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Treatment-Related Changes in Cardiovascular Reactivity to Trauma Cues in Motor Vehicle Accident–Related PTSD

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We have conducted a randomized, controlled trial comparing a combination of cognitive and behavioral treatments (CBT), supportive psychotherapy (SUPPORT), or an assessment-only wait-list (WAITLIST) control. To study psychophysiological reactivity in PTSD we measured heart rate (HR) reactivity to idiosyncratic audiotaped descriptions of the motor vehicle accident (MVA) that the participants had survived, both before and after each of the treatments. Results showed significantly greater reduction in HR reactivity for those receiving CBT (n = 25) than for either those in SUPPORT (n = 26) or WAITLIST (n = 22). The latter two conditions did not differ. There were significant but low-level correlations between changes in CAPS scores and changes in HR reactivity collapsing across all groups.

It has been repeatedly demonstrated across a variety of traumatized populations that individuals suffering from posttraumatic stress disorder (PTSD) show greater physiological reactivity to cues reminiscent of the trauma than similarly traumatized individuals who do not meet criteria for PTSD (see Blanchard & Buckley, 1999, for a recent comprehensive review). This physiological reactivity has been shown for combat veterans (Blanchard, Kolb, Taylor, & Wittrock, 1989; Keane et al., 1998; Pitman, Orr, Forgue, de Jong, &

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Claiborn, 1987), sexual assault victims (Griffin, Resick, & Mechanic, 1994), and motor vehicle accident (MVA) survivors (Blanchard et al., 1996; Blanchard, Hickling, Taylor, Loos, & Gerardi, 1994), to name a few of the populations studied. The two chief physiological response channels that have been studied are cardiovascular, especially heart rate (HR), and electrodermal.

Almost all of this research has been conducted as part of an initial assessment, essentially before treatment. In the one study of which we are aware that measured physiological reactivity to trauma cues before and after treatment, Boudewyns and Hyer (1990) compared HR, electrodermal (skin conductance level; SCL), and forehead electromyogram (EMG) responses to three playings of a 5-minute audiotape from inpatient Vietnam veterans with PTSD. Half (n = 19) were assigned to direct therapeutic exposure (DTE) while the other half received individual counseling. Results showed a reduction in reactivity from pretreatment to posttreatment only for SCL with no differential change between the two treatment conditions. Internal analyses showed a reduction in HR reactivity to one of the three playings for the DTE condition but not for the other two playings. There were no significant within-group changes in the other treatment condition. For SCL, the DTE group showed less reactivity to two of the three playings of the audiotape whereas the comparison group showed a change for only one playing. On a clinical interview measure those participants in DTE showed significantly greater improvement at a 3-month follow-up than those in the comparison condition. For those nine veterans who showed the greatest clinical improvement, combined from both conditions, there was a reduction in HR and SCL reactivity from before to after treatment.

To the best of our knowledge, no one else has examined whether physiological reactivity changes as a result of treatment. We are in the fortunate position of having recently completed a randomized controlled trial of MVA survivors with PTSD or severely symptomatic subsyndromal PTSD (Blanchard et al., in press). We obtained psychophysiological assessment data before and after treatment and report below on the effects of the three treatment conditions on cardiovascular reactivity: a combination of cognitive and behavioral procedures tailored for the MVA survivor (CBT); a supportive psychotherapy condition (SUPPORT); and an assessment-only, wait-list control condition (WAITLIST).

Methods

Overview of Treatment Trial

The treatment trial, described in detail elsewhere (Blanchard et al., in press), was a randomized controlled comparison of CBT, SUPPORT, and WAITLIST. The chief dependent variable was the Clinician-Administered PTSD Scale (CAPS; Blake et al., 1995), a structured interview of well-established reliability and validity. With the CAPS patients are asked about the frequency and intensity of each of the 17 symptoms of PTSD as well as about associated symptoms. It yields both a categorical diagnosis and a summary score obtained by summing the frequency (0 to 5) and intensity (0 to 5) scores for the 17 symptoms. On this measure CBT was superior to SUPPORT and WAITLIST, and SUPPORT was superior ($p = .05$) to WAITLIST. All 3 groups showed significant within-group change on the CAPS from before to after treatment. Cardiovascular reactivity to trauma-related cues was measured as part of the pretreatment and posttreatment assessments.

Participants

Seventy-eight MVA survivors completed the treatment trial. We have psychophysiological assessment data on 73 of those. Three individuals (1 from CBT, 1 from SUPPORT, and 1 from WAITLIST) declined to participate in either pre- or postpsychophysiological assessments and 2 (1 from CBT and 1 from WAITLIST) declined to participate in the postassessment. Demographic data on the 73 participants in this study, subdivided by treatment condition, are presented in Table 1. Comparison of the three groups revealed no significant differences among the three groups on any of the variables in Table 1.

Participants were assessed by advanced doctoral students in clinical psychology who had been trained in all of the assessment procedures by the first two authors. Diagnosis of PTSD was based on the CAPS. We also diagnosed individuals as subsyndromal PTSD if they met the *DSM-IV* criteria A, E, and F, and two of three symptom clusters for criteria B, C, or D. Diagnostic interviews were tape-recorded. Forty-nine were re-scored by a doctoral student blinded to initial diagnosis. This yielded a diagnostic agreement kappa of 0.789, $p < .001$, representing very good diagnostic agreement.

TABLE 1
DEMOGRAPHIC INFORMATION ON SUBSAMPLES

Variables	Groups			
	CBT	SUPPORT	WAITLIST	Total
Gender (M/F)	5/20	5/21	9/13	19/54
Age				
M	39.4	41.4	41.2	40.7
SD	9.7	12.6	10.9	11.1
Months since MVA				
M	11.5	14.9	14.7	13.7
SD	8.1	11.0	8.9	9.5
Ethnicity				
Caucasian/minority	24/1	24/2	19/3	67/6
Initial diagnoses				
PTSD	20	21	19	60
Subsyndromal PTSD	5	5	3	13
Initial CAPS scores				
M	67.3	66.4	62.0	66.3
SD	19.7	25.5	27.5	24.0

Psychophysiological Assessment Procedures

The psychophysiological assessment procedures have been described in detail in earlier publications (Blanchard et al., 1994; Blanchard, Hickling, Buckley, & Veazey, 1999). Briefly, the participants were comfortably seated in a recliner with feet on the floor in a sound-attenuated room in voice contact with the experimenter, who was in another room with the monitoring equipment. We measured blood pressure (BP) and heart rate (HR) with a Kritikon Dinamapp device that samples once per minute and provides a digital printout. The BP cuff was on the left upper arm at the level of the heart.

We measured skin resistance level with a Grass Model 7 polygraph and a 7P1 preamplifier. Silver-silver chloride electrodes were attached to the ventral surface of the index and third finger of the right hand using TECA electrode gel as the contact medium. The skin surface had been previously cleaned with isopropranol. Skin resistance level was read from the potentiometer by zeroing the bridge circuit once per minute coincident with the BP determination and then written down.

After an approximately 10-minute adaptation phase, the following conditions were run with the duration specified in the parentheses: Baseline-1 (BL-1) 5 min; Mental Arithmetic (subtracting 7s serially) (3 min), BL-2 (5 min), Audio Tape-1 (3 min), BL-3 (5 min), Audio Tape-2 (3 min), BL-4 (5 min), Relaxation (3 min), BL-5 (5 min).

The mental arithmetic was used as a standard stressor. The two audiotapes were constructed by the initial interviewer to capture the essence of the participant's MVA experience, including a description of the setting, the MVA itself and the participant's description of sights, sounds, and thoughts. The two tapes were slightly different accounts of the same MVA. Figure 1 displays a verbatim copy of an audiotape.

The participant was asked to imagine (as vividly as possible) him- or herself in the situation. This procedure of using idiosyncratic audiotaped descriptions was originated by Pitman et al. (1987) and has been used with several populations. We averaged the five readings from each baseline phase and the two or three readings from the stressor phases. For the occasional missing value we averaged the remaining available readings within a phase.

Treatments

As noted earlier the full description of the treatment conditions has been previously submitted (Blanchard et al., in press). Participants were matched into triads based on initial CAPS scores. Then they were randomized to one of three treatment conditions: a combination of cognitive and behavioral treatment procedures (CBT); a supportive psychotherapy condition (SUPPORT) or a wait-list, assessment-only control (WAITLIST). Three experienced therapists each treated patients in the two active treatment conditions, following detailed treatment manuals. The two active treatments each lasted from 8 to 12 sessions based upon therapist's judgment; the mean number of visits was 9.9 and did not differ between conditions.

> I want you to imagine this scene: I want you to try re-creating it in your mind's eye, as if you were back there. . . . It is October, it is about 4:00 P.M., and you are on your way home from the supermarket. . . . You are traveling west on Hoosick Street. You are approaching the intersection of Hoosick and ——. You notice that there is a lot of traffic today. It feels congested, traffic is stalled and no one is moving. . . . You come to the intersection, the light is green and you are about to make a left turn onto ——. A guy in a red truck motions to you to go ahead and get into the intersection. You motion back, you go into the intersection, and you are right in the middle of the intersection. You think how else are you going to make the turn? . . . While you are preparing to make the turn, a guy is coming from your left; he is coming like a "bat out of hell." He's flying. You hear the screeching of the brakes and then you hear the crash.... He has just hit you; he hit you on the driver's side of the car. Your car is going in one direction while your head is going in the opposite direction. You are scared. You feel helpless. You have no control. You hit the side of your head on the frame. . . . Now take that scene away.

FIG. 1. Verbatim transcript of audiotape used with participant. Total time for the tape was 176 seconds.

The CBT condition is manualized and is described in detail in Hickling and Blanchard (1997). It combined exposure to a written description of the MVA, gradual exposure to auto travel situations, relaxation training, cognitive techniques to become aware of and then alter self-talk (Meichenbaum, 1985) and to challenge irrational beliefs and cognitive fallacies (Beck & Emery, 1979), and behavioral activation to help overcome estrangement and loss of interest in previous activities.

The SUPPORT condition is also manualized and is described in detail in Hickling and Blanchard (1999). At the first visit the participant was given a detailed description of the symptoms of PTSD and how his or her symptoms fit this picture. It was designed in part to normalize the experience of the PTSD symptoms. The next three sessions were devoted to gathering a detailed developmental history with emphasis on past traumatic events and other losses and how the patient had coped with these past events. The remaining six sessions were spent being supportive of the participant's dealing with life events other than symptoms of PTSD from the MVA. Care was taken to avoid explicit advice concerning exposure and to avoid directly challenging family cognitions.

Scores of audiotapes of therapy sessions showed very good therapist adherence to the protocol, 97% or higher. These ratings were done by having a doctoral student score tapes of therapy sessions for presence or absence of specific therapist behaviors. These ratings were compared to what was called for in the therapy manuals. Very importantly, we were checking that cognitive and behavioral procedures were absent from the SUPPORT condition.

Treatment Outcome

The initial results of treatment (Blanchard et al., in press) showed significant within-group improvement on the CAPS for all three conditions. The CBT group improved significantly more than the SUPPORT group or the WAITLIST. The SUPPORT also improved ($p = .05$) more than WAITLIST.

Results

The average values for each psychophysiological response were subjected to a 3 (Treatments) × 7 (Phases) × 2 (Time [pre-post]) MANOVA with repeated measures on the last two independent variables. There was the expected main effect of phases ($p < .01$, Huyn-Feldt corrected) for each response. However, only for HR was there a significant main effect of time, $F(1, 64) = 9.13$, $p = .004$, Pillai's, and phase, $F(8, 57) = 33.8$, $p < .001$, Pillai's, and a significant interaction of Time × Phase, $F(8, 57) = 5.75$, $p < .001$, Pillai's. On this basis, the remainder of the paper will focus only on HR responses.

In order to reduce the complexity of the analyses, and following previous research on this problem (Blanchard et al., 1994, 1996; Boudewyns & Hyer, 1990), we took two further data-reduction steps. First, we calculated reactivity scores for each of the three stressors—mental arithmetic, audiotape-1, and audiotape-2—by subtracting the value from the preceding baseline from the value for the stressor. Next, we combined the values for the two audiotapes to have a single value for the MVA-specific stressor.

These two HR reactivity scores were then separately subjected to 3 (Treatments) × 2 (Time [pre-post]) repeated measures ANOVA. For Mental Arithmetic, there was a significant main effect of time, $F(1, 70) = 8.54$, $p = .005$, Pillai's, but no main effect of treatment or Treatment × Time interaction. The mean reactivity scores, across groups, decreased from 9.5 bpm to 7.5 bpm.

The analysis of the combined audiotapes HR reactivity scores showed a significant main effect of time, $F(1, 70) = 26.5$, $p < .001$, Pillai's, and an interaction of Treatments × Time, $F(2, 70) = 4.87$, $p = .010$, Pillai's, but no main effect of treatments ($p = .23$). The mean values for HR reactivity for each treatment condition at pretreatment and at posttreatment are presented in Table 2.

To further explicate the interaction, we calculated an ANCOVA on posttreatment reactivity scores, using pretreatment reactivity scores as the covariate. This yielded a significant effect of treatments, $F(2, 69) = 5.88$, $p = .004$. Follow-up analyses showed significantly greater reduction in HR reactivity from pretreatment to posttreatment in the CBT condition than was found for the SUPPORT condition ($p = .001$) and for the WAITLIST condition ($p = .001$). SUPPORT and WAITLIST did not differ.[1]

[1] We repeated the analyses on the combined audiotape HR reactivity scores using only the participants with PTSD. This again yielded a significant main effect of time, $F(1, 58) = 26.9$, $p < .001$, and interaction of treatment by time, $F(2, 57) = 4.74$, $p = .012$. Follow-up analyses showed the CBT to have a significantly greater change than WAITLIST ($p = .003$) but only a trend ($p = .08$) to be greater than the change for SUPPORT. SUPPORT and WAITLIST did not differ.

TABLE 2
COMBINED HEART REACTIVITY SCORES TO AUDIO TAPES FOR EACH TREATMENT GROUP AT PRETREATMENT AND POSTTREATMENT

	Treatment Condition		
Time	CBT	SUPPORT	WAITLIST
Pretreatment	11.8 (9.6)	11.9 (9.7)	8.5 (6.1)
Posttreatment	3.4 (3.7)	9.2 (10.2)	6.1 (6.9)

Note. Table entries are means (and standard deviations) of heart rate reactivity scores in beats per minute for the sum of two reactivity scores (value from audiotape minus preceding baseline) for idiosyncratic audiotaped descriptions of participant's MVA.

Is the Change in HR Reactivity Related to Clinical Improvement?

One possible explanation for these results favoring the CBT condition could be that a larger percentage of the participants in this condition showed clinically meaningful improvement than in the other two conditions. If one counts as a success, any participant with PTSD at pretreatment who is diagnosed with less than PTSD at posttreatment and anyone with sub-syndromal PTSD at pretreatment who is non-PTSD at posttreatment, then the success rate for CBT was 78%, for SUPPORT was 56%, and for WAITLIST was 29%.

We reanalyzed the HR reactivity to audiotapes data by combining the participants in CBT and SUPPORT and then subdividing them into "successes" ($n = 33$) and "nonsuccesses" ($n = 18$) and comparing these two groups to the WAITLIST condition. The main effect of time was significant ($p < .001$) but neither the main effect of group nor the interaction of Group × Time was significant. Those who were clinically successful did show a significant within-group change, $t(32) = 4.22, p < .001$, whereas the other two groups showed only trends. When the analyses were repeated using only participants who met criteria for PTSD, the same results were obtained: only the successes showed a significant within-group change. A similar success versus nonsuccess analysis, using only participants from the CBT condition, also failed to yield a significant effect of group or Group × Time interaction. It thus appears that it is not solely achieving clinical success that accounts for the reduction in HR reactivity.

We also calculated correlation coefficients between change in CAPS score and change in HR reactivity to see if there was a dose-response relation. This correlation was significant, $r(73) = .298, p = .010$, but accounts for very little variance. The similar correlation for change in PTSD symptom B-5, physiological reactivity to cues reminiscent of the stressor, with change in HR reactivity was likewise significant but accounted for little variance, $r(73) = .295, p = .011$.

Discussion

The primary results of this study are that HR reactivity to cues reminiscent of the MVA (audiotaped descriptions) is significantly decreased by a combination of cognitive and behavioral treatment procedures and that the decrease is significantly greater for CBT than for SUPPORT or WAITLIST. Although Boudewyns and Hyer (1990) measured physiological reactivity to trauma cues before and after treatment, this study is the first to find differential changes in physiological reactivity to trauma cues as a result of treatment. It thus demonstrates, in part, that this nonverbal measure yields treatment results similar to those found with structured interviews such as the CAPS.

We must qualify this conclusion because the HR reactivity measure did not show the degree of improvement manifested by those in the SUPPORT condition on the CAPS. In our earlier study (Blanchard et al., in press), the SUPPORT condition showed more improvement on the CAPS than the WAITLIST condition. The HR reactivity measure showed no such trend. Thus, it seems clear to us that psychophysiological responding cannot substitute for a structured clinical interview but could be a valuable adjunct to it. The low-level correlation between changes in those two measures supports this view.

As in other work with MVA survivors (Blanchard et al., 1996; Shalev et al., 1998), we found HR response to idiosyncratic audiotaped descriptions of the MVA to be the most sensitive physiological variable we measured. In other studies, electrodermal reactivity and blood pressure have also been of value (Keane et al., 1998; Pitman et al., 1987). For example, for Boudewyns and Hyer (1990), the electrodermal response was the only one that showed changes from before to after treatment.

We were surprised that the internal analysis of clinical successes versus nonsuccesses did not yield positive findings, especially when confined solely to those in the CBT condition. However, this negative finding is also consistent with the correlational data. Boudewyns and Hyer (1990) also found only marginal relations between change in physiological reactivity and change in clinical status as measured by interview.

In the CBT treatment, since exposure was a large element, we might have expected to see an extinction of physiological arousal to trauma cues as part of the treatment response. Whereas as a group those receiving CBT were clearly less reactive at posttreatment, there was a relative lack of an overall dose response relation between diminution of physiological reactivity and overall clinical improvement. Given that overall clinical status in PTSD is a multiply determined phenomenon, it is perhaps surprising that the correlation between change in the total CAPS score and change in HR reactivity is significant. The low-level (but significant) relation between change in symptom B-5 (physiological reactivity to reminiscent cues) and change in HR reactivity is more problematic. It could be that patients' responses to the CAPS item are determined by multiple physiological cues and that HR is only one of the determinants. Obviously, further research is needed to fully understand this phenomenon.

There are several limitations in this study. Because we used the Dinamapp and once-per-minute recordings, it is not possible to track moment-by-moment changes in HR and correlate them with specific aspects of the MVA audiotapes. A different method of recording HR could yield more interesting data. The sample sizes were large enough to yield the reported differences; however, larger samples could have yielded differences on the other physiological responses.

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