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Psychophysiologic Reactivity, Subjective Distress, and Their Associations With PTSD Diagnosis

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Intense subjective distress and physiologic reactivity upon exposure to reminders of the traumatic event are each diagnostic features of posttraumatic stress disorder (PTSD). However, subjective reports and psychophysiological data often suggest different conclusions. For the present study, we combined data from five previous studies to assess the contributions of these two types of measures in predicting PTSD diagnosis. One hundred fifty trauma-exposed participants who were classified into PTSD or non-PTSD groups based on structured diagnostic interviews completed the same script-driven imagery procedure, which quantified measures of psychophysiologic reactivity and self-reported emotional responses. We derived four discriminant functions (DiscFxs) that each maximally separated the PTSD from the non-PTSD group using (1) psychophysiologic measures recorded during personal mental imagery of the traumatic event; (2) self-report ratings in response to the trauma imagery; (3) psychophysiologic measures recorded during personal mental imagery of another highly stressful experience unrelated to the index traumatic event; and (4) self-report ratings in response to this other stressor. When PTSD status was simultaneously regressed on all four DiscFxs, trauma-related psychophysiological reactivity was a significant predictor, but physiological reactivity resulting from the highly stressful, but not traumatic script, was not. Self-reported distress to the traumatic experience and the other stressful event were both predictive of PTSD diagnosis. Trauma-related psychophysiologic reactivity was the best predictor of PTSD diagnosis, but self-reported distress contributed additional variance. These results are discussed in relation to the Research Domain Criteria framework.

Keywords: PTSD, trauma cues, psychophysiology, self-reported distress, imagery

A fundamental challenge to the study of emotional experience, whether normal or pathological, is to determine what constitutes a reliable and valid index of emotion. For psychopathology research, this is a particularly salient issue because emotional experience provides the basis for establishing the presence of most forms of psychopathology and for differentiating among diagnoses. In a seminal article on this topic, Miller (1996) noted that researchers "assume (at least implicitly) that self-report is the gold standard for measures of emotional state (p. 623)." This assumption is commonly made in the study of posttraumatic stress disorder (PTSD). As described by Miller (1996), psychophysiological activity also reflects emotion and has the advantage of being relatively independent of an individual's ability to accurately discern and describe their own emotional state.

Negative emotion in response to traumatic reminders is a hallmark symptom of PTSD that can be manifest as either "intense

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psychological distress" (*DSM-IV-TR* PTSD symptom B.4) or "physiological reactivity" (*DSM-IV-TR* PTSD symptom B.5) to internal or external trauma-related cues (American Psychiatric Association, 2000). The presence and reliability of these diagnostic markers is supported by a large literature demonstrating heightened subjective emotional distress (e.g., Blanchard, Hickling, Taylor, Loos, & Gerardi, 1994; McDonagh-Coyle et al., 2001; Wolf, Miller, & McKinney, 2009), as well as heightened psychophysiologic (e.g., skin conductance [SC], heart rate [HR], and facial electromyogram [EMG] reactivity to cues reminiscent of a traumatic event in individuals with current PTSD; see Pole, 2007, for a review and meta-analysis). Several studies have shown that overall physiological responsiveness (as measured by combining the responses of multiple psychophysiologic measures) can reliably differentiate individuals with PTSD from trauma-exposed individuals without the disorder (e.g., Keane et al., 1998; Laor et al., 1998; Shalev, Orr, & Pitman, 1993). Aligning with research on phobias and other fear-based disorders, increased psychophysiologic reactivity in individuals with PTSD appears to be specific to fear-relevant targets, in this case the trauma-related scripts (e.g., McNeil, Vrana, Melamed, Cuthbert, & Lang, 1993; Shalev et al., 1993). Recent evidence also suggests that psychophysiological assessment of trauma-related cues is less influenced by response bias, or a general tendency to endorse distress, than semistructured interviews (Bauer et al., 2013). Accordingly, there is mounting evidence that psychophysiologic reactivity during script-driven imagery is a reliable, uniquely valid, and useful methodology for assessing PTSD.

Composite measures of overall psychophysiological responsiveness to trauma-related stimuli tend to have high specificity but lower sensitivity for identifying PTSD (see Keane et al., 1998; Laor et al., 1998; Pole, 2007 for review) Thus, psychophysiologic measures are much more successful in correctly identifying individuals without, rather than with, current PTSD as diagnosed with structured clinical interviews. This suggests that there exists a sizable minority of individuals who meet diagnostic criteria for PTSD but who do not react physiologically while recalling their traumatic events. However, these individuals may report distress upon exposure to trauma-related cues even though they do not respond physiologically. Incorporating self-report measures of distress, in addition to physiological measures, may help increase the sensitivity of the script-driven imagery protocol. The few studies that have examined both psychophysiologic and self-reported emotions in response to script-driven imagery suggest that these measures may complement each other (McDonagh-Coyle et al., 2001; Pitman et al., 2001). For example, self-reported negative affect and psychophysiologic reactivity during a trauma-imagery task were not significantly correlated in McDonagh-Coyle et al.'s study and Pitman et al. showed that individuals with PTSD were more psychophysiologically reactive to trauma scripts than individuals without PTSD, but the groups did not differ on self-reported emotional distress. Thus, it may be that measures of subjective and physiological reactivity to trauma-related cues have unique or complementary predictive value for determining the presence of PTSD among individuals exposed to trauma.

Research examining co-occurrence or shared symptoms of mood and anxiety disorders consistently shows that there are common factors across diagnoses along with factors unique to different diagnoses. Specifically, negative affect is a shared global distress factor found in all mood and anxiety disorders, including PTSD, and is usually measured by self-report (Clark, Watson, & Mineka, 1994; Simms, Watson, & Doebbeling, 2002). It is possible that the broad construct of negative affect has a greater influence on subjective emotional experience than it has on the measures of psychophysiologic reactivity used in the script-driven imagery protocol (HR, SC, and frontalis EMG). These measures of psychophysiologic reactivity may be more specifically related to fear or arousal. These differential relationships might contribute to the discrepant findings often found between subjective and psychophysiologic measures. Relatedly, report of subjective levels of distress to trauma cues might be associated with subjective report of distress to other stressful events because of the pervasive nature of negative affect. This contrasts with the psychophysiologic findings, which are specific to the feared targets (e.g., McNeil et al., 1993; Shalev et al., 1993).

The current study combined data from five studies that used the same well-validated, script-driven imagery procedure to assess the relative contribution of psychophysiologic reactivity and self-reported distress in response to both trauma reminders and other stressful, but nontraumatic events in distinguishing trauma exposed individuals with and without a PTSD diagnosis (Carson et al., 2000; Orr et al., 1998; Orr, Pitman, Lasko, & Herz, 1993; Pitman et al., 1990; Pitman, Orr, Forgue, de Jong, & Claiborn, 1987). We hypothesized that psychophysiologic reactivity and self-reported distress to the trauma-related scripts would both significantly predict PTSD diagnosis. Additionally, because PTSD is associated with generalized negative affect and/or distress, we predicted that self-reported distress to the other stressful script (most stressful life experience not related to the traumatic event) would also significantly predict PTSD (Bauer et al., 2013; Simms et al., 2002). Finally, we examined a model that included psychophysiologic reactivity to trauma-related scripts, self-reported distress to trauma-related scripts, psychophysiologic reactivity to other stressful scripts, and self-reported distress to other stressful scripts to assess the relative contribution of each in predicting the PTSD diagnosis. Based on the strong research support for increased psychophysiologic reactivity to trauma-related scripts in PTSD, we hypothesized that this measure would account for the most variance in the PTSD diagnosis.

Method

Participants

Participants from five published script-driven imagery studies (Carson et al., 2000; Orr et al., 1993, 1998; Pitman et al., 1987, 1990) are combined in the current study ($n = 150$). Seventy-eight participants met criteria for current PTSD, and 72 participants had experienced a traumatic event, but never developed PTSD. Sample information for the five studies that comprise the data set are reported in Table 1. In brief, approximately two thirds of participants included in the current study are women, and the mean ages for the studies ranged from late thirties to late sixties. No significant age differences between the PTSD and non-PTSD groups were observed in any of the studies. Mean education level ranged from high school graduate to college graduate, and there were no significant education level differences between groups, with the exception of one study in which participants in the PTSD group

Table 1
Descriptive Data of Studies Included in Current Study Sample

Study	Description of sample	Participants with other diagnoses		Gender	Ethnicity	Age[a]		Education (years)[a]	
		PTSD	Non-PTSD			PTSD	Non-PTSD	PTSD	Non-PTSD
Pitman et al. (1987)	33 Vietnam combat veterans (18 with PTSD; 15 without PTSD)	$n = 8$ (44%) 7 MDD, 2 OCD, 1 Panic Disorder, 1 Social Phobia	$n = 0$	100% male	100% Caucasian	41.0 (6.3)	40.1(3.7)	13.8 (2.4)	15.5 (2.4)
Pitman et al. (1990)	14 Vietnam combat veterans (7 with PTSD; 7 with non-PTSD anxiety disorder)	$n = 2$ (29%) 2 Panic Disorder, 1 MDD, 1 OCD	$n = 7$ (100%) 2 Panic Disorder, 2 Generalized Anxiety Disorder, 1 OCD, 1 Social Phobia, 1 Simple Phobia	100% male	100% Caucasian	40.1 (3.5)	38.9 (3.6)	14.3 (2.1)	12.9 (2.3)
Orr et al. (1993)	20 World War II and Korean War veterans (8 with PTSD; 12 without PTSD)	$n = 2$ (25%) 2 Simple Phobia, 1 Social Phobia	$n = 0$	100% male	100% Caucasian	65.3 (5.5)	68.6 (5.1)	14.4 (2.6)	13.8 (2.0)
Orr et al. (1998)	47 sexual abuse survivors (29 with current PTSD; 18 without PTSD)	$n = 24$ (83%) 9 Panic Disorder, 8 MDD, 8 Simple Phobia, 7 Dysthymia, 7 Social Phobia, 4 Bipolar, 4 Eating Disorder, 2 Somatoform, 1 Alcohol Dependence, 1 Cannibis Abuse	$n = 3$ (17%) 1 Panic Disorder, 1 Simple Phobia, 1 Alcohol Dependence, 1 Cannibis Dependence	100% male	Not available[b]	40.3 (7.6)	44.0 (13.1)	**13.4 (2.1)**[c]	**15.3 (2.2)**[c]
Carson et al. (2000)	38 Medication free female Vietnam nurses (17 with PTSD; 21 without PTSD)	$n = 13$ (76%) 7 MDD, 4 Panic Disorder, 3 Bipolar, 2 Agoraphobia, 2 Social Phobia, 2 Eating Disorder, 1 Dysthymia, 1 Simple Phobia, 1 OCD, 1 Alcohol Abuse	$n = 2$ (10%) 1 Dysthymia, 1 Simple Phobia	100% female	Not available[b]	53.9 (3.8)	54.0 (3.7)	15.9 (2.3)	16.3 (1.6)

Note. PTSD = posttraumatic stress disorder; MDD = major depressive disorder; OCD = obsessive compulsive disorder.
[a] Values are means with standard deviation in parentheses. [b] Data characterizing the ethnicity of participants was not collected as part of the Orr et al. (1998) and Carson et al. (2000) studies. [c] There was a statistically significant difference in years of education for the PTSD and non-PTSD groups in the Orr et al. (1998) study ($p < .05$). There are 152 participants included in this table; however, 150 participants were included in the current study because only participants with complete psychophysiologic and self-report data were included in the current study and there was no self-report data included for two participants in these studies. The individual participant demographic data are not available for this study. Therefore, we have opted to present the summarized demographic information as previously published in each study.

reported lower education levels than did the non-PTSD group (Orr et al., 1998).

Measures and Procedures

Script-driven imagery procedure. Script preparation for the script-driven imagery procedure was conducted according to published procedures (e.g., Pitman et al., 1987). Two personalized "scripts" approximately 30 s in length, composed in the second person, present tense, were created portraying each individual's traumatic events. In addition, three scripts related to other types of personal experiences, including stressful, positive, and neutral experiences, were also created. Participants also were presented with six standard scripts portraying various hypothetical experiences (two neutral, two fear, one positive, and one action) (Miller et al., 1987). Although participants heard all of the aforementioned scripts, only the personalized scripts portraying each individual's traumatic and stressful events were analyzed for the current study.

After the electrodes were attached, participants first listened to a 3-min recording of relaxation instructions and then began the script-driven imagery task. Participants were instructed to listen to the audio recorded scripts and vividly imagine the described events as though they were actually happening until they heard a tone. HR, SC, and facial (left lateral frontalis) EMG were measured throughout this imagery period. At the tone, participants were told to stop imagining the script and to relax until they heard a second tone. At the second tone, participants rated the degree to which they had experienced six basic emotions (i.e., happiness, sadness, anger, fear, disgust, and surprise) while listening to and imagining the events, using a 13-point (range 0–12) Likert-type scale (Izard, 1972). In addition, participants used similar 13-point Likert-type scales to rate the valence (unhappy/displeased-happy/pleased), arousal (calm/unaroused-excited/aroused), and vividness (not vivid/unclear-vivid/clear) of their imagery for each script (Lang, 1985). Following the ratings, there was a baseline period before the onset of the next script. The next script was initiated when at least 1 min had passed *and* HR had returned to within 5% of its value during the previous baseline period.

Scripts were recorded and played back to participants for each event. With minor variations, the scripts were presented in the following order: a standard neutral script was presented first, followed by two blocks of five scripts each. Each block included the following scripts: (a) a personalized trauma-related script, (b) a standard neutral script (sitting in a lawn chair, looking out a living room window, (c) a standard positive script (at a beach), (d) either a personalized other stressor script or a standard fear script (speaking in public), and (e) either the action (riding a bicycle) or the other standard fear script (speaking in public). The order of script presentation was randomized within block.

In all of the studies, HR, SC, and left lateral frontalis EMG, were recorded using a Coulbourn modular system (Coulbourn Instruments LLC, Whitehall, PA) and stored on a Microsoft Windows-based computer system. Electrodes attached to the participant were connected via wires to the Coulbourn system, which was located in an adjoining control that also contained the computer used to record physiologic responses, play back the scripts, and control presentation of the self-report scales.

Interbeat intervals were recorded using 8-mm Ag/AgCl electrodes filled with electrolyte paste and placed on each forearm and then converted to HR. SC was measured by a Coulbourn Isolated Skin Conductance coupler using a 0.5-V constant DC through 8-mm Ag/AgCl surface electrodes filled with isotonic paste and placed on the hypothenar surface of the subject's nondominant hand, according to published guidelines (Fowles et al., 1981). EMG responses of the left lateral frontalis muscle were recorded using 4-mm Ag/AgCl surface electrodes filled with electrolyte paste and integrated using a 200-ms time constant. The EMG electrodes were placed on abraded skin and were located according to published specifications (Fridlund & Cacioppo, 1986).

PTSD diagnosis. PTSD diagnostic status was based on Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised (*DSM-III-R*; American Psychiatric Association, 1987) criteria in four of the five studies (Orr et al., 1993; 1998; Pitman et al., 1987, 1990). In the Carson et al. (2000) study, PTSD diagnostic status was based on Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (*DSM-IV*; American Psychiatric Association, 1994) criteria.[1]

The Structured Clinical Interview for *Diagnostic and Statistical Manual of Mental Disorders-IV-revised, non-patient version, Vietnam* (*DSM-III-R*-NP-V), which was designed for use with Vietnam veterans (Spitzer & Williams, 1985), was used in three of the studies (Orr et al., 1993; Pitman et al., 1987, 1990). A slightly different version of the Structured Clinical Interview for *DSM-III-R* (*SCID-P*; Spitzer, Williams, Gibbon, & First, 1989) was used to classify participants into groups according to their PTSD diagnostic status in the Orr et al. (1998) study. The Clinician-Administered PTSD Scale, Diagnostic Version (Blake et al., 1995) was used in the Carson et al. (2000) study. In all studies, the interviews were administered by doctoral-level psychologists trained in administration of the diagnostic instrument.

Data Reduction

A response score was calculated for each psychophysiologic dependent variable (i.e., HR, SC, and EMG) by subtracting the average baseline period value that preceded each script presentation from the average value during the respective imagery period, separately for each of the two trauma-related scripts and the other stressful script. The psychophysiologic response scores for each physiologic measure were averaged for the two trauma-related scripts. Emotion self-report scores were represented by the Likert-scale ratings for each of the nine subjective measures separately for the two trauma-related scripts and the other stressful script. The emotion self-report scores for the respective subjective measure were averaged for the two trauma-related scripts.

Data Analytic Plan

Discriminant analysis is used for two primary purposes: (a) to identify variables that best discriminate members of two or more groups (e.g., clinician-diagnosed PTSD vs. non-PTSD) and (b) to

[1] *DSM-III-R* and *DSM-IV* diagnoses for PTSD differ in the following ways: (a) slight differences in the definition of a potentially traumatic event; (b) the addition of Criterion A2 (i.e., the person's response to the trauma involved intense fear, helplessness, or horror); and (c) the symptom of physiologic reactivity to trauma reminders was moved from the arousal cluster (Cluster D) to the reexperiencing cluster (Cluster B).

predict group membership by computing a discriminant function that produces weights (i.e., discriminant coefficients) for each variable that leads to the most accurate classification of each case into one of the groups (Silva & Stam, 1995). Predicted probabilities of group membership (based on values of the predictor variables) can be derived for each participant and analyzed in subsequent analyses. For the current study, four discriminant functions that maximally separated the clinician-diagnosed PTSD from non-PTSD group were derived from the combined data from the five studies. This methodology has the advantage of using all available data to empirically derive models that best predict PTSD diagnosis. First, a trauma-related psychophysiologic discriminant function was derived from the SC, HR, and lateral frontalis EMG responses during personalized trauma-related imagery (average of two scripts). This procedure mathematically determined the optimal weightings for the combination of HR, SC, and lateral frontalis EMG responses during trauma-related imagery that best predicted the PTSD diagnosis (see Orr, Metzger, Miller, & Kaloupek, 2004). Using similar procedures, we derived a self-report-based discriminant function that maximally separated the PTSD from the non-PTSD group based on items assessing subjective emotional experience and arousal in response to trauma-related scripts. This trauma-related, self-report discriminant function was derived from the nine self-report scores to trauma-related imagery using the same procedure as for the psychophysiologic reactivity scores described above. Discriminant functions were likewise derived for the psychophysiologic and subjective emotional responses to a personal, non-PTSD-related stressful event to assess the presence and predictive contribution of reactivity and emotional distress during nontraumatic mental imagery in individuals with PTSD. Predicted probabilities of a PTSD diagnosis, based on each of the discriminant functions, were saved and used in subsequent analyses.

Bivariate associations among the predicted probabilities of the discriminant functions were examined. In addition, their unique associations with PTSD diagnosis were tested using a series of univariate logistic regressions. A multiple logistic regression was also conducted to evaluate the predictive ability of the four predicted probabilities from each discriminant function (trauma-related psychophysiologic reactivity; other stressful psychophysiologic reactivity; trauma-related self-reported distress; and other stressful self-reported distress) simultaneously for PTSD diagnosis.

Finally, to provide a more fine-grained analysis of the prediction of PTSD diagnostic status by the respective probability measures, a communality analysis was conducted. Communality analysis (Nimon & Reio, 2011; Reichwein Zientek & Thompson, 2006) consists of a series of regressions that decompose the variance in the outcome into variance that is (a) accounted for and (b) unaccounted for by the predictor variables. The shared, or overlapping, variance is then further partitioned into unique and common effects. Unique effects identify how much variance is uniquely accounted for by an observed variable, and common effects identify how much variance is accounted for by the overlap among two or more predictors.

Results

The means and standard deviations for the psychophysiologic and self-reported emotional responses during script-driven imagery of the traumatic event(s) and other stressful event are presented in Table 2. As discussed above, these measures were entered into the different discriminant functions examined in this study. Participants with PTSD had greater physiologic reactivity during trauma-related script-driven imagery (as measured by HR, SC, and frontalis EMG response scores) and reported feeling more sadness,

Table 2

Psychophysiologic and Self-Reported Emotional Responses to Trauma-Related and Other Stressful Scripts in Individuals Who Met Criteria for a Diagnosis of PTSD Versus Those Who Did Not Meet Criteria for PTSD

	Trauma-related script-driven imagery						Other-stressor script-driven imagery					
			Mean differences						Mean differences			
Measure	PTSD[a]	No PTSD[a]	*t*	*df*	*p*	Loadings	PTSD[a]	No PTSD[a]	*t*	*df*	*p*	Loadings
Psychophysiologic measures												
HRR (BPM)	8.53 (10.48)	3.07 (5.10)	4.00	148	.000	0.29	4.68 (6.65)	2.93 (5.28)	1.78	148	.076	0.64
SCR (μS)	1.02 (1.20)	0.24 (0.70)	4.81	148	.000	0.66	0.57 (1.23)	0.36 (0.94)	1.19	148	.234	0.24
F-EMG (μV)	2.79 (4.00)	0.69 (1.99)	4.01	148	.000	0.38	1.06 (2.84)	0.50 (1.94)	1.42	148	.157	0.40
Self-report measures												
UNP	11.38 (1.24)	10.70 (1.64)	2.90	148	.004	0.24	10.79 (2.06)	10.57 (2.10)	0.66	148	.508	0.23
AR	9.92 (2.57)	9.78 (2.28)	0.33	148	.740	−0.26	9.23 (2.77)	9.69 (2.41)	−1.09	148	.278	−0.82
VIV	1.38 (2.15)	2.00 (2.21)	−1.73	148	.086	−0.07	2.18 (2.66)	2.29 (2.88)	−0.25	148	.804	−0.01
HAP	0.23 (0.99)	0.38 (0.91)	−0.10	148	.332	0.01	0.46 (1.37)	0.58 (1.78)	−0.47	148	.638	−0.09
SAD	9.37 (3.10)	8.12 (3.69)	2.25	148	.026	−0.09	8.73 (4.18)	8.53 (4.31)	0.29	148	.770	−0.27
ANG	9.78 (3.16)	7.56 (3.86)	3.88	148	.000	0.44	8.45 (3.81)	6.92 (3.88)	2.44	148	.015	0.59
FE	9.38 (2.93)	7.95 (3.52)	2.72	148	.007	0.18	8.27 (4.06)	7.11 (4.39)	1.68	148	.095	0.43
DIS	9.28 (3.48)	7.07 (4.00)	3.61	148	.000	0.36	6.05 (4.68)	4.76 (4.62)	1.69	148	.092	0.22
SUR	7.90 (3.78)	6.44 (3.84)	2.35	148	.020	0.33	6.77 (4.58)	6.01 (4.31)	1.04	148	.300	0.20

Note. $n = 150$. PTSD = posttraumatic stress disorder; *df* = degrees of freedom; Loadings = standardized canonical discriminant function coefficients; HRR = heart rate response; BPM = beats per minute; SCR = skin conductance response; F-EMG = frontalis electromyogram; UNP = unpleasantness; AR = arousal; VIV = vividness; HAP = happiness; SAD = sadness; ANG = anger; FE = fear; DIS = disgust; SUR = surprise. PTSD diagnosis based on semi-structured diagnostic interviews. The self-report measures were rated on a Likert-type scale ranging from 0 to 12. Significant differences are at $p < .05$.

[a] Values are means with standard deviation in parentheses.

anger, fear, disgust, and surprise than individuals without PTSD ($ps < .05$). Individuals with PTSD also described the trauma scripts as more unpleasant than did individuals without PTSD ($p < .05$). In contrast, the only significant group difference for the other stressful imagery was for anger ratings; individuals with PTSD reported more anger than those without PTSD ($p < .05$).

Discriminant Function Analyses

Psychophysiologic response scores for trauma-related script-driven imagery. The trauma-related psychophysiologic discriminant function produced a sensitivity of 59% and a specificity of 90%. In other words, psychophysiological activity in response to trauma scripts is able to correctly identify 59% of individuals diagnosed with PTSD and correctly identify 90% of participants without PTSD.

Emotion self-report scores for trauma-related script-driven imagery. The trauma-related, self-report discriminant function produced a sensitivity of 67% and a specificity of 61%. Thus, subjective "distress" in response to trauma scripts is able to correctly identify 67% of individuals diagnosed with PTSD and correctly identify 61% of participants without PTSD.

Psychophysiologic response scores for other stressful script-driven imagery. A discriminant function was derived from the SC, HR, and lateral frontalis EMG responses during personalized imagery of the other stressful event. This other stressor psychophysiologic discriminant function produced a sensitivity of 46% and a specificity of 72%.

Emotion self-report response scores for other stressful script-driven imagery. A discriminant function was derived from the nine subjective ratings during personalized imagery of the other stressful event. This other stressor self-report discriminant function for the other stressful event produced a sensitivity of 64% and a specificity of 63%.

Bivariate Associations Among the Measures of Psychophysiologic and Self-Reported Distress

Bivariate associations among the predicted probabilities derived from the four discriminant functions (i.e., psychophysiologic and self-report functions for the trauma-related and other stressor-related scripts) are presented in Table 3. The predicted probabilities derived from trauma-related psychophysiologic reactivity and other stressful psychophysiologic reactivity were significantly and moderately correlated ($r = .50$), as were probabilities derived from the trauma-related self-reported distress and other stressful self-reported distress ($r = .42$). The probabilities derived from trauma-related psychophysiologic reactivity and trauma-related self-reported distress exhibited a small but significant association ($r = .18$). None of the other three bivariate associations was significant.

Logistic Regression Predictions of PTSD Diagnosis

Table 4 displays the coefficients from the logistic regression analyses. At a bivariate level (i.e., coefficients from the univariate logistic regressions), each of the discriminant function predictive probabilities was significantly associated with PTSD diagnostic status; the odds ratios ranged from 1072.13 for the trauma-related psychophysiological reactivity to 76.63 for the trauma-related, self-reported distress. Cox & Snell R^2 values ranged from .24 for the trauma-related psychophysiologic reactivity to .03 for the other stressful psychophysiologic reactivity. In the multiple logistic regression with each measure simultaneously predicting PTSD diagnosis, trauma-related psychophysiologic reactivity, trauma-related self-reported distress, and other stressful self-reported distress remained significant predictors of PTSD diagnosis, whereas other stressful psychophysiologic reactivity was no longer significantly associated with PTSD diagnosis. The Cox & Snell R^2 value for the multiple logistic regression was .34.

Table 3
Descriptive Statistics and Bivariate Associations Among Discriminant Function-Derived Predicted Probabilities

Discriminant function	1	2	3	4	*M*	*SD*
1. Trauma-related psychophysiology	—				0.48	0.19
2. Other stressful psychophysiology	.50***	—			0.50	0.08
3. Trauma-related self-report	.18*	.06	—		0.51	0.18
4. Other stressful self-report	.09	.04	.42***	—	0.50	0.14

Note. M = mean; SD = standard deviation; PTSD = posttraumatic stress disorder. The discriminant function derived predicted probabilities range from 0 to 1; 0 = 0% probability of meeting criteria for PTSD; PTSD based on clinician diagnosis and 1 = 100% probability of meeting criteria for PTSD based on clinician diagnosis.
$^{*} p < .05$. $^{***} p < .001$.

Communality Analysis

The results of the communality analysis are summarized in Table 5. The multiple logistic regression reported above indicated that all of the measures together account for approximately 34% of the variance in PTSD diagnosis. The communality analysis indicated that 48% of the total accounted-for variance (i.e., 48% of 34%) was due to the unique effect of the trauma-related psychophysiologic reactivity. The next largest contributor to the prediction of PTSD diagnosis status was the common effect of trauma-related and other stressful self-reported distress, which accounted for 11% of the total accounted for variance (i.e., 11% of 34%). Of the 34% total variance accounted for by the combination of the four measures, the total contribution of the trauma-related psychophysiologic reactivity (i.e., the sum of its unique effect and all common effects that included this measure) was 68%, and the total contribution of the trauma-related self-reported distress, other stressful self-reported distress, and other stressful psychophysiologic reactivity was 37%, 27%, and 9%, respectively.[2]

Discussion

The current study used a combined dataset of five studies to assess the relative utility of psychophysiologic reactivity versus self-reported emotional distress in predicting PTSD diagnosis. This study further examined whether the predictive power of these two different measures of emotional response was specific to trauma-related stimuli or generalized to other highly stressful, but not trauma-related, events. To accomplish these aims, we devel-

[2] Because the common effects include multiple measures, the sum of these percentages exceeds 100%.

Table 4
Summary of the Logistic Regression Equations Predicting PTSD Status

Analysis of discriminant function	Variable	*b*	*Wald*	*OR*	R^2
Univariate 1	Intercept	-3.13^{***}	24.51	0.04	.24
TRP	TRP	6.98^{***}	24.98	1072.13	
Univariate 2	Intercept	-2.35^{***}	3.70	0.10	.03
OSP	OSP	4.89^{***}	3.98	133.09	
Univariate 3	Intercept	-2.12^{***}	14.70	0.12	.13
TRSR	TRSR	4.34^{***}	17.79	76.63	
Univariate 4	Intercept	-2.23^{***}	11.07	0.11	.09
OSSR	OSSR	4.61^{***}	12.66	100.36	
Multiple 1	Intercept	-5.02^{**}	8.16	0.01	.34
TRP, OSP, TRSR, OSSR	TRP	8.19^{***}	21.11	3607.01	
	OSP	-4.55	1.62	0.01	
	TRSR	3.39^{**}	7.18	29.69	
	OSSR	3.71^{*}	5.74	41.02	

Note. PTSD = posttraumatic stress disorder; *Wald* = Wald statistic; *b* = unstandardized regression coefficient; *OR* = odds ratio; TRP = trauma-related psychophysiology; OSP = other stressful psychophysiology; TRSR = trauma-related self-report; OSSR = other stressful self-report. Univariate refers to results from the univariate logistic regression equations and multiple refers to the results from the multiple logistic regression equation.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

oped a series of discriminant functions (DiscFxs) that maximally separated participants with clinician-diagnosed PTSD from trauma-exposed individuals who did not meet criteria for PTSD. The first DiscFx measures psychophysiologic response to trauma-related, script-driven imagery procedures and is similar to the DiscFxs previously used in several studies (Carson et al., 2000; Orr et al., 1993, 1998; Pitman et al., 1987, 1990; Shalev et al., 1993). Following the same method, three additional DiscFxs were developed. The first included the nine self-report items that participants use to describe their subjective emotional responses to the trauma-related scripts. The remaining two DiscFxs were based on psychophysiologic and self-report emotional responses to another stressful, but not trauma-related, event.

Table 5
Summary of the Communality Analysis

Unique and Common Effects of DiscFxs	R^2	R^2/34
Unique (TRP)	16.4	47.7
Common (TRSR, OSSR)	3.8	11.1
Unique (TRSR)	3.4	10.0
Common (TRP, TRSR)	2.8	8.0
Unique (OSSR)	2.7	8.0
Common (TRP, TRSR, OSSR)	2.2	6.3
Common (TRP, OSP)	1.6	4.7
Unique (OSP)	0.7	2.1
Common (TRP, OSP, TRR, SR)	0.3	1.0
Common (TRP, OSP, TRSR)	0.1	0.4
Common (OSP, TRSR)	0.1	0.4
Common (TRP, OSSR)	0.1	0.3
Common (OSP, TRSR, OSSR)	0.0	0.0
Common (OSP, OSSR)	0.0	0.0
Common (TRP, OSP, OSSR)	0.0	0.0

Note. DiscFx = discriminant functions; TRP = trauma-related psychophysiologic reactivity; OSP = other stressor-related psychophysiologic reactivity; TRSR = trauma-related self-reported distress; OSSR = other stressor-related self-reported distress; R^2 = Cox & Snell R^2 (variance accounted for); R^2/34 = the ratio of variance accounted for by the effect divided by the total variance accounted for (i.e., out of all of the variance accounted for by the predictors how much did this particular effect contribute).

Notably, the two DiscFxs comprised of self-reported measures of distress, which were based on participants' subjective emotional responses to the trauma-related and other stressful scripts, were similarly sensitive (67% and 64%, respectively) for the PTSD diagnosis. These DiscFxs were slightly more sensitive than the psychophysiologic DiscFx for the trauma-related script (59%) and notably more sensitive than the psychophysiologic DiscFx for the other stressful script (46%). Interestingly, one might have anticipated even higher sensitivities for the self-report-based DiscFxs, given that the PTSD diagnosis being predicted is also based to a large extent on self-reported emotional experiences.

Although the self-report-based discriminant functions were slightly more sensitive predictors of PTSD, the psychophysiologic DiscFx for the trauma-related script had substantially better specificity (90%) than the three other DiscFxs. Specificity for the DiscFx based on psychophysiologic response scores to the other stressful script (72%) also outperformed both self-report DiscFxs (61% and 63%). Although 90% of individuals who did *not* meet criteria for PTSD as assessed by a semistructure interview were correctly classified as not meeting PTSD based on patterns of physiological activity in response to trauma scripts, only 61% of individuals without semistructure interview based PTSD diagnosis were correctly classified as such based on their self-reports of emotional distress. Thus, it appears that although self-reported distress may be slightly more likely to identify "true" PTSD diagnoses, psychophysiologic reactivity is notably less likely to produce false positives.

After developing these discriminant functions, we further tested their relative usefulness in predicting PTSD diagnosis with a series of regression equations followed by communality analyses. Perhaps not surprisingly, both self-reported distress and psychophysiologic reactivity in relation to the trauma scripts were significant predictors of PTSD diagnosis. These measures were significant predictors when evaluated separately in univariate regression equations and when the four DiscFxs were entered simultaneously in a multiple regression equation. These findings align with current *DSM-IV* criteria and the substantial literature documenting both increased self-reported distress and psychophysiologic reactivity to trauma cues in individuals with PTSD, compared with those without a diagnosis (Blanchard et al., 1994; Keane et al., 1998; Laor et al., 1998; McDonagh-Coyle et al., 2001; Shalev et al., 1993; Wolf et al., 2009); see Pole, 2007 for a review. As hypothesized, the self-reported distress to the other stressful script was also a significant predictor of PTSD diagnosis even after controlling for the three other measures. This suggests that individuals with PTSD report heightened emotional distress to negative events that extend beyond their traumatic experiences, perhaps reflecting more general negative affect (Simms et al., 2002). The finding that increased self-reported distress generalizes to other stressful events stands in contrast to the psychophysiologic reactivity results. Heightened psychophysiologic reactivity associated with PTSD appears to be specific to trauma memories and does not generalize to other highly stressful emotional events. These findings are congruent with the literature documenting that heightened psychophysiologic reactivity appears to characterize anxiety disorders that are associated with a specific fear, as in PTSD or specific phobia (McNeil et al., 1993; Shalev et al., 1993).

Because the multiple regression equation can only indirectly address the relative contributions of psychophysiologic reactivity versus self-reported distress in predicting PTSD diagnosis, we conducted a communality analysis. Notably, almost half of the total variance in PTSD diagnosis that was accounted for by the four measures was due to the unique effect of the trauma-related psychophysiologic reactivity. Self-reported emotional distress to the trauma-related script and other stressful script were also important contributors in explaining the total variance accounted for by the four measures; the combination of the overlapping variance and each measure's unique variance accounted for an additional 29% of the total explained variance.

Taken together, our findings suggest that psychophysiologic reactivity to trauma-related memories is a robust predictor of PTSD diagnosis. These findings are consistent with the extensive literature documenting heightened psychophysiologic reactivity to trauma cues in individuals with PTSD as compared to those without a diagnosis (Pole, 2007). These data also suggest that psychophysiologic and self-report measures of emotional response are not duplicative. Although significant, the correlation coefficient between the psychophysiologic reactivity and self-reported emotional distress to the trauma-related script was small to moderate ($r = .18$). Furthermore, the common effects of trauma-related psychophysiologic reactivity and self-report distress only accounted for 8% of the total variance explained by the four probability measures in predicting PTSD diagnosis. This is in stark contrast to the unique effects of these measures; trauma-related psychophysiologic reactivity accounted for 48% and trauma-related, self-reported distress accounted for 10% of the total explained variance in the PTSD diagnosis.

As exemplified by the Research Domain Criteria (RDoC) framework, there is a movement in psychopathology research to shift focus away from particular clinical diagnoses to the identification of phenotypes of psychological and biological processes that may explain psychiatric symptoms (Sanislow et al., 2010). Consistent with this framework, heightened psychophysiologic reactivity to script-driven imagery may represent a biological process that reflects acquisition of an intense emotional response to trauma-related cues and/or impaired extinction of these emotional responses. Thus, psychophysiologic reactivity to script-driven imagery is a potential experimental paradigm that could be used to index the acute threat construct of the negative valence system domain within the RDoC. The potential usefulness of this paradigm is supported by its objectivity, standardized procedure, established algorithms to best differentiate individuals with and without PTSD, and good test–retest reliability (Bauer et al., 2013). Furthermore, unlike psychological diagnoses that change over time with each subsequent DSM, psychophysiologic reactivity measures do not. Future research may extend the use of this paradigm to other populations. For example, it is possible that individuals with other fear-based disorders (e.g., specific phobia, agoraphobia) would exhibit similar patterns of reactivity to scripts describing their fears (cf., McNeil et al., 1993; Shalev et al., 1993).

Heightened psychophysiologic reactivity appears to be distinct from self-reported emotional distress to the trauma-related and other stressor-related scripts. Self-reported emotional distress may be an index of negative affect, that is, a shared global distress factor found in all mood and anxiety disorders (Clark et al., 1994; Simms et al., 2002). As applied to the RDoC framework, self-reported distress may either fall within the specific construct of potential harm (i.e., anxiety related to potential harm rather than imminent threat) or might overlap more broadly with the various components of the negative valence system domain, which includes responses to acute threat, potential harm, sustained threat, frustrative nonreward, and loss (National Institute of Mental Health, 2011, March).

It is an interesting possibility that individuals who experience trauma-related sequelae characterized by subjective reports of distress to trauma cues in the absence of heightened psychophysiological reactivity may be qualitatively different from individuals who experience trauma-related sequelae that include heightened psychophysiological reactivity to trauma reminders. This distinction could have important implications for our understanding and treatment of individuals diagnosed with PTSD. It is possible that these phenotypes might inform future conceptualizations of PTSD symptom clusters. Perhaps individuals with PTSD characterized primarily by psychophysiologic reactivity to trauma-related stimuli would be best described as having a fear-based disorder, whereas individuals with PTSD characterized primarily by self-reported distress would be best described as having a distress-based disorder. In turn, these subtypes, fear-based PTSD versus distress-based PTSD, would likely warrant different treatment approaches. If future research supports these subtypes, script-driven imagery procedures could be implemented in PTSD clinics as part of a pretreatment assessment battery. A probability score denoting the likelihood of meeting PTSD diagnostic criteria could be developed by applying the discriminant functions described in the current study to an individual patient's psychophysiological response scores. Comparing the probability scores for the emotional distress and psychophysiological reactivity discriminant functions would provide an indication of the relative role of fear versus distress in their PTSD diagnostic profile.

An important limitation of the present study is the assumption that the measures and methodology used to assess subjective emotional distress are as valid as the measures and methodology used to assess psychophysiologic reactivity. When rendering their emotion self-reports, the subjects tended to answer at the extremes of the Likert scales, thereby potentially diminishing their accuracy. If these scales could be refined to provide a more sensitive measure of subjective/self-reported emotions, a different pattern of results might be observed. An additional potential limitation is the use of *DSM-III-R* diagnostic criteria in several of the studies and *DSM-IV* criteria in another. However, the possible impact seems mitigated by the relatively minor differences in the PTSD criteria as defined by *DSM-III-R* and *DSM-IV*. Prior research has also demonstrated good agreement between *DSM-III-R* and *DSM-IV* diagnoses (Schwarz & Kowalski, 1991). Regardless, these findings await replication with independent datasets in which PTSD was diagnosed using *DSM-IV* (and eventually *DSM-5*) PTSD diagnostic criteria. The current study's findings align with proposed changes in *DSM-5* including the elimination of the subjective reaction component of the index traumatic event and the new four-symptom cluster conceptualization that includes reexperiencing, avoidance, negative cognitions and mood, and arousal. A related limitation is the use of different structured clinical interviews across studies. However, this limitation is also mitigated by the high diagnostic agreement shown in research comparing the clinician-administered PTSD scale and SCID (Barlow, 2002). It is also important to acknowledge that although the present study includes a diverse range of participants with regard to gender, age, and type of trauma experiences, all participants for whom there were available race or ethnicity data reported their race to be Caucasian and had very chronic PTSD. Research is needed to determine the extent to which the present findings generalize to ethnically diverse samples and samples with more acute PTSD. In addition, because this study was a secondary analysis of archival data, we did not have access to person-level data on comorbid diagnoses, and therefore, could not examine how comorbid diagnoses such as depression or panic disorder would impact the pattern of associations among psychophysiological reactivity, emotional distress and PTSD. Future research should examine comorbid diagnoses and other potential moderators of these relationships such as trauma type, chronicity of PTSD, and gender.

Despite its limitations, the present study provides compelling evidence for the distinctiveness of emotional experience as indexed by measures of psychophysiologic reactivity and subjective reports as well as their unique contributions to the prediction of the PTSD diagnosis. Of the four indices examined, psychophysiologic reactivity to trauma-related cues appears to be the most robust predictor. Furthermore, the relatively weak relationship between psychophysiologic reactivity and self-reported emotion to script-driven imagery and the different predictive relationships of these emotion measures to PTSD provide a strong rationale for identifying and exploring different posttrauma phenotypes. For PTSD specifically, it appears that phenotypes of self-reported negative affect in combination with heightened psychophysiologic arousal to script-driven imagery would be particularly promising avenues to pursue.

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