fredrickson, 1998, 2001) experiences of positive emotions during times of stress prompt individuals to pursue novel and creative thoughts and actions. Thus, through exploration and experimentation, in time they may be able to build an arsenal of effective coping resources that help buffer (psychologically and physiologically) against negative emotional life experiences."*

Journal of Happiness Studies; September 2007, Volume 8, Issue 3, pp 311-333. Michele M. Tugade, Barbara L. Fredrickson. Regulation of Positive Emotions: Emotion Regulation Strategies that Promote Resilience. *From the Abstract: "The regulation of emotions is essential in everyday life. In this paper, we discuss the regulation of positive emotional experiences. Our discussion focuses on strategies aimed at maintaining and increasing experiences of positive emotions. We discuss the importance of these strategies for well-being, and suggest that cultivating positive emotions may be particularly useful for building resilience to stressful events. Then, we explore possible mechanisms that link positive emotions to coping for resilient people, with a focus on the automatic activation of positive emotions while coping. We conclude by discussing alternative models and proposing future directions in the work on positive emotion regulation and resilience."*

J Pers. 2004 December; 72(6): 1161–1190. Michele M. Tugade, Barbara L. Fredrickson, and Lisa Feldman Barrett. Psychological Resilience and Positive Emotional Granularity: Examining the Benefits of Positive Emotions on Coping and Health. *From the Abstract: In conclusion, "positive emotions can be an important factor that buffers individuals against maladaptive health outcomes. Emerging research indicates that finding ways to cultivate meaningful positive emotions is a critical necessity for optimal physical and psychological functioning. Indeed,*

positive emotions are good for your health. With increasing research, we continue to substantiate empirically age-old folk theories about positive emotions and health that have persisted through time."

Personality and Individual Differences; Volume 41, Issue 7, November 2006, Pages 1263–1273. Anthony D. Ong, Lisa M. Edwards, C.S. Bergeman, Department of Psychology, University of Notre Dame, Notre Dame, IN, United States, Department of Counseling and Educational Psychology, Marquette University, Milwaukee, WI, United States. Hope as a source of resilience in later adulthood. *From the Abstract: "This research provided a preliminary investigation of how variations in trait and state hope are associated with positive adaptation to stress in later adulthood. Trait hope and neuroticism were measured by questionnaires and state hope, stress, and negative emotions were assessed daily for 45 days. Results from multilevel random coefficient modeling analyses suggested that daily hope provides protective benefits by keeping negative emotions low, while also contributing to adaptive recovery from stress. The dynamic linkages between daily hope, stress, and emotion were further moderated by individual differences in trait hope. Compared with those low in trait hope, high-hope individuals showed diminished stress reactivity and more effective emotional recovery."*

European Heart Journal (1996) 17, 354-381. Guidelines, Heart rate variability Standards of measurement, physiological interpretation, and clinical use, Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology. *From the Abstract: "Heart rate variability has considerable potential to assess the role of autonomic nervous system fluctuations in normal healthy individuals and in patients with various cardiovascular and non-cardiovascular disorders. HRV studies should enhance our understanding of physiological phenomena, the actions of medications, and disease mechanisms. Large prospective longitudinal studies are needed to determine the sensitivity, specificity, and predictive value of HRV in the identification of individuals at risk for subsequent morbid and mortal events."*

Circulation 1993; 88: 180-5. Algra A, Tijssen JG, Roelandt JR, Pool J, Lubsen J., Department of Cardiology, Erasmus University, Rotterdam, The Netherlands. Heart rate variability from 24-hour electrocardiography and the 2-year risk for sudden death. *From the Abstract: "These findings support the theory that patients with low parasympathetic activity (low short-term RR interval variability) have an increased risk for sudden death independent of other risk factors."*

Circulation 1994; 90: 878-83. Tsuji H, Venditti FJ, Manders ES et al. Lahey Clinic Medical Center, Burlington, Mass. Reduced heart rate variability and mortality risk in an elderly cohort: The Framingham Study.
From the Abstract: "The estimation of heart rate variability by ambulatory monitoring offers prognostic information beyond that provided by the evaluation of traditional risk factors."

Am J Epidemiol; 145:899-908. Dekker JM, Schouten EG, Klootwijk P et al. 1997, Department of Epidemiology and Public Health, Agricultural University, Wageningen, Netherlands. Heart rate variability from short electrocardiographic recordings predicts mortality from all causes in middle aged and elderly men: the Zutphen study. *From the Abstract: "In conclusion, in middle-aged men and probably in elderly men, low heart rate variability is predictive of mortality from all causes. This suggests that low heart rate variability is an indicator of compromised health in the general population."*
Circulation. 1998 May 26;97(20):2031-6.

Heikki V. Huikuri, MD; Timo H. Mäkikallio, MD; K. E. Juhani Airaksinen, MD; Tapio Seppänen, PhD; Pauli Puukka, MA; Ismo J. Räihä, MD; Leif B. Sourander, MD, Division of Cardiology, Department of Medicine, University of Oulu, Finland. Power-Law Relationship of Heart Rate Variability as a Predictor of Mortality in the Elderly
From the Abstract: "Power-law relationship of 24-hour HR variability is a more powerful predictor of death than the traditional risk markers in elderly subjects. Altered long-term behavior of HR implies an increased risk of vascular causes of death rather than being a marker of any disease or frailty leading to death."

Acta Diabetol. 2011 Mar;48(1):55-9. Epub 2010 Sep 16. May O, Arildsen H., Department of Medicine, Region Hospital Herning, 7400 Herning, Denmark. Long-term predictive power of heart rate variability on all-cause mortality in the diabetic population. *From the Abstract: "During the period following the first 5 years, the baseline LF continued to be a significant predictor of mortality. This long-term follow-up study indicates that the*

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LF power is the strongest HRV predictor with regard to mortality. A reduced HRV at baseline still holds prognostic information after 5 years."

BMC Cardiovasc Disord. 2005 Nov 11;5:33. Greiser KH, Kluttig A, Schumann B, Kors J, Swenne CA, Kuss O, Werdan K, Haerting J., Institute of Medical Epidemiology, Biostatistics. Cardiovascular disease, risk factors and heart rate variability in the elderly general population: design and objectives of the cardiovascular disease, Living and Ageing in Halle (CARLA) Study. *From the Abstract: "Heart rate variability parameters offer prognostic information beyond that of traditional risk factors. In the elderly, increased HRV measured on a 10-second ECG is an even stronger indicator of cardiac death than decreased HRV."*

J Clin Neuropsychol. 1982 Sep; 4(3):193-218. Broughton R. Human consciousness and sleep/waking rhythms: a review and some neuropsychological considerations. *From the Abstract: "The relevance of sleep/waking rhythms to issues of human consciousness is reviewed from data in the literature and from personal studies. Consciousness is often considered to be markedly attenuated or absent in sleep. There is, however, much evidence for a rich subjective experience during sleep, much of which is not recalled later. This implies that William James' "stream of consciousness" persists continuously throughout sleep as well as wakefulness, but that problems of memory recall interfere with its being reported as such. Sleeping subjects show selective awareness of external stimuli, with significant stimuli generally leading to awakening and relatively non-significant stimuli, at least at times, being incorporated into the on-going mental activity of REM or NREM sleep.*

Mentation throughout sleep is characterized by a high degree of autonomy and little willful control. Creative insight and problem solving of a very high order may occur in sleep and involve either dreaming or thought-like mentation. Parameters of waking consciousness show possibly sleep-related rhythmic fluctuations at both circadian (24 hr sleep/waking) and ultradian (90-120) min, NREM/REM sleep) rates. Moreover, waking consciousness is markedly influenced by the quality of temporal stability of preceding sleep. A substantial number of so-called "altered states of consciousness" is found to involve primarily or exclusively dysfunction of sleep/waking mechanisms. Cerebral lesions can produce selective impairment of aspects of sleep mentation. It is concluded that further analysis of subjective awareness in sleep or in partial sleep states is very relevant and indeed vital to a more comprehensive understanding of human consciousness."

Psychosom Med. 2004 Jan-Feb;66(1):56-62. Hall M, Vasko R, Buysse D, Ombao H, Chen Q, Cashmere JD, Kupfer D, Thayer JF., University of Pittsburgh Department of Psychiatry, Pittsburgh, PA, USA. Acute Stress Affects Heart Rate Variability During Sleep. *From the Results: "Acute psychophysiological stress was associated with decreased levels of parasympathetic modulation during non-rapid eye movement (NREM) and rapid eye movement sleep and increased levels of sympatho-vagal balance during NREM sleep. Parasympathetic modulation increased across successive NREM cycles in the control group; these increases were blunted in the stress group and remained essentially unchanged across successive NREM periods. Higher levels of sympatho-vagal balance during NREM sleep were associated with poorer sleep maintenance and lower delta activity." From the Conclusion: "Changes in heart rate variability associated with acute stress may represent one pathway to disturbed sleep. Stress-related changes in heart rate variability during sleep may also be important in association with chronic stressors, which are associated with significant morbidity and increased risk for mortality."*

Am Heart J. 2000 Oct; 140 (4 Suppl):77-83. Gorman JM, Sloan RP. Department of Psychiatry, College of Physicians and Surgeons, New York, NY, USA. Heart rate variability in depressive and anxiety disorders. *From the Abstract: "Individuals with high hostility scores and patients with anxiety or depressive disorders have low heart rate variability and may be at increased risk for cardiovascular death associated with coronary heart disease and arrhythmias. After myocardial infarction, depressed patients exhibit higher mortality rates compared with non-depressed patients. Men with "phobic anxiety," a construct that appears to overlap substantially with panic disorder, also have higher rates of sudden cardiac death and coronary artery disease than control populations. The reduction in autonomic nervous system control to the heart may be one link between psychopathology and heart disease. Although tricyclic antidepressants reduce heart rate variability, at least one study has suggested that, in patients with panic disorder, treatment with the selective serotonin reuptake inhibitor paroxetine normalizes heart rate variability. Hence there is potential for the treatment of psychiatric disorders to affect positively the development and course of cardiovascular disease."*

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Psychosom Med. 2009 Jun;71(5):508-18. Licht CM, de Geus EJ, van Dyck R, Penninx BW., Department of Psychiatry, EMGO Institute, VU University Medical Center, AJ Ernststraat 887, 1081 HL, Amsterdam, The Netherlands. Association between anxiety disorders and heart rate variability in The Netherlands Study of Depression and Anxiety (NESDA). *From the Abstract: "This study shows that anxiety disorders are associated with significantly lower HR variability, but the association seems to be driven by the effects of antidepressants."*

Arch Gen Psychiatry. 2008;65(12):1358-1367. Carmilla M. M. Licht, MSc; Eco J. C. de Geus, PhD; Frans G. Zitman, MD, PhD; Witte J. G. Hoogendijk, MD, PhD; Richard van Dyck, MD, PhD; Brenda W. J. H. Penninx, PhD
Association Between Major Depressive Disorder and Heart Rate Variability in the Netherlands Study of Depression and Anxiety (NESDA) FREE. *From the Abstract: "This study shows that depression is associated with significantly lowered heart rate variability. However, this association appears to be mainly driven by the effect of antidepressants. Depression results in unfavorable health outcomes, such as cardiovascular morbidity and mortality. Alterations in the autonomic nervous system have been hypothesized to be an underlying physiological mechanism that may partly explain these unfavorable health outcomes among depressed persons. Such alterations are believed to reduce heart rate variability, a well-known prognostic risk factor for cardiovascular disease (e.g., myocardial infarct and arrhythmias), and mortality. In research on autonomic nervous system correlates of depression, most attention has been focused on low cardiac vagal control, which may impair social engagement and flexible adjustment to environmental demands and may be a major determinant of a reduction in heart rate variability. Cardiac vagal control can be assessed by examining heart rate variability, particularly that in the respiratory frequency range. This part of heart rate variability is also known as respiratory sinus arrhythmia (RSA).In a recent meta-analysis, Rottenberg examined the association between depression and RSA. The meta-analysis summarized 13 studies that reported on RSA measures, with a total of 312 depressed subjects and 374 controls.*

Depressed persons were found to have a significantly shorter RSA, though the summarized effect size was small to medium according to Cohen conventions (d = 0.332). As pointed out by Rottenberg, data collection and analysis differed considerably among the studies and only a few of them had the required sample size to address confounding by lifestyle (smoking, use of alcohol, high body mass index, and low physical activity) and comorbid anxiety. However, many of these factors—substance use, low physical activity, and comorbid anxiety—occur frequently in depression and have been associated with decreased cardiac vagal control.

Finally, antidepressants are a particularly relevant source of potential confounding when examining the association between depression and cardiac vagal control. The suppressive effects of tricyclic antidepressants (TCAs) on autonomic function are already well established. The effect of other antidepressants on autonomic function, however, are not as well studied and inconsistent results have been reported.
The present study reports cross-sectional analyses from a large depression cohort study (Netherlands Study of Depression and Anxiety [NESDA], N = 2981). We examined whether heart rate variability, as indexed by the standard deviation of normal-to-normal beats (SDNN), and cardiac vagal control, as indexed by RSA derived from peak-valley estimation, differed between depressed individuals and healthy controls. The study was sufficiently powered to examine the extent to which these associations are confounded by lifestyle, comorbid anxiety, and effect of antidepressants."

International Journal for Psychophysiology 37 (2000) 121-133. Rod K. Dishman, Yoshio Nakamura, Melissa E. Garcia, Ray W. Thompson, Andrea L. Dunn, Steven N. Blair, Department of Exercise Science, Ramsey Center, The University of Georgia, 300 River Road, Athens, GA, USA. Division of Epidemiology and Clinical Applications, The Cooper Institute, 12330 Preston Road, Dallas, TX, USA. Heart rate variability, trait anxiety, and perceived stress among physically fit men and women. *From the Abstract: "There was an inverse relationship between perceived emotional stress during the past week and the normalized HF component of HRV (P=0.038). This indicates a lower cardiac vagal component of HRV among men and women who perceived more stress. That relationship was independent of age, gender, trait anxiety, and cardiorespiratory fitness. It was also independent of heart rate; mean arterial blood pressure; and respiration rate, factors which can influence HRV and might be elevated among people reporting anxiety and perceived stress. We conclude that vagal modulation of heart period appears to be sensitive to the recent experience of persistent emotional stress, regardless of a person's level of physical fitness and disposition toward experiencing anxiety."*

International Journal of Psychophysiology 63 (2007) 39–47. Jos F. Brosschot, Eduard Van Dijk a, Julian F. Thayer

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Division of Clinical and Health Psychology, Department of Psychology, Leiden University, Leiden, The Netherlands, Department of Psychology, The Ohio State University Columbus, OH, USA. Daily worry is related to low heart rate variability during waking and the subsequent nocturnal sleep period. *From the Abstract: "The finding of a link between worry and low waking and sleeping HRV extends previous findings with HRV (Brosschot et al., 2006). As mentioned, low HRV is a risk factor for CV disease and overall somatic morbidity and mortality, but it also has specific significance for psychopathology (Friedman and Thayer, 1998; Musselman et al., 1998; O'Connor et al., 2005; Thayer et al., 1998; Yeragani et al., 2002). Low HRV is an index of low parasympathetic activity, and as such also an index of disinhibition of sympathoexcitatory neural circuits that are normally under tonic inhibitory control via the prefrontal cortex.*

During worry and other states characterized by vigilance and arousal, priority is given to pre-potent cognitive and behavioral programs, and the prefrontal cortex is taken temporarily "offline." Parasympathetic inhibitory action is withdrawn (i.e. low HRV) and a relative sympathetic dominance associated with disinhibited defensive circuits is released. The result is a pattern of perseverations in cognitive, affective, and autonomic behavior that when sustained for long periods, can be pathogenic, somatically as well as psychologically. Psychopathological conditions such as anxiety, depression, post-traumatic stress disorder, and schizophrenia are all associated with prefrontal hypo-activity and a lack of inhibitory neural processes. This is reflected in poor habituation to novel neutral stimuli, a pre-attentive bias for threat information, deficits in working memory and executive function, and poor affective information processing and regulation (Thayer and Friedman, 2004), all of which have been linked to low HRV (Thayer and Brosschot, 2005). Together, low HRV may be the final common pathway linking psychopathology with psychosomatics, including cardiovascular disease."

Hansen, A., Johnsen, B., & Thayer, J. (2008). Relationship between heart rate variability and cognitive function during threat of shock. Anxiety, Stress & Coping, 9, 1-12. *From the Abstract:" The aim of the study was to investigate the relationship between resting heart rate variability (HRV) and cognitive functions during threat of shock. A Continuous Performance Task and a Working Memory Task were used to measure cognitive functions. Sixty-five male participants from the Royal Norwegian Navy participated. HRV was measured during baseline, test conditions and recovery. Participants were randomly assigned into non-threat and threat groups. Based on the median split of the high frequency (HF) spectral power, groups were divided into two additional groups. Overall, the high HRV participants showed superior performance on cognitive tasks independent of non-threat or threat conditions. During threat condition the low HRV group showed improved performance. Thus, individuals with high HRV were more stress tolerant and resilient in the face of environmental changes. The results from the study might have implications with regard to performance in operational settings, but also for other fields of psychological research such as individual differences, anxiety and coping."*

Integrative Physiological and Behavioral Science; April–June 1997, Volume 33, Issue 2, pp 151-170. Rollin McCraty M.A., Bob Barrios-Choplin Ph.D., Deborah Rozman Ph.D., Mike Atkinson, Alan D. Watkins M.D. The impact of a new emotional self-management program on stress, emotions, heart rate variability, DHEA and cortisol. *From the Abstract: "This study examined the effects on healthy adults of a new emotional self-management program, consisting of two key techniques, "Cut-Thru" and the "Heart Lock-In." These techniques are designed to eliminate negative thought loops and promote sustained positive emotional states. The hypotheses were that training and practice in these techniques would yield lowered levels of stress and negative emotion and cortisol, while resulting in increased positive emotion and DHEA levels over a one-month period. In addition, we hypothesized that increased coherence in heart rate variability patterns would be observed during the practice of the techniques.*

Forty-five healthy adults participated in the study, fifteen of whom acted as a comparison group for the psychological measures. Salivary DHEA/DHEAS and cortisol levels were measured, autonomic nervous system function was assessed by heart rate variability analysis, and emotions were measured using a psychological questionnaire. Individuals in the experimental group were assessed before and four weeks after receiving training in the self-management techniques.

The experimental group experienced significant increases in the positive affect scales of Caring and Vigor and significant decreases in the negative affect scales of Guilt, Hostility, Burnout, Anxiety and Stress Effects, while no significant changes were seen in the comparison group. There was a mean 23 percent reduction in cortisol and a 100 percent increase in DHEA/DHEAS in the experimental group. DHEA was significantly and positively related to the affective state Warmheartedness, whereas cortisol was significantly and positively

related to Stress Effects. Increased coherence in heart rate variability patterns was measured in 80 percent of the experimental group during the use of the techniques.

The results suggest that techniques designed to eliminate negative thought loops can have important positive effects on stress, emotions and key physiological systems. The implications are that relatively inexpensive interventions may dramatically and positively impact individuals' health and well-being. Thus, individuals may have greater control over their minds, bodies and health than previously suspected."

Psychosomatic Medicine, 65, 796–805. Lehrer, P. M., Vaschillo, E., Vaschillo, B., Lu, S.-E., Eckberg, D. L., Edelberg, R., et al. (2003). Department of Psychiatry, Robert Wood Johnson Medical School, 671 Hoes Lane, Piscataway, NJ, USA. Heart rate variability biofeedback increases baroreflex gain and peak expiratory flow.
From the Abstract: "Heart rate variability biofeedback had strong long-term influences on resting baroreflex gain and pulmonary function. It should be examined as a method for treating cardiovascular and pulmonary diseases. Also, this study demonstrates neuroplasticity of the baroreflex."

Journal of Electrocardiology, Volume 23, Supplement, 1990, Pages 85–94. Marie J. Cowan, RN, PhD, Helen Kogan, RN, PhD, FAAN, Robert Burr, MSEE, PhD, Sue Hendershot, RN, PhC, Lynne Buchanan, RN, PhD
School of Nursing, University of Washington, Seattle, Washington, USA. Power spectral analysis of heart rate variability after biofeedback training. *From the Abstract: "These data indicate that subjects who have had sudden cardiac arrest can, through biofeedback/self-management, cognitively increase their HRV over a 5-week period, consequently increasing parasympathetic activity."*

Psychosom Med. 2003 Sep-Oct; 65 (5):796-805. Paul M. Lehrer, PhD, Evgeny Vaschillo, PhD, Bronya Vaschillo, MD, Shou-En Lu, PhD, Dwain L. Eckberg, MD, Robert Edelberg, PhD, Weichung Joe Shih, PhD, Yong Lin, PhD, Tom A. Kuusela, PhD, Kari U. O. Tahvanainen, MD and Robert M. Hamer, PhD, Department of Psychiatry Robert Wood Johnson Medical School, Piscataway, New Jersey, USA. Heart Rate Variability Biofeedback Increases Baroreflex Gain and Peak Expiratory Flow. *From the Abstract: "Heart rate variability biofeedback had strong long-term influences on resting baroreflex gain and pulmonary function. It should be examined as a method for treating cardiovascular and pulmonary diseases. Also, this study demonstrates neuroplasticity of the baroreflex."*

The American Journal of Cardiology, Volume 76, Issue 14, 15 November 1995, Pages 1089–1093. Rollin McCraty, MA[1], Mike Atkinson, William A. Tiller, PhD, Glen Rein, PhD, Alan D. Watkins, MBBS. From the Institute of HeartMath, Boulder Creek, California, USA. The effects of emotions on short-term power spectrum analysis of heart rate variability. *From the Abstract: "In summary, this work extends previous findings by demonstrating that anger produces a sympathetically dominated power spectrum, whereas appreciation produces a power spectral shift toward MF and HF activity. Results suggest that positive emotions lead to alterations in HRV, which may be beneficial in the treatment of hypertension and in reducing the likelihood of sudden death in patients with congestive heart failure and coronary artery disease."*

Applied Psychophysiology and Biofeedback, September 2000, Volume 25, Issue 3, pp 177-191. Paul M. Lehrer, Evgeny Vaschillo, Bronya Vaschillo. Resonant Frequency Biofeedback Training to Increase Cardiac Variability: Rationale and Manual for Training. *From the Abstract: "Heart rate and blood pressure, as well as other physiological systems, among healthy people, show a complex pattern of variability, characterized by multi-frequency oscillations. There is evidence that these oscillations reflect the activity of homeostatic reflexes. Biofeedback training to increase the amplitude of respiratory sinus arrhythmia (RSA) maximally increases the amplitude of heart rate oscillations only at approximately 0.1 Hz. To perform this task, people slow their breathing to this rate to a point where resonance occurs between respiratory-induced oscillations (RSA) and oscillations that naturally occur at this rate, probably triggered in part by baroreflex activity. We hypothesize that this type of biofeedback exercises the baroreflexes, and renders them more efficient. A manual is presented for carrying out this method. Supporting data are provided in Lehrer, Smetankin, and Potapova (2000) in this issue."*

Applied Psychophysiology and Biofeedback, June 2006, Volume 31, Issue 2, pp 129-142. Evgeny G. Vaschillo, Bronya Vaschillo, Paul M. Lehrer. Characteristics of Resonance in Heart Rate Variability Stimulated by Biofeedback. *From the Abstract: "As we previously reported, resonant frequency heart rate variability*

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biofeedback increases baroreflex gain and peak expiratory flow in healthy individuals and has positive effects in treatment of asthma patients. Biofeedback readily produces large oscillations in heart rate, blood pressure, vascular tone, and pulse amplitude via paced breathing at the specific natural resonant frequency of the cardiovascular system for each individual. This paper describes how resonance properties of the cardiovascular system mediate the effects of heart rate variability biofeedback. There is evidence that resonant oscillations can train autonomic reflexes to provide therapeutic effect. The paper is based on studies described in previous papers. Here, we discuss the origin of the resonance phenomenon, describe our procedure for determining an individual's resonant frequency, and report data from 32 adult asthma patients and 24 healthy adult subjects, showing a negative relationship between resonant frequency and height, and a lower resonant frequency in men than women, but no relationship between resonant frequency and age, weight, or presence of asthma. Resonant frequency remains constant across 10 sessions of biofeedback training. It appears to be related to blood volume."

Applied Psychophysiology and Biofeedback; September 2010, Volume 35, Issue 3, pp 229-242. Amanda L. Wheat, Kevin T. Larkin. Biofeedback of Heart Rate Variability and Related Physiology: A Critical Review. *From the Abstract: "Low heart rate variability (HRV) characterizes several medical and psychological diseases. HRV biofeedback is a newly developed approach that may have some use for treating the array of disorders in which HRV is relatively low. This review critically appraises evidence for the effectiveness of HRV and related biofeedback across 14 studies in improving (1) HRV and baroreflex outcomes and (2) clinical outcomes. Results revealed that HRV biofeedback consistently effectuates acute improvements during biofeedback practice, whereas the presence of short-term and long-term carry-over effects is less clear. Some evidence suggests HRV biofeedback may result in long-term carry-over effects on baroreflex gain, which is an area most promising for future investigations. On the other hand, concerning clinical outcomes, there is ample evidence attesting to efficacy of HRV biofeedback. However, because clinical and physiological outcomes do not improve concurrently in all cases, the mechanism by which HRV biofeedback results in salutary effects in unclear. Considerations for the field in addressing shortcomings of the reviewed studies and advancing understanding of the way in which HRV biofeedback may improve physiological and clinical outcomes are offered in light of the reviewed evidence."*

The American Journal of Cardiology, Volume 76, Issue 14, 15 November 1995, Pages 1089–1093. Rollin McCraty, MA[1], Mike Atkinson, William A. Tiller, PhD, Glen Rein, PhD, Alan D. Watkins, MBBS. From the Institute of HeartMath, Boulder Creek, California, USA. The effects of emotions on short-term power spectrum analysis of heart rate variability. *From the Abstract: "In summary, this work extends previous findings by demonstrating that anger produces a sympathetically dominated power spectrum, whereas appreciation produces a power spectral shift toward MF and HF activity. Results suggest that positive emotions lead to alterations in HRV, which may be beneficial in the treatment of hypertension and in reducing the likelihood of sudden death in patients with congestive heart failure and coronary artery disease."*

Applied Psychophysiology and Biofeedback, June 2009, Volume 34, Issue 2, pp 135-143. Terri L. Zucker, Kristin W. Samuelson, Frederick Muench, Melanie A. Greenberg, Richard N. Gevirtz. The Effects of Respiratory Sinus Arrhythmia Biofeedback on Heart Rate Variability and Posttraumatic Stress Disorder Symptoms: A Pilot Study. *From the Abstract: "Recent studies have found a significant association between PTSD and low heart rate variability (HRV), a biomarker of autonomic dysregulation. Research indicates that respiratory sinus arrhythmia (RSA) biofeedback increases HRV while reducing related pathological symptoms. This controlled pilot study compared RSA biofeedback to progressive muscle relaxation (PMR) as adjunctive interventions for 38 persons with PTSD symptoms in a residential treatment facility for a substance use disorder. Both groups were assessed at pre-intervention and 4-week post-intervention. Group × time interactions revealed significantly greater reductions in depressive symptoms and increases in HRV indices for the RSA group. Both groups significantly reduced PTSD and insomnia symptoms and a statistical trend was observed for reduced substance craving for the RSA group. Increases in HRV were significantly associated with PTSD symptom reduction. Overall, these results provide preliminary support for the efficacy of RSA biofeedback in improving physiological and psychological health for individuals with PTSD."*

Biomedical Research 29 (5) 242-250, 2008. Shr-Da Wu, Pei-Chen Lo, Department of Electrical and Control Engineering, National Chiao Tung University. Inward-attention meditation increases parasympathetic activity: a study based on heart rate variability. *From the Abstract: "Phenomenon of the heart rate variability (HRV) during*

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various meditation techniques has been reported. However, most of these techniques emphasized the skill of slow breathing (< 0.15 Hz). This paper reports our study on HRV during meditation, which emphasizes inward attention. Inward attention has been an important approach for the Zen-meditation practitioners to enter into transcendental consciousness. Two groups of subjects were investigated, 10 experimental subjects with Zen-meditation experience and 10 control subjects without any meditation experience. We analyzed HRV both in time and frequency domains. The results revealed both common and different effects on HRV between inward-attention meditation and normal rest. The major difference of effects between two groups were the decrease of LF/HF ratio and LF norm as well as the increase of HF norm, which suggested the benefit of a sympathovagal balance toward parasympathetic activity. Moreover, we observed regular oscillating rhythms of the heart rate when the LF/HF ratio was small under meditation. According to previous studies, regular oscillations of heart rate signal usually appeared in the low-frequency band of HRV under slow breathing. Our findings showed that such regular oscillations could also appear in the high-frequency band of HRV but with smaller amplitude."

International Journal of Cardiology, Volume 130, Issue 3, 28 Nov. 2008, Pages 481–484. Sukanya Phongsuphap, Yongyuth Pongsupap, Pakorn Chandanamattha, Chidchanok Lursinsap, Department of Computer Science, Faculty of Science, Mahidol University, Bangkok, Health Care Reform Project, National Health Security Office, Nonthaburi, Thailand, Department of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Department of Mathematics, Faculty of Science, Chulalongkorn University, Bangkok. Changes in heart rate variability during concentration meditation. *From the Abstract: "This study aims at investigating changes in heart rate variability (HRV) measured during meditation. The statistical and spectral measures of HRV from the RR intervals were analyzed. Results indicate that meditation may have different effects on health depending on frequency of the resonant peak that each meditator can achieve. The possible effects may concern resetting baroreflex sensitivity, increasing the parasympathetic tone, and improving efficiency of gas exchange in the lung."*

David Nunan, Ph.D.; Gavin R. H. Sandercock, Ph.D.; David A. Brodie, Ph.D. A Quantitative Systematic Review of Normal Values for Short-term Heart Rate Variability in Healthy Adults.

Task Force. Heart rate variability: Standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Circulation 1996; 93:1043–1065.

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Coll. Antropol. 29 (2005) 1: 295–300 UDC 612.172:616.1. Goran Miličević, Intensive Cardiac Care Department, General Hospital Sveti Duh., University Medical School Osijek, Zagreb, Croatia. Low to High Frequency Ratio of Heart Rate Variability Spectra Fails to Describe Sympatho-Vagal Balance in Cardiac Patients.