A PSYCHOPHYSIOLOGICAL STUDY OF POST TRAUMATIC STRESS DISORDER IN VIETNAM VETERANS

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Comparisons were made between a group of male Vietnam veterans suffering from Post-Traumatic Stress Disorder (PTSD) (n = 11) and an age and sex matched group of nonveteran controls (n = 11) on their psychophysiological responding (heart rate (HR), blood pressure (BP), forehead EMG, skin resistance level, and peripheral temperature) to mental arithmetic and an audiotape of combat sounds played at gradually increasing volume levels. The two groups responded differently to the combat sounds in terms of HR, systolic BP, and forehead EMG. The HR response could correctly classify 95.5% of the combined sample. Implications of these findings for the basis of PTSD are discussed.

Although the condition now officially known as Post Traumatic Stress Disorder (PTSD)[1] has been recognized for years,[2,3] interest in it has recently increased, probably because of both professional[4-6] and lay[7] concerns about the problem in veterans of the Vietnam War.

In 1941, in one of the first systematic studies of the condition (which he called a chronic war neurosis) Kardiner identified five constant clinical features of the condition now denoted Post Traumatic Stress Disorder: (1) irritability, (2) startle pattern, (3) fixation on the trauma, (4) atypical dream life, and (5) proclivity to an explosive aggressive reaction.[3] Kardiner related irritability to exposure to auditory stimuli, which induced the startle reflex followed by fright, sometimes explosive violence or tremor. He also noted in the sufferers, sensitivity to other stimuli (light, smell, or special physical percepts) associated significantly to the circumstances of the original trauma. The sensitivity of his subjects to such stimuli were postulated as in "the character of a conditioned reflex" not learned over time but automatically recurring. To him, as with Freud,[2] the condition

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differed from the ordinary social neurosis in that there existed a central physioneurosis with impairment of those personality functions that aid adaptation to the real external world. In contrast, in the usual neurosis of civilian life, conflicts exist between inner world representations of humanity and society and innate drives. Gillespie also suggested that the features of the acute war neurosis seen during World War II were due to conditioning.[8] Gillespie described the immediate physical responses to sound startle as states of "generalized muscular tension, palpitation and a sinking feeling," indicating also a distinct psychophysiological component to the disorder.

In the first systematic laboratory psychophysiological study of the disorder, Dobbs and Wilson compared EEG alpha, heart rate (HR) and respiration rate (RR) responses of three groups to combat sounds and photic stimulation.[9] The groups were (1) 8 "decompensated" combat veterans who were described as suffering from "combat neurosis"; (2) 13 veterans of approximately the same age who had combat experience but who were seen as "compensated"; and (3) 10 university students who had never been in combat and *who were all younger than any member of groups 1 or 2.* Although several groups showed significant within group changes in all three responses from baseline to the presentation of the combat sounds, no specific data on the "decompensated combat veterans" were presented and no comparisons between this patient group and the other two groups were made. Despite these deficits in reporting, Dobbs and Wilson (1961) concluded that there existed a "remarkable similarity of the behavioral and physiological responses of the war neurosis to those produced experimentally in animals through conditioning."

In the present study we have replicated a portion of the work of Dobbs and Wilson (1961) with certain improvements: (1) the diagnostic criteria for patients with PTSD are explicitly stated; (2) the nonveteran control group is matched for age with the patient group; (3) a "neutral" stressor was included along with the disorder-specific stressor of combat sounds; (4) a neutral auditory stimulus was included; (5) several different psychophysiological responses were added based on Gillespie's previously mentioned observations[8] and (6) direct comparisons were made between the patient group and the controls.

METHOD

Subjects

The patient population in this study were 11 male Vietnam veterans diagnosed as suffering from Post Traumatic Stress Disorder as defined by DSM-III. They ranged in age from 32 to 42 with a mean of 34.8 (SD = 3.0).

The controls were selected in part to maximize differences between the two groups at this initial development stage. They were 11 males ranging in age from 28 to 44 with a mean of 34.2 (SD = 4.8). None had served in the armed forces during the Vietnam era. They were recruited from among friends and acquaintances of the research team.

All participants gave written informed consent to all procedures as a first step in the experiment.

Procedures

Self-Report Measures. Three standardized psychological tests were given to each participant after the physiological assessment stage. They included measures of (1) depression (Beck Depression Inventory[10]) (2) anxiety (State-Trait Anxiety Inventory[11]) and (3) hostility (Buss-Durkee Hostility Scale[12]).

Physiological Assessment. All physiological assessments took place in a two room suite. The subject sat comfortably relaxed in a recliner in a sound attenuated room containing the physiological monitoring equipment (Grass Model 7 polygraph) and stimulus equipment. The experimenter could observe the subject at all times and was in constant voice communication through an intercom.

Physiological Measures Taken. The following psychophysiological measures were taken:

1. *Heart rate* was measured using plate electrodes connected in a standard ECG lead II configuration. Both the raw ECG and heart rate in beats per minute (BPM) were recorded on the polygraph.

2. *Blood pressure* was measured using an automatically inflating cuff placed on the upper right arm and a microphone placed over the brachial artery to detect Korotkoff sounds, which were superimposed on the pressure tracing. Both systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded as pressure in the cuff at onset (SBP) and offset (DBP) of Korotkoff microphonics. Pressure was assessed approximately once per minute.

3. *Peripheral surface temperature* was measured using a Yellow Springs YSI 409A thermistor taped to the ventral surface of the most distal phalange of the index finger of the left hand. Temperature was measured once per 10 seconds using Med Associates modules.

4. *Forehead muscle activity* was measured using two small precious metal electrodes containing Glass Electrode Cream attached to the forehead approximately 2.5 cm above the eyebrow centered on each eye. A ground electrode was placed midway between the two active electrodes. The forehead was cleaned using isopropyl alcohol and a mild abrasive. The raw EMG signal as well as the averaged EMG were recorded using a 7P3. For data purposes the raw signal was intergrated on a once per minute basis using a 7P10.

5. *Skin resistance level* (SRL) was measured using Beckman silver-silver chloride electrodes filled with Beckman electrode gel attached to the palm and back of the left hand. Recordings were made using a 7P1. The pen was recentered in each condition and the value of skin resistance read from the values on the bridge circuit. *Skin conductance level* (SCL) was calculated by taking the reciprocal of SRL and was used in all analyses.

Experimental Conditions. Each participant was exposed to the following conditions. In all cases he was asked to keep his eyes closed and refrain from large movement.

1. *Adaptation.* The subject rested quietly for eight to ten minutes.

2. *Initial Baseline.* The subject continued to rest quietly for ten minutes during which two sets of data were obtained, one from the first five minutes and a second from the last five minutes.

3. *Mental Arithmetic.* As a "neutral" stressor the subject was asked to perform several calculations in his head and to report the answers aloud: (a) count backwards from ten to one; (b) count backwards from 30 to zero by threes and (c) count backwards by sevens from 100. Physiological data were taken from the last 60 seconds of this condition.

4. *Return to Baseline.* The subject was asked to again rest quietly for six minutes.

5. *Music and Combat Sounds Tape.* Next the subject was told that a tape would be played on which there were 30 seconds of somewhat strident music, followed by a period of silence lasting 30 seconds, followed in turn by 30 seconds of combat sounds. This same sequence would be repeated at gradually increasing sound intensities. The subject was told that he

could discontinue the playing of the tape at any point. There were approximately 90 seconds between each trial. The strident music thus provided a neutral auditory stimulus of the same sound intensity.

There were five trials at sound intensities of 42, 52, 62, 72, and 82 decibels (as measured at the subject's head). The combat sounds were taken from the sound track of the movie "Apocalypse Now."

For all measures except blood pressure, physiological readings were made from the last 30 seconds of each part of each trial: music, silence, combat sounds. For blood pressure, values were obtained only from the music and combat sounds portions.

6 *Continuous Combat Sounds.* The last condition was exposure to another audiotape of combat sounds from the same source that lasted up to 480 seconds. The sound sequence gradually increased in intensity from 41 to 78 decibels.

Again the subject was told the tape would be immediately discontinued if he so requested. This condition was not run on all the veterans; two declined to participate in it.

In addition to the psychophysiological measures described above, a measure of *behavior,* similar to the informal observations reported by Dobbs and Wilson,[9] was available in this study. The final sound level to which each subject listened to the Music and Combat Sound condition was measured in decibels and the length of time to which the subject listened in the Continuous Combat Sounds condition was measured in seconds.

RESULTS

Psychophysiological Responses

Since all participants listened to at least two trials of the music and combat sound tape, values from all phases through this point were included in the initial analysis. A decision was also made to use the values from a third trial: the last (thus loudest) trial to which the individual was exposed was also included. For one veteran this was the second trial.

Initially, data from each of the six physiological responses (HR, SBP, DBP, Temp, EMG and SCL) were subjected to two way analyses of variance (Groups X Experimental Conditions). The results of these analyses are presented in Table 1.

As can be seen in Table 1, two responses, DBP and Finger Temperature, failed to show any significant effects. There were, however, trends ($p<.10$) in both responses demonstrating an Experimental Conditions effect but no effect of Group or its interaction.

For three physiological responses the two Groups responded differentially as indicated by the highly significant interaction of Group X Multi-Experimental Conditions. These are displayed graphically in Figures 1, 2, and 3 for Heart Rate, Systolic Blood Pressure and Forehead EMG, respectively.

Further analysis of these results using Duncan's multiple range test reveals that there was a significant ($p<.01$) increase in HR for the mental arithmetic condition for each group and that the veterans showed significant ($p<.01$) increases in HR to the combat sounds on each trial while the controls did not change. The same pattern of significant results was also found for SBP.

Table 1
Summary of Analyses of Physiological Responses

Response	F values from ANOVAs		
	Groups (df=1,20)	Conditions (df=12,240)	Gps. X Cond. (df=12,240)
Heart Rate	3.78	7.80***	8.56***
Systolic Blood Pressure	5.85*	6.39***	8.41***
Diastolic Blood Pressure	3.58	1.65	0.72
Forehead EMG	0.04	5.96***	3.66***
Finger Temperature	0.01	1.74	0.34
Skin Conductance Level	3.44	5.49***	0.19

*Significant at $p < .05$
*** Significant at $p < .001$

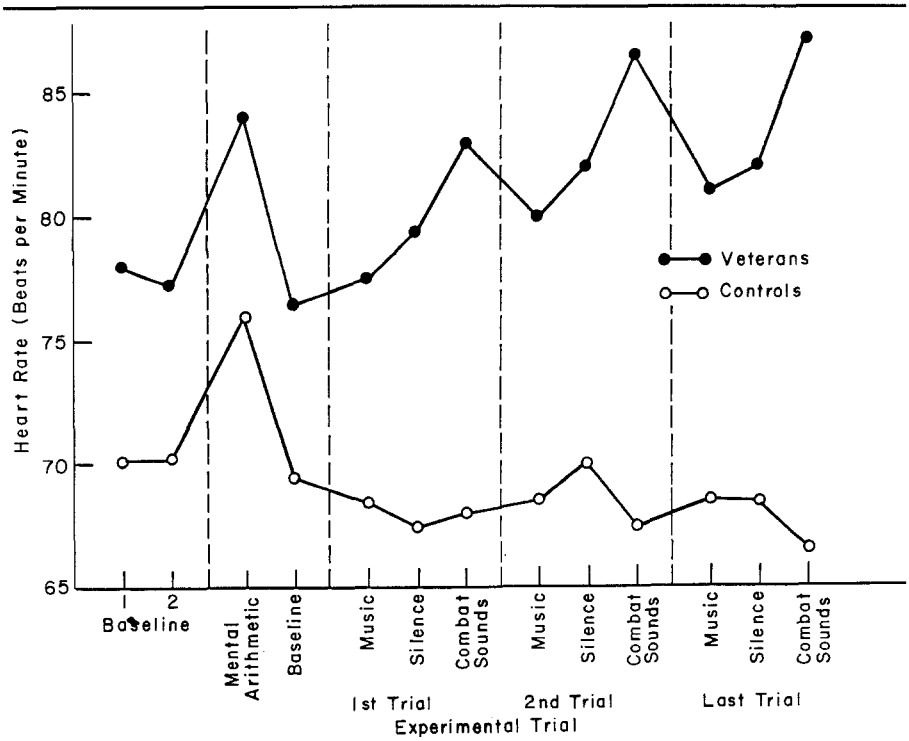

Figure 1. Heart rate response of PTSD and control groups to experimental conditions.

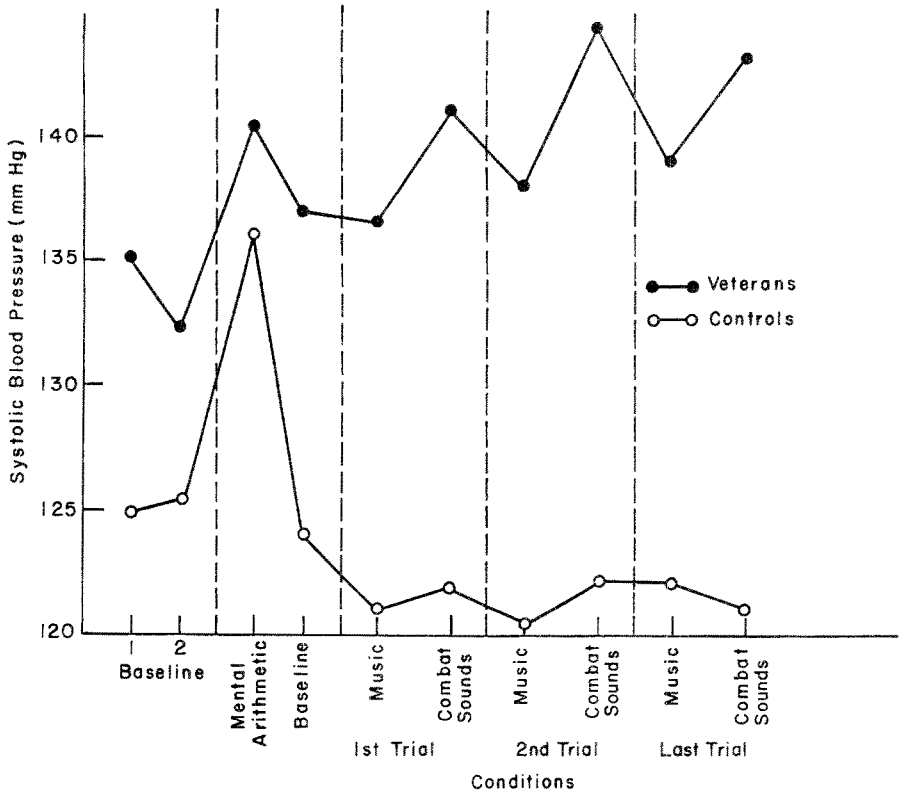

Figure 2. Systolic blood pressure response of PTSD and control groups to experimental conditions.

For forehead EMG, the controls showed a significant increase ($p<.01$) during mental arithmetic while the increase for the veterans was not significant. For each of the trials of combat sounds, however, the veterans showed significant ($p<.05$ or better) increase in forehead EMG, while the controls were unchanged.

Discriminant Analyses. While the highly significant group mean differences on several physiological responses under certain conditions are interesting, in our opinion, a more rigorous test of these differences would be to determine exactly how different the two groups were on these reponses using the multi-variate procedure of discriminant function analyses.[13] These analyses are summarized in Table 2.

From Table 2, one can see that HR is by far the best response for discriminating between the groups, achieving correct classification in 21 of 22 cases (95.5%). Interestingly, the one participant who was incorrectly classified was a veteran who was on 10 mg. of haloperidol at the time he was assessed.

In Figure 4, we have shown the change in HR for the two groups of subjects under two conditions, on going from baseline to the mental arithmetic and the average change from music to the combat sounds for the first two trials and the last trial. As is obvious, mental arithmetic is provocative for both groups but the combat sounds lead to radically different HR responses. While the controls show no increase in HR, 10 of the 11 patients show increases of 2 to 13 BPM. The sole exception to this finding was the one veteran who was on haloperidol.

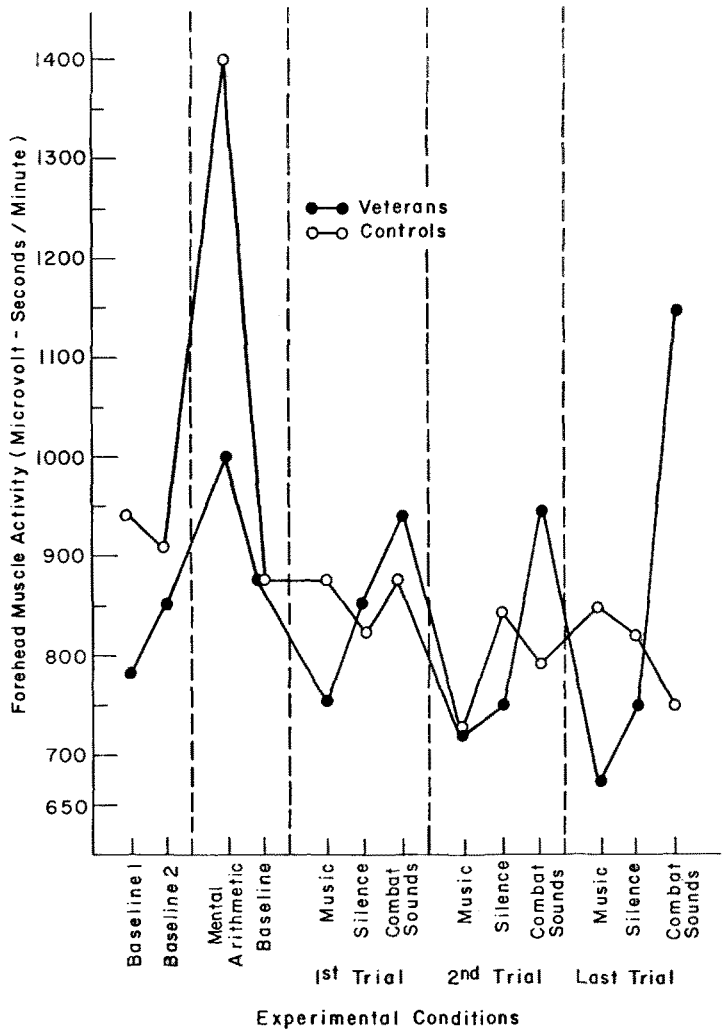

Figure 3. Forehead EMG response of PTSD and control groups to experimental conditions.

Psychological Tests Results

In the self-report domain, we compared the two groups on their scores on several standard psychological tests to ascertain current levels of psychological responding. The values for the group means and *t* statistics comparing them are presented in Table 3.

From Table 3, one can see that the veterans describe themselves as much more psychologically distressed than the controls. This includes being more depressed and more anxious.

Behavioral Measures

There were two measures of differences between the two groups: the highest sound level to which the participant listened and the number of seconds of the continuous combat sounds tape to which the participant listened before

Table 2

Summary of Discriminant Function Analyses

of Physiological Responses

Parameters	Response System		
	Heart Rate	Systolic BP	Forehead EMG
Wilks Lambda for Discriminant Function	0.3718	0.3906	0.6109
Significance	.0014	0.0021	0.028
Veterans Correctly Classified (Percentage)	10 (90.9)	9 (81.8)	8 (72.7)
Controls Correctly Classified (Percentage)	11 (100)	10 (90.9)	9 (81.8)
Total Percent Correct Classification	95.5	86.4	77.3

requesting that it be shut off. As noted earlier, both of these measures are analogous to behavioral avoidance tests used in research on fears and phobias.

For both tests, the veterans showed more avoidant behavior. On sound intensity, the veterans listened to the first tape at an average final level of 71 db compared to 80 db for the controls ($t(20) = 2.94$, $p = .008$). On the continuous combat tape, for which the sound intensity became progressively greater, the veterans listened to 250 seconds as compared to the controls' 472 seconds ($t(20) = 3.92$, $p = .001$).

DISCUSSION

The results of this study confirm and extend the previous work of Dobbs and Wilson[9] on the psychophysiology of PTSD in several ways: first, the data from the patient group were analyzed, unlike the case with Dobbs and Wilson, and were compared directly to that from the control group. Consistent differences in responding to auditory presentations of combat sounds were found between the two groups in heart rate, systolic blood pressure and forehead muscle activity. The latter finding confirms Gillespie's earlier clinical observation about muscle tension.[8] Second, the specificity of the psychophysiological differences was documented: whereas both groups respond to the neutral stressor of mental arithmetic, only the patients with PTSD resonded to the combat sounds. Third,

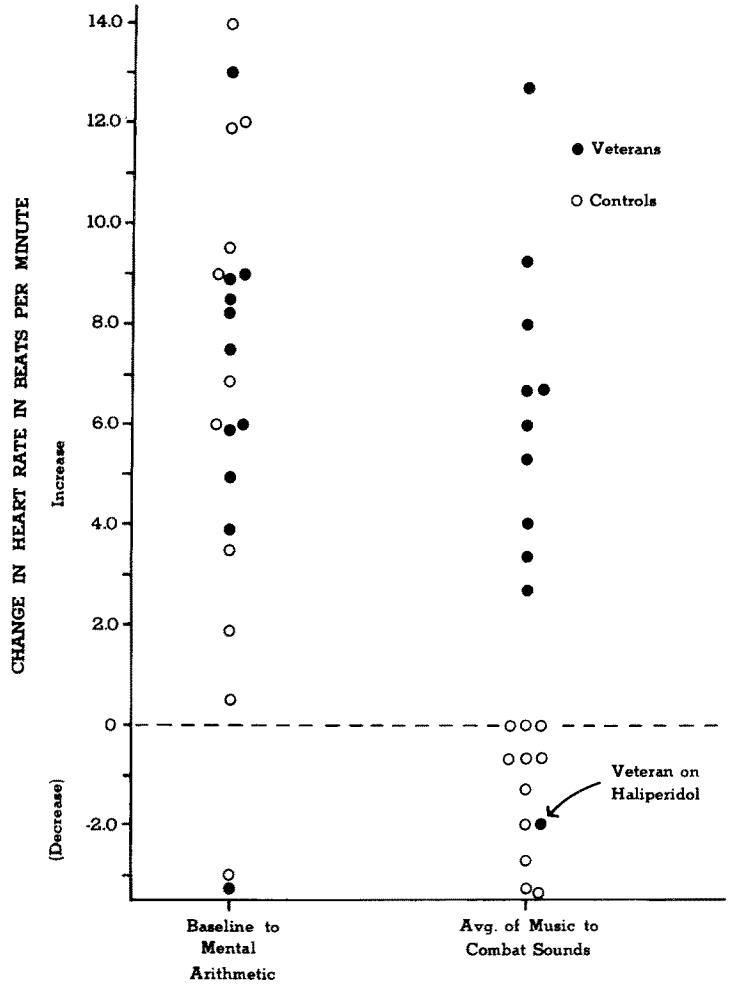

Figure 4. Individual subject data on change in heart rate response from baseline to mental arithmetic and from music to combat sounds.

Table 3
Summary of Psychological Tests

Test	Group means		t	p
	Veterans	Controls		
Beck Depression Inventory	26.2	2.4	6,95	<,001
State Anxiety	54.4	32.1	4.58	<.001
Trait Anxiety	58.6	32.1	6.29	<.001
Buss Durkee Hostility	52.1	26.3	5.33	<.001

the systematic behavioral data confirm the informal observations of Dobbs and Wilson about the distress and avoidance their patients manifested during exposure to the combat sounds.

We will add our own caveat that the procedure is not without mild risk to the patient. One of the 11 veterans who have been assessed with the procedure reported after effects such as nightmares and panic attacks after participating.

In our opinion, the data in Figure 4, the individual subject HR responses, depict one of the main features of this disorder: the cardiac rate increase to a stimulus that elicits no response in the control group. Literally years after the exposure to the traumatic events of combat, our patient group still shows marked physiological reactivity to mild stimuli suggestive of their experiences. This responsiveness is consistent with the view advanced by Kolb and Mutalipassi[14] that "the nuclear pathology...rests in persistence of a conditioned emotional response." With growing public and professional awareness of this problem, hopefully a full-fledged therapeutic attack will be launched on this unfortunate legacy of the Vietnam war.

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