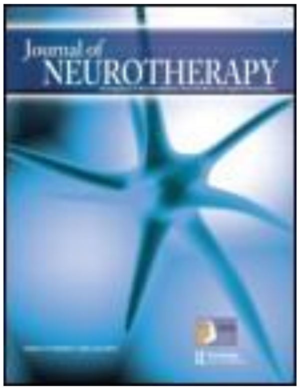

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APPLIANCE OF HEART RATE VARIABILITY BIOFEEDBACK IN ACCEPTANCE AND COMMITMENT THERAPY: A PILOT STUDY

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Mindfulness, defined as a fourfold process consisting of being present with aversive experiences, accepting their aversive content, focusing on the observing perspective, and creating a distinction between content of private experiences and behavior, is an essential part of the so-called third wave behavior therapies, such as Acceptance and Commitment Therapy (ACT). Besides being a behavioral intervention and an important theoretical construct, training mindfulness has been shown to change brain structures and neuronal functioning. In this article the effects and processes of an integrative approach in which heart rate variability (HRV) biofeedback combined with ACT is investigated. Seven clients who were referred to an outpatient facility filled out mindfulness questionnaires (Mindful Attention Awareness Scale) prior and after mindfulness-based HRV biofeedback. In addition mean weighted HRV scores were computed before, during, and after training. Finally, qualitative analyses were performed to investigate specific client–trainer interactions during training as well as subjective training effects and eventual problems resulting from the training. Qualitative and quantitative results were as expected in predefined hypotheses, indicating that HRV training may be an effective way to train the clients' abilities to increase their amounts of HRV and increasing their mindfulness skills. The relationship between HRV as a biological marker and mindfulness are discussed along with the clinical implications of this integrative approach.

Taken from an overall perspective, it is postulated that the efficacy of psychotherapy and neurotherapy depends on the degree to which clients or ''systems'' are capable of learning.

Learning can be defined as the behavioral, cognitive, or emotional result of making optimal use of experiences as they are presented to the organism, so that stable, lasting changes in the central nervous system lead to new, more adaptive behaviors. The ability to learn is reflected in activation of neural circuitry that may lead to long-lasting changes in neural activity (reflecting neuroplasticity) caused by synaptogenesis and neurogenesis (Siegel, 2007). In this respect psychotherapy can be considered a specific form of neurotherapy and psychotherapists therefore as clinical neuroscientists (Cozolino, 2002). However, when psychotherapy, more specifically behavior therapy, and neurotherapy are combined within one integrative intervention we hereby propose the usage of the term ''behavioral neurotherapy.''

If treatment-efficacy is in part the result of the ability to learn, then the question is how to create an optimal learning environment, designed to enhance growth of neurons and the integration of neural networks. Combining therapeutic modalities that create a more enriched learning environment may be of benefit when offered alone or sequentially.

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Such an approach supports a more ''personalized medicine'' orientation to treatment. To this end we started a small-scale research program to study the potentiating effects of integrated treatment modalities. This article presents a study on the therapeutic use of mindfulness and heart rate variability (HRV) biofeedback within a behavioral neurotherapeutic approach. In the Discussion section of this article some ideas are presented on the use of combined treatment modalities, and theoretical issues as well as clinical implications are discussed.

MINDFULNESS

Teaching a client mindfulness skills is an excellent example of an intervention that fits very well within a behavioral neurotherapeutic approach. Although the direct goal is to master a specific ability, for example, being present with one's private experiences as they are elicited at that moment regardless of their aversiveness, it not only may lead to an increase of coping abilities in a number of disorders but also has been shown that mindfulness practice has the potential of activating neural circuitry leading to long-lasting changes in neural activity and brain structure (Pagnoni & Cekic, 2007; Hölzel et al., 2011; Siegel, 2007).

Mindfulness is a relatively new concept in behavior therapy and is becoming increasingly popular with clinicians. On one hand, mindfulness refers to a trainable ability that is applied within certain behavioral therapies, such as Mindfulness-Based Cognitive Therapy (MBCT; Teasdale et al., 2000). Although most famous for being a new evidence-based method in the prevention of relapse in chronic depression, research has shown that mindfulness-based therapies also are effective in several other forms of psychopathology and chronic physical problems (Hölzel et al., 2011). On the other hand, the concept of mindfulness refers to a broader concept, namely, as an inviting, compassionate, and nonevaluative attitude toward one's own experiences, no matter how painful these experiences may be. Mindfulness is theorized to be a compound factor consisting of four core processes in the theoretical model underlying a new behavioral therapy called Acceptance and Commitment Therapy (ACT; Hayes, Luoma, Bond, Masuda, & Lillis, 2006). According to this model (see Figure 1) mindfulness consists of taking an accepting stance toward one's experiences, being able to focus on present experiences, taking a distance from the content of thoughts (cognitive defusion), and being able to focus on the perspective from which one is observing (self as context). As such, mindfulness and the other processes are thought to increase psychological flexibility, the main therapeutic goal of ACT. Psychological flexibility is defined as ''the ability to contact the present moment more fully as a conscious human being, and to change or persist in behavior when doing so serves valued ends'' (Hayes et al., 2006, p. 7).

The main difference between the way mindfulness is taught in ACT versus MBCT is that within ACT mindfulness is trained less formally than in MBCT. In ACT the form of mindfulness exercises is less important than their effectiveness and generalizability to daily life, whereas in MBCT a manualized way to do the exercises is described. Some well-known problems can occur while teaching formal mindfulness skills to clients. Clients may feel aversive toward mindfulness techniques when they have doubts about psychological

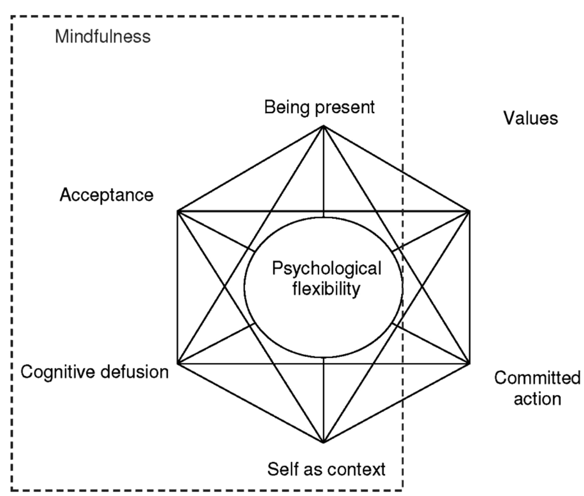


FIGURE 1. The theoretical ACT model.

interventions in the first place. They may not like the ''vague,'' meditation-like techniques. Clients may have religious objections against meditation techniques. Also, clients may feel upset or even unsafe while performing silent meditations, simply because they are not used to ''doing nothing'' or when they are afraid of ''losing control.'' Most of these issues are worth discussing in therapy, and in some cases motivational techniques will be helpful to overcome resistance. However, therapeutic techniques may also be adapted to the preferences of clients.

HRV BIOFEEDBACK

HRV biofeedback involves mastering a specific behavioral ability (e.g., a specific breathing pattern), with the direct goal to increase HRV. In the current article, HRV biofeedback is considered to be a neurotherapeutical intervention that addresses a neurophysiological phenomenon, that is, the increase of HRV that results from a changed interplay between the parasympathetic and sympathetic nervous systems modulated by both the peripheral mechanisms and the central nervous system on the basis of feedback. In this approach behavioral abilities are trained for specific (neuro) physiological purposes that may produce positive effects on psychological well-being and to ameliorate clinical symptoms in a number of health-related disorders. HRV biofeedback can then be described as a behavioral neurotherapeutic procedure. It is generally suggested that this intervention has the potential to modulate the bidirectional neural (vagal) pathways between the central nervous system and the autonomic nervous system. It is hypothesised that these pathways are involved in regulating appropriate social, emotional, and communication behaviors. Hence, HRV biofeedback may have therapeutic value in psychiatric and behavioral disorders that involve difficulties in regulating these behaviors (Porges, 2007).

As stated before, HRV biofeedback is an intervention in which clients are trained to increase their HRV. HRV is a physiological phenomenon where the time interval between heartbeats varies. Spectral analysis techniques can distinguish among the intrinsic sources of HRV, as these rhythms occur at different frequencies. Of importance here are the high frequency fluctuations (0.15–0.4 Hz). These fluctuations, also called *respiratory sinus arrhythmia* (Berntson, Cacioppo, & Quigley, 1993), are associated with a phasic relationship between respiratory activity and heart rate changes. Each inspiration is accompanied with an increase in heart rate influenced by sympathetic nervous system activation, and each expiration is accompanied by a decrease in heart rate influenced by the parasympathetic nervous system activation (McCraty, Atkinson, & Tomasino, 2001). The parasympathetic nervous system type of activation is often described as parasympathetic tone or vagal tone (Porges, 1995). Lower vagal tone equates to higher stress vulnerability. Studies have generally suggested that individuals who have greater vagal influence are quicker to respond to stimuli, respond more strongly, calm down again more quickly, and are more emotionally expressive than individuals whose vagal tone and capacity for vagal suppression is lower (Lehrer et al., 2003). However, with regard to psychiatric disorders Rottenberg (2007) concluded that the suggested relation between cardiac vagal control and depression is suggestive rather than conclusive. In a critical analysis on 13 cross-sectional studies Rottenberg found major depression to exert a small to medium effect size on cardiac vagal control.

Another component of HRV is the low-frequency oscillations ranging from 0.04 to 0.15 Hz including the component referred to as the 10-s rhythm or the Mayer wave. Whereas the high-frequency oscillations are believed to be of more parasympathetic origin, the low-frequency frequencies are both sympathetic and parasympathetic in origin.

Put in clinical terms, HRV biofeedback, as it is applied in many commonly used HRV biofeedback protocols, involves asking individuals to slow down their breathing to a rate of about six times per minute, with about six cycles of HRV within the same period, thus facilitating the increase of a 10-s rhythm. When the proper breathing rate is found, called the individual's ''resonance frequency,'' real-time HR and respiration covary in a perfect phase relationship such that users inhale until their HR peaks and exhale as it falls, until it begins to rise again (Lehrer, Vaschillo, & Vaschillo, 2000; Vaschillo, Vaschillo, & Lehrer, 2004). Some HRV biofeedback protocols, such as the Heartmath protocol we adapted in the current study, add a cognitive intervention to this breathing control procedure (McCraty, Tiller, & Atkinson, 1996) in which clients are asked to focus on pleasant experiences.

Although methodologically sound empirical research on the effectiveness and processes involved in HRV biofeedback is very limited, promising preliminary results have been found. HRV biofeedback has shown significant positive correlations with increased HRV in cardiac patients (Gevirtz & Lehrer, 2003), reduced pain and depression in fibromyalgia patients (Hassett et al., 2007) reduced depression symptoms in patients diagnosed with major depressive disorder (Karavidas et al., 2007), reduced pain in children and teenagers diagnosed with recurrent abdominal pain (Humphreys & Gevirtz, 2000), and improved respiratory function in asthma patients (Lehrer et al., 2004).

Our interest in HRV biofeedback as a possible mindfulness intervention was raised by the focus in the HRV biofeedback protocols on breathing and increasing direct experience. Although mindfulness is conceptually much broader than just slow breathing, and change of experiential content (symptom relief) is not the main aim of mindfulness- and acceptance-based treatments, in many mindfulness practices the focus on breathing and bodily experiences is the starting point for further nonjudgmental observation of other private experiences, such as emotions and thoughts. Therefore we hypothesized that (a) commonly used mindfulness interventions such as mindful breathing and the body scan would probably increase HRV scores and (b) an acceptance- and mindfulness-adapted HRV biofeedback protocol could be a useful instrument to teach clients mindfulness skills.

THE ACT-ADAPTED HRV PROTOCOL

In the Netherlands, a frequently used HRV biofeedback protocol is provided by the Heartmath organization (Culbert, Martin, & McCraty, 2004). McCraty et al. (1996) described the Heartmath protocol as follows:

> The Freeze-Frame technique instructs subjects to consciously disengage from stressful mental and emotional states by shifting attention to the heart, which most people associate with positive emotions, and focus on sincerely feeling appreciation or a similar positive emotion toward someone or something (in contrast to solely mentally recalling or visualizing a past positive experience). Previous experience with this technique has shown that it is an effective method for shifting the focus of attention away from current stressors. The conscious shifting of awareness to a positive emotional feeling state appears to be a key to the successful application of this manoeuvre. (p. 3)

Theoretically, the HRV biofeedback protocol provided by Heartmath organization can be considered to be an application of Brewin's (2006) concept of ''schema retrieval competition.'' Brewin hypothesized that when an individual is experiencing a situation as stressful, what is happening is that cognitive self-schemas with negative content (e.g., helplessness, inadequacy, fearfulness) are winning a competition for retrieval from memory over more positive self-schemas. From this hypothesis Brewin derived that cognitive therapy assists positive self-schemata to win such a competition for retrieval. Therefore, the main goal of the HRV protocol as provided by Heartmath is more or less the same as any other cognitive behavioral therapy protocol, namely, a reduction of symptoms and a change in experiential content.

As stated before, in ACT a reduction of symptoms is not the main goal. Developed from a behavior analytical tradition (Hayes, Barnes-Holmes, & Roche, 2001), in ACT the causality between content of thoughts or cognitions and behavior is denied, and thus the usefulness of interventions aimed at changing content of thought are questioned. Research has confirmed that changing thoughts is not a necessary aspect of effective therapy (Longmore & Worrell, 2007). Instead, ACT aims at increasing psychological flexibility by teaching clients to accept inevitable human suffering and content of cognitions, distancing from this content of thoughts, teaching clients to focus on the observer-self, choose valued life directions and helping clients take committed action toward those directions. In ACT, mindfulness is considered to be a combination of acceptance, cognitive defusion, self-as-context (observer self), and being present, which is being fostered by teaching mindfulness exercises and modeling a mindful attitude during therapy sessions (Wilson & DuFrene, 2009). Therefore, to use HRV within the context of an ACT treatment, the protocol had to be adapted to the theoretical ACT model. The adapted HRV–ACT protocol consists of two separate stages: skill training and exposure.

In the first stage of HRV–ACT, the so-called skill training stage, a client is taught to observe his or her breath as an ongoing flow and use it as a starting point to observe other private experiences as they arise at that very moment, such as emotions, bodily experiences, and thoughts, without taking action upon those experiences. While focusing on private experiences the client is asked to watch the biofeedback provided by the biofeedback computer program. The skill training ends when a client is able to induce medium to high levels of HRV relatively quickly (within a minute), as indicated by the HRV biofeedback software. It should be noted that during skill training the client is not asked to relax his or her muscles or to control his or her breath; instead, the client is asked to observe breathing as a process that is happening at that very moment.

In the second stage, the so-called exposure stage, a client is asked to try to induce an increased HRV while being exposed to conditioned stimuli that are related to negative emotions or cognitions and avoidant behavior. Conditioned responses are elicited by talking about negative experiences that happened in the past or recent history, or by bringing cues to the therapy room that are associated with negative emotions or psychological trauma. In some cases, clients were asked to bring along photographs of significant moments in their past or, for instance, symbolic letters to the person who had violated them in the past. The aim in the exposure stage is to teach the client to continue focusing on breath and private experiences, accepting the aversiveness of the conditioned responses elicited by the cues and refrain from taking any behavioral or cognitive action to diminish or control one's private experiences. In this stage ACT techniques were applied, such as cognitive defusion: A client is taught to observe his or her thoughts from an experiential distance, for instance, by projecting them on the screen above the balloon. Cognitive defusion is aimed at teaching a client to see that his or her thoughts are, in fact, just thoughts. Again, similar to what was taught in the skill training stage, it is important to notice that no control or relaxation procedures were applied during the exposure stage. Instead, the client is asked to observe rather than to control or avoid, regardless of the content of the private experiences. The exposure stage ends when a client is able to quickly (within a minute) induce medium to high levels of HRV while being exposed to negative experiences.

In the current pilot study the following hypotheses are tested: (a) HRV–ACT is applicable as a practical intervention to increase a clients' mindfulness skills and (b) HRV–ACT leads to an increase in qualitative and quantitative measures of mindfulness. More precisely, the following was expected with respect to the quantitative results: an increase in HRV scores from baseline to the end of the skill training, followed by a decrease at the beginning of exposure, and finally an increase in HRV scores at the end of the exposure stage.

METHOD

Sample

The sample of this study consisted of seven nonrandomized Dutch participants (two men and five women, average age = 32.3, age ranging 20–51) who were referred to an outpatient facility for mild to severe psychiatric problems and gave permission to use their data for scientific research. All participants were diagnosed with a *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev. [*DSM–IV–TR*]; American Psychiatric Association, 2000) Axis I disorder, two with major depressive disorder, two with generalized anxiety disorder, one with panic disorder, one with attention deficit hyperactive disorder, and one with an identity disorder. One participant was diagnosed with a comorbid borderline personality disorder on Axis II of the *DSM–IV–TR*. Clients were included if the functional analysis of the problem behavior, as assessed in a clinical interview with a certified health psychologist (MK), indicated that experiential avoidance played a major role in the maintenance of the psychological complaints. Experiential avoidance was defined as a rigid behavioral pattern characterized by avoidance of negatively evaluated experiences, emotions, or cognitions (Hayes et al., 2006).

Intervention: ACT Supplemented with HRV–ACT Biofeedback

HRV measurement started with measuring the baseline HRV–ACT skills. Raw biofeedback data on HRV was provided by the Freeze-Framer program for exactly 10 min without any further intervention or breathing exercises. After baseline measurement the weekly therapy sessions of 45 min each commenced. During one session, three HRV–ACT trials of 7 min were performed. HRV–ACT was provided by a trained ACT therapist with more than 6 years' experience in ACT (MK). After finishing the skill training, the exposure stage commenced. HRV–ACT ends when a client is able to willingly increase his or her HRV levels within 1 min and succeeds to maintain high levels of HRV.

ACT-based HRV biofeedback was provided by means of the Freeze-Framer, an HRV biofeedback system developed by the Institute of Heartmath. The Freeze-Framer consists of a small hardware component including a sensor that is connected to a computer by USB and a software component in which feedback on the amount of one's HRV at a moment is presented to the client in the form of a computer game. In the game a client is asked to fly an image of a balloon over a landscape, in which the height of the balloon is controlled by the clients' amount of HRV. The balloon ascends at higher levels of HRV and descends at lower levels of HRV. One complete HRV trial takes 7 min. HRV–ACT was offered as a complementary intervention next to the usual interventions of an ACT treatment, such as described in ACT handbooks (Hayes, Strosahl, & Wilson, 1999).

Measures

Mindfulness. Self-reported amounts of mindfulness were measured by the Dutch version of the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003; Schroevers, Nyklícek, & Topman, 2008). The MAAS is aimed at measuring "individual differences in the frequency of mindful states over time," by letting respondents rate their opinion on questions such as "I find it difficult to stay focused on what's happening in the present," "I rush through activities without being really attentive to them," and "I find myself preoccupied with the future or the past." According to the developers, the MAAS "is focused on the presence or absence of attention to and awarenessof what is occurring in the present rather than on attributes such asacceptance, trust, empathy and gratitude" (Brown & Ryan, 2003, p. 824). Research on the validity of the MAAS in community samples show the psychometric properties to be adequate (MacKillop & Anderson, 2007). Several translations have been made (Hansen, Lundh, Homman, & Wångby-Lundh, 2009). Mindfulness as measured by the MAAS has shown to be related to important (neuro)psychological aspects of functioning, such as exaggerated lapses of attention (Schmertz, Anderson, & Robins, 2009), physiological functioning (O'Loughlin & Zuckerman, 2007), and secure attachment styles (Cordon & Finney, 2008). Also, the MAAS has been applied as a measure of mindfulness in several clinical samples, such as persons suffering from cancer (Carlson & Brown, 2005) and chronic pain (McCracken, Gauntlett-Gilbert, & Vowles, 2007). Although the direction of the items of the MAAS reflect that a higher score indicates less mindfulness, for the ease of reading this article we reversed the scores after administration, so higher MAAS scores in this article reflect higher self-reported amount of mindfulness. The MAAS was filled in by the clients at two separate times: before and after HRV–ACT.

HRV Scores. HRV scores were collected continually during the HRV–ACT trials by the Freeze-Framer program. Although the program provides the use of five "difficulty levels," for comparability reasons the only level used was Level 2. The program provides normalized HRV scores: low-level HRV (red), medium-level HRV (blue), and high-level HRV (green). At the end of each HRV–ACT trial, the percentage of low-, medium-, and high-level HRV is presented by the program. To increase the distinction between medium and high levels of HRV, the percentage of high-level HRV was multiplied by 2, thus resulting in a weighted HRV score ranging from 0 (*full-time low-level HRV*) to 200 (*full-time high level HRV*). HRV scores used in this study were assessed four times: before training (baseline), after skill training, on the first session of the exposure stage, and at the end of the exposure stage. To compare the results, the mean weighted HRV scores of all participants was computed.

Qualitative Measurement. Directly after every HRV–ACT session, important impressions of the therapist were noted in a logbook, in nonsystemized fashion (no predefined coding system was used). After all qualitative data were collected, the data were sorted into three categories: (a) data on interaction between client and therapist, (b) data on reported effects of the training, and (c) data on problems resulting from the training.

Statistical Analysis

Because of the small sample size, only nonparametrical tests were applied. To compare the difference scores resulting from subtracting the MAAS scores before and after HRV–ACT, difference scores resulting from subtracting HRV scores of the four measurements during HRV–ACT (baseline – end of skill training, end of skill training – beginning of exposure stage, beginning of exposure stage – end of exposure stage) and difference scores resulting from subtracting baseline and end of exposure stage, a series of Wilcoxon Signed Ranks Test was performed. To investigate the influence of experience with meditation on baseline HRV, a chi-square test was performed. Results from statistical analyses were considered significant if $p < .05$. All statistical analyses were performed with SPSS 16.0.

RESULTS

Quantitative Results

In Figure 2 the mean weighted HRV scores per time of measurement are presented, providing an overview of quantitative training results in terms of HRV scores. The difference in mean weighted HRV scores between baseline and end of skill training and end of skill training and beginning of exposure stage are significant (resp. $p = .012$ and $p = .017$); the increase of mean weighted HRV scores between beginning of exposure stage and end of exposure stage is not significant ($p = .063$). The increase in mean weighted HRV scores between baseline and end of exposure stage is significant ($p = .043$).

Figure 3 is a graphical representation of the change in MAAS scores, before and after HRV–ACT. The mean increase in MAAS scores from baseline to the end of the training is significant ($p = .024$), indicating a significant increase in self-reported amount of mindfulness skills.

Qualitative Results

As stated before, three types of qualitative results were analyzed afterward from the logbook of the therapist: (a) characteristics of the interaction between clients and the therapist, (b) training effects, and (c) encountered problems. First, the interaction between therapist and subject was characterized by the subject's

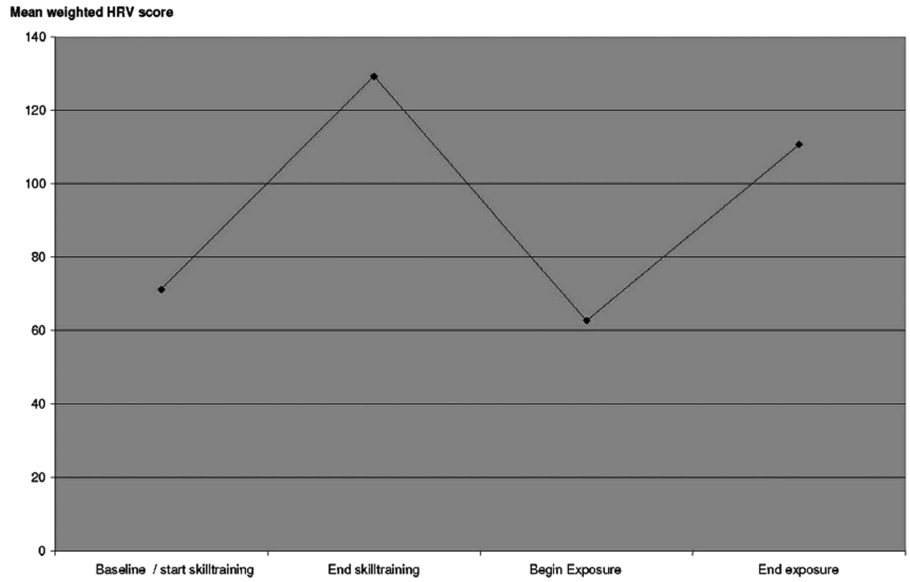
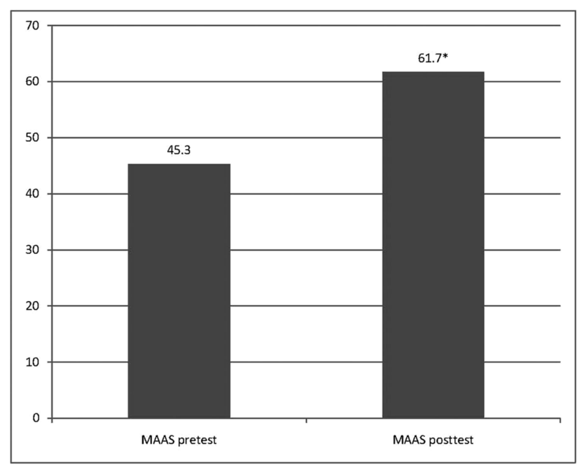


FIGURE 2. Mean weighted heart rate variability (HRV) scores per time of measurement.

cooperation and commitment to the training. There were no dropouts; all clients completed the entire training. Clients reported interest in the intervention and the research project when being offered biofeedback as a method to increase their mindfulness skills. Clients reported some increase in arousal during the baseline measurement, but this did not result in abortion of the intervention. On many occasions clients experienced negative emotions during the exposure sessions. Second, all clients reported an increase in their self-awareness and mindful attention in stressful daily situations. They reported to be more able to react mindfully in stressful situations, for instance, when having an argument with their intimate partner. Some clients reported HRV–ACT having a relaxing effect and making them sleep better. No significant problems in the interaction between clients and therapist were encountered, nor did any client report negative side effects of HRV–ACT. There were two times when an HRV–ACT session was disrupted due to technical problems or disruption of the heart rate signal. In these two sessions no valid measurement was obtained. In one occasion the trainer aborted an HRV–ACT session because the client could not stop laughing, resulting in an invalid measurement.



* N = 7, d = 16.4, p < 0.05

FIGURE 3. Self-reported mindfulness scores before and after HRV-ACT.

DISCUSSION

In this article we presented an integrative approach in which a behavioral therapeutic approach (ACT) is combined with a neurotherapeutic intervention (HRV biofeedback). We also proposed to call this integrative approach ''behavioral neurotherapy.'' Within this frame of reference a pilot study is presented with the global idea that the integration of two interventions creates an enriched therapeutic environment that may benefit the therapeutic process.

The quantitative and qualitative results of the current pilot study indicate that HRV–ACT may be a useful instrument to teach mindfulness skills to clients with mild to severe psychosocial problems. The pattern of an increase in HRV scores from baseline to the end of the skill training stage, a decrease resulting from exposure to negative experiences, followed by an increase in HRV scores at the end of the training was exactly as hypothesized. Also, the significant increase in self-reported mindfulness in daily life, as measured by the MAAS, indicates that HRV–ACT maybe used as a practical form of mindfulness training within the context of an ACT treatment. More methodologically stronger research is needed to investigate whether HRV–ACT indeed has an additional effect above the effect ACT in itself has on MAAS scores. The results of the quantitative analyses were confirmed by the qualitative results, which indicate high client satisfaction and commitment, an increase of mindful attention, and generalization of acquired skills in daily activities of clients. No problems were encountered either in the interaction with the client or resulting from the HRV–ACT itself. Taken together these results indicate that HRV may be useful as a complementary intervention in ACT, especially as a practical and relatively easy way to increase mindfulness skills.

We hypothesize that the reason why clients easily commit themselves to HRV–ACT is that HRV–ACT connects with the situational context of the clients. Contemporary clients have little time for extensive homework assignments, which are common in formal mindfulness training. In MBCT clients are asked to do about 45 min of homework assignments a day. In contrast, in HRV–ACT as described in the current study participants are asked to do about 10 min of brief mindfulness assignments. Also, the design of the training, a biofeedback method in which a computer game is played, may contribute to the client's adherence to the mindfulness training.

The results of the current pilot study are promising and call for further research, but because of small sample size, a possible selection bias and the lack of randomization and control groups, conclusions about causal relations between HRV, mindfulness, and other concepts cannot be drawn. Future research, preferably a clinical trial in which the additional effects of HRV–ACT are tested against regular breathing techniques aimed at relaxation, techniques described in HRV protocols and ACT without HRV, may provide answers to the question whether HRV and mindfulness are in fact related and whether HRV–ACT is an effective and efficient intervention that can be used to improve mindfulness, acceptance, and cognitive defusion skills in addition to regular ACT interventions. This study, however, does confirm the practical usability of HRV–ACT within an ACT context.

A more theoretical reason to do further research on the relationship between HRV and mindfulness is that we hypothesize HRV–ACT to be closely related to mindfulness. There appears to be considerable overlap between techniques used in HRV biofeedback and mindfulness. Both HRV biofeedback and mindfulness focus on breathing and compassionate, friendly attention to the direct experience of private experiences as they arise in the present moment as the main vehicle for change. Also, as shown in the Results section of this article, HRV training leads to an increase in the self-reported amount of mindfulness as well as an increase in HRV scores. We suspect that HRV training without specific HRV–feedback, but instead applying, for instance, regular mindfulness exercises, will also lead to an increase in HRV. In the end no one is interested solely in increased HRV levels (or an increase in beta levels or changed theta-beta ratios), because what really counts is the changed experience of the client as a result of these phenomena.

Of course the results of our pilot study are only preliminary and other hypotheses could be stated to explain the increase in self-reported amount of mindfulness and HRV scores we encountered. HRV–ACT was applied as a supplementary intervention to regular ACT, so the increase in MAAS and HRV scores may be explained by ACT alone. It should be noted, however, that HRV–ACT replaced the regular mindfulness exercises of ACT. Another hypothesis is that despite the explicit instruction to only observe and accept private experiences and defuse from the literal content of thoughts as they arise in the moment, HRV–ACT only teaches clients to breathe slowly, apply relaxation, and increase their respiratory sinus arrhythmia without ever learning the essence of mindfulness, acceptance, or cognitive defusion. This would mean that HRV–ACT is a procedure that is more comparable to systematic desensitization (Wolpe, 1958) than mindfulness. More experimental research is necessary to test the hypothesized relation between the constructs of mindfulness and HRV.

We started this article with the notion that enriched learning environments may be beneficial in therapy. The integrative approach we present in this article, behavioral neurotherapy, can then be seen as an orientation that specifically focuses on designing and evaluating such situations. In this article we presented an example of an approach in which the combination of behavioral interventions and neurotherapy create a context in which people who suffer from a wide variety of psychological disorders can learn effective strategies to cope with their problems. Studies yet to come may focus for instance on applying mindfulness techniques in combination with other forms of biofeedback, in particular EEG biofeedback, or neurofeedback. In our clinical practice this combination of procedures has already been tested and evaluated on its effectiveness and clinical feasibility. It is our clinical impression not only that these combinations of treatment modalities enhance treatment efficacy but also that a common factor is underlying mindfulness, HRV biofeedback, and specific forms of neurofeedback, such as alpha- or SMR training. It was observed that depending on the task involved, clinically induced higher levels of HRV often co-occur with an increase in the speed with which a client masters an increase in alpha-amplitudes or SMR amplitudes in the EEG. Studies are being designed to substantiate these findings empirically. Another example of behavioral neurotherapy is a combination of repetitive Transcranial Magnetic Stimulation and cognitive behavioral therapy in depression. Research suggests that this combination is more efficacious than repetitive Transcranial Magnetic Stimulation or cognitive behavioral therapy alone (Arns, Spronk, & Fitzgerald, 2010).

Finally, there are other reasons to integrate behavioral interventions and neurotherapeutic procedures. Although "stand-alone" neurotherapy is hypothesized to result in a more flexible, stable, and resilient "brain," thereby creating a neurophysiologic base for change, generalizability of therapeutic effects of neurotherapy may be suppressed due to respondent conditioning of the experienced cognitive, behavioral, and emotional changes to the very physical setting in which neurotherapy is provided. Additional behavioral interventions, such as brief behavioral homework, mindfulness assignments, and applied skill training, expand the learning environment in which new behaviors and the attending to private experiences are trained. This in turn may assist the generalizability of the strengthening of neural circuitry and networks.

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