Psychophysiologic Testing for Post-Traumatic Stress Disorder: Forensic Psychiatric Application

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The validity of the post-traumatic stress disorder (PTSD) diagnosis is limited by both the illusory objectivity of the traumatic event and the subjectivity of the ensuing syndrome. These limitations are especially problematic in the forensic setting. Psychophysiologic measurements may strengthen PTSD's forensic value by offering a more objective assessment technique for cases that find their way into the courtroom. Based upon the results of published research studies conducted in a range of military and civilian, PTSD and non-PTSD subjects, psychophysiologic data can provide evidence helping to establish or refute the presence of the DSM-III-R PTSD arousal criteria, as well as aid psychiatric experts in estimating the probability of the disorder's presence in a given claimant. Psychophysiologic testing should be viewed as one component of a multimethod forensic psychiatric evaluation for PTSD. It is likely that it will soon be offered and, given current legal standards, admitted as evidence in civil and criminal litigation.

An expanding role is being played in the legal system by post-traumatic stress disorder (PTSD), a diagnostic entity created by committee consensus little more than a decade ago for inclusion in the 1980 Diagnostic and Statistical Manual, Third Edition (DSM-III).[1] Yet PTSD has been characterized as a "forensic minefield,"[2] and in the courtroom the PTSD diagnosis itself is put on trial. The revised 1987 edition of DSM-III (DSM-III-R)[3] includes a "Cautionary Statement" that a diagnostic category "does not imply that the condition meets legal standards . . . for what constitutes mental disease, mental disorder, or mental disability . . . categorization of these conditions as mental disorders may not be wholly relevant to legal judgments."[3, p.xxix] This disclaimer has received as much credence as labels on children's water wings warning that they are not to be used for flotation. Zealous legal advocates will seize upon anything to buoy their arguments and may be expected to continue to use the diagnostic categories in DSM-III-R and its successor Manuals until a more suitable alternative emerges.[4] The current forensic value of the DSM-III-R PTSD diagnosis, however, is plagued by several limitations.

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Table 1
DSM-III-R Diagnostic Criteria for Post-Traumatic Stress Disorder (Abridged)

A. An event outside the range of usual human experience that would be markedly distressing to almost anyone
B. Reexperiencing criteria (one required)
   1. Recurrent, intrusive, distressing recollections of the event
   2. Recurrent, distressing dreams of the event
   3. Flashbacks to the event
   4. Intense psychological distress at exposure to events that symbolize or resemble the traumatic event
C. Avoidance criteria (three required)
   1. Of thoughts and feelings associated with the trauma
   2. Of activities or situations that arouse recollections of the trauma
   3. Inability to recall an important aspect of the trauma
   4. Markedly diminished interest in significant activities
   5. Feelings of detachment or estrangement from others
   6. Restricted range of affect (numbing)
   7. Sense of a foreshortened future
D. Arousal criteria (two required)
   1. Insomnia
   2. Irritability or outbursts of anger
   3. Difficulty concentrating
   4. Hypervigilance
   5. Exaggerated startle response
   6. Physiological reactivity to events that symbolize or resemble the traumatic event
E. Duration at least one month

Forensic Limitations of the PTSD Diagnosis

Illusory Objectivity of the Stressor

Table 1 presents the abridged DSM-III-R diagnostic criteria for PTSD. In addition to defining the components of the PTSD syndrome in criteria "B" through "D," criterion "A" attempts to set an objective floor for the causal stressor, requiring that it be "outside the range of usual human experience [and] markedly distressing to almost anyone." The need to incorporate a version of the legal concept of foreseeability into the clinical diagnostic criteria points to limited confidence in the syndromal diagnosis of PTSD. Moreover, operationalizing this stressor floor is no simple matter. The assumption that there exists a "range of usual human experience" is dubious from a cross-cultural perspective. For example, gang-related shootings may be rare in rural Minnesota but all too common in urban Los Angeles. A recent study[5] found that at some time in their lives, 39 percent of the middle-class Detroit population was exposed to traumatic events potentially capable of causing PTSD, and 25 percent of exposed persons went on to develop the disorder. Another study[6] reported that stressors falling within the range of usual human experience are sometimes capable of resulting in the PTSD syndrome.

The examples presented in DSM-III-R of stressors that may cause PTSD raise as many questions as they settle. Does the "sudden destruction of one's home" include losing one's summer house in a fire? Does driving past a body under a sheet at the scene of a car crash constitute "seeing another person who has recently been . . . killed as the result of an accident?" Of all the examples provided in DSM-III-R, "serious threat to one's life or physical integrity" appears the most straightforward. However, not all experts would accept the sudden denuding of a litigant's scalp by a faulty hair rinse[7] as a stressor sufficient to cause PTSD.

The illusion of an "objective" stressor is further evidenced by the consideration that the victim's appraisal constitutes a

necessary link in the causal chain from event to stress response. An identical event may not be experienced the same way by two people. Pilowsky[8] has coined the term "cryptotrauma" for a situation in which a stressor that appears innocuous to an observer may be perceived by the victim as life-threatening. Retrospective discovery that the appraisal was incorrect doesn't erase the distress associated with the original experience.

It has been cogently suggested[9] (and intimated in the descriptive DSM-III-R text accompanying the formal diagnostic criteria) that the appropriate characterization of the relationship between apparent stressor severity and psychopathologic outcome is one of probability.

Subjective Nature of the Symptomatology Obstacles to objectively defining the stressor in PTSD increase the importance of objectively defining the response. Unfortunately, of all the problems posed by PTSD in the courtroom, the most daunting is the subjective nature of the disorder's manifestations. "Although the assessment of [PTSD-specific] symptoms is the most crucial link in the chain of proximate causation, it remains uniquely vulnerable because of its dependence upon the veracity of the complainant."[10, p.124] Except for the infrequent case in which a witness can testify to the claimant's "sudden acting ... as if the traumatic event were recurring," the presence of the DSM-III-R "B" (intrusion) criteria (Table 1) is based upon the claimant's report of such subjective matters as "recollections," "dreams," "feeling," and "distress." Similarly, determination of the "C" (avoidance) criteria is primarily based on the claimant's report of "efforts to avoid thoughts or feelings associated with the trauma," "efforts to avoid activities or situations that arouse recollections of the trauma," "diminished interest," "feelings of detachment and estrangement," and a "sense of a foreshortened future," although on occasion a witness may substantiate, or a jury may directly observe, avoidance behavior and/or restricted affect. Substantial opportunity for objective quantification appears to exist for the "D" (arousal) criteria, but even here the usual practice is to determine the presence of these items from the claimant's self-report.

Estimates of the occurrence of PTSD have shown substantial variation. The incidence of the disorder has been set at between 1 percent[11] and 9 percent[5] in the general population, between 34 percent and 78 percent in rape victims,[12] between 3 percent[11] and 37 percent[13] in assault victims, and between 15 percent[14] and 31 percent[15] in Vietnam veterans. Much of this variation is due to differences in clinical diagnostic techniques. Under the ideal conditions of trained raters applying the same structured interview instrument to members of a well-defined population, diagnostic agreement for the PTSD diagnosis can achieve respectable levels, e.g., $\kappa = .65$ (test-retest reliability).[16] Unfortunately, such conditions are not commonplace in forensic psychiatric interviews. Furthermore, reliability does not equate with validity; high interrater agreement

does not protect against biases shared by raters or built into the instrument itself.

Estimates of the incidence of PTSD have been found to differ with the instrument employed. For example, use of the Structured Clinical Interview for DSM-III-R (SCID) has been reported[17] to yield a four-fold higher estimate of the incidence of PTSD than use of the Diagnostic Interview Schedule (DIS). The SCID differs from the DIS in that it calls for more probing into specific DSM-III-R symptoms. That different instruments yield different results illustrates a dilemma in the interview-based diagnosis of PTSD. On the one hand, because of the tendency of PTSD patients to avoid recalling the trauma, superficial questioning may miss the diagnosis. On the other hand, recitation of structured interview items incorporating the PTSD diagnostic criteria may be treated by motivated respondents as a series of leading questions evoking answers that too readily lead to a PTSD diagnosis. Since the diagnostic criteria for PTSD are available through publication and word-of-mouth, there is little to stop a motivated claimant from learning what symptoms must be reported to qualify for the diagnosis. In consideration of this, the Department of Veterans Affairs requires an administrative determination that a veteran has experienced adequate combat exposure, in addition to a clinical diagnosis of PTSD, in order to be awarded a service-connected PTSD disability.

Psychometrics appear to offer limited protection against overreporting of symptoms. Untraumatized persons are able to produce scores similar to those obtained from genuinely traumatized persons on two psychometric instruments commonly used to diagnose PTSD: the Impact of Event Scale[18] and the Minnesota Multiphasic Personality Inventory (MMPI).[19]

Role of Psychophysiology in the Assessment of PTSD

It has been proposed that expert witness testimony regarding PTSD should be "increasingly supported by empirically based research data."[10, p.115] In this regard, a growing body of research[20–22] illustrates the potential for psychologically traumatic events to induce lasting biologic changes in exposed persons. Just as advances in the biologic understanding of schizophrenia and affective disorder have refuted the once popular suggestion that mental illness is a myth,[23] the demonstration of biologic changes in traumatized persons may refute the suggestion that PTSD is a scam. Biologic measurement has the potential to redeem the PTSD diagnosis from its current subjectivity and to help separate the wheat from the chaff in the forensic evaluation of PTSD claims. "A subjective interpretation of whether anxiety is pathologic or not can be avoided if anxiety is conceptualized strictly in terms of autonomic system functioning."[7, p.14]

As early as 1941, Kardiner[24] coined the term "physioneurosis" to characterize the PTSD condition. Biologic considerations have found their way into the DSM-III-R conceptualization of PTSD mainly within the "D" (arousal) criteria (Table 1). Items such as difficulty falling

or staying asleep, hypervigilance, exaggerated startle response, and physiologic reactivity to reminders of the traumatic event all lend themselves to biologic measurement. Contemporary psychophysiologic investigation involves measuring the physiologic responses of PTSD and control (comparison) research subjects to stimuli both related and unrelated to the original traumatic event.

Studies of Physiologic Responding to Trauma-Related Stimuli "Currently the best and most specific biological diagnostic test for PTSD is psychophysiological assessment."[25, p.74] This conclusion is based on research (reviewed in reference 26) addressing DSM-III-R PTSD criterion D.6 (Table 1), viz., "physiologic reactivity upon exposure to events that symbolize or resemble an aspect of the traumatic event."

Studies with Standard Trauma-Related Stimuli In 1982, Blanchard and colleagues[27] reported that Vietnam combat veterans with PTSD showed greater heart rate and blood pressure responses to combat-related sounds (machine gun fire, explosions) in the laboratory than did noncombat control subjects. These investigators subsequently replicated this finding in a study[28] using combat control subjects. In 1983, Malloy and colleagues[29] observed larger heart rate responses to combat pictures and sounds in Vietnam veterans with PTSD, in comparison with mentally healthy Vietnam veterans and non-PTSD psychiatric inpatients. These authors described their approach as a "multimethod assessment," in which physiologic data supplement self-reports and behavioral observations in the assessment of PTSD. Each of the above studies employed standard stimuli, i.e., the same stimuli were presented to all subjects within a study.

Script-Driven Imagery Technique A limitation of standard stimuli is that they may not effectively reproduce what was uniquely stressful about even a war veteran's particular traumatic combat experience. For example, pictures and sounds of ground combat may have little meaning for a pilot whose stress involved being shot down and held as a prisoner of war. In applications to the wide variety of potentially traumatic events experienced by civilians, the use of standard stimuli becomes impractical. However, Lang[30] has devised a procedure that circumvents this difficulty by substituting script-driven imagery of personal events for standard audio-visual stimuli. Pitman and colleagues have applied Lang's script-driven imagery procedure to the study of PTSD. In this procedure, the research subject meets with a mental health professional, who elicits specific information concerning the subject's various past personal experiences. From this information, a 30-second "script" is derived, written, and recorded for each event.

The following script is based on an event that befell a Vietnam veteran research subject who did not develop PTSD in connection with his combat experience but who did meet clinical criteria for PTSD as the result of a subsequent industrial accident, although he had not sought treatment.

You're doing a high-pressure test of a tanker's air system. Suddenly you see the gas pressure on a gauge drop. Knowing that something is desperately wrong, you begin to feel jittery. You yell to _____ to shut the valve. With your heart pounding, you descend the tanker's hatch to the lower level. There you see a worker unconscious on the floor. As you drag him toward the ladder, your breathing intensifies, and you feel limp. You look up to see _____ falling. Then you lose consciousness. Upon reviving, you learn that _____ has died.

Laboratory Procedure In the psychophysiology laboratory, the subject's traumatic and other personal scripts are played back to him or her one at a time. Standard scripts, e.g., pleasant and fearful scenes, are also presented. The subject is instructed to imagine the event each script portrays as vividly as possible, as if he or she were actually experiencing it, while measurements are made of heart rate, sweat gland activity (skin conductance), and tension in one or more muscles of the face (e.g., lateral frontalis electromyogram or EMG). A response score for each physiologic measure is calculated for each script by subtracting the measure's baseline value immediately preceding the script from its value during imagery of that script; these response scores are then subjected to statistical analysis. For example, the industrial accident subject's physiologic responses during imagery of the above traumatic script, as well as during imagery of his other personal and standard scripts, are presented in Table 2. This physically noninvasive procedure is generally well tolerated by research subjects.

Studies with Imaginal Stimuli Pitman and colleagues have successfully utilized the script-driven imagery procedure in four independent studies. A first study[31] found that 18 Vietnam combat veterans with PTSD produced markedly higher physiologic responses during imagery of their personal combat events than did 15 mentally healthy combat control subjects. A second study[32] found higher physiologic responding during personal combat imagery in a new group of seven PTSD Vietnam combat veterans, compared with seven Vietnam combat veterans with non-PTSD anxiety disorders. An analysis[33] of the combined data from the first and second studies demonstrated significant correlations between subjects' physiologic responses and psychometric measures of PTSD. A third study[34] found significantly higher physiologic responses during combat imagery in a group of eight World War II and Korean veterans with PTSD compared with 12 mentally healthy combat veterans of the same wars. These studies all used male American combat veteran subjects. However, a fourth study[35] compared nine male and four female PTSD, and six male and seven female non-PTSD, civilian Israeli victims of road accidents, assaults, and other noncombat traumata. This study again found significantly higher physiologic responses during personal traumatic imagery in the PTSD subjects.

Sixteen of the non-PTSD Vietnam combat veteran subjects from the first study returned to the laboratory for a second session.[36] They were instructed to attempt to simulate the physiologic

Table 2
Industrial Accident Subject's Physiologic Responses during Script-Driven Imagery

Script	Type	HRR	SCR	EMGR
Sitting in a lawn chair	Standard	+1.3	+0.15	0.0
Marriage proposal	Personal	+2.4	+0.43	−0.2
Rocket explosion in Vietnam	Personal	+0.6	+0.11	0.0
Feeding the dog	Personal	−1.9	0.00	−0.2
Industrial accident	Personal	+5.2	+0.66	+0.4
Riding a bicycle	Standard	−1.2	−0.17	−2.3
Fight in a club	Personal	+4.1	0.00	0.0
Sitting in the living room	Standard	−2.1	−0.04	0.0
Giving a public speech	Standard	+3.0	−0.02	+1.6
Mortar attack in Vietnam	Standard	+1.0	+0.02	+0.2
Lying on a sandy beach	Standard	−0.8	−0.02	0.0

HRR = Heart rate response, SCR = skin conductance response; EMGR = lateral frontalis electromyogram response.

responses of PTSD subjects. Only 25 percent were able to do so successfully. No data are available regarding the potential ability of pretest practice or training to affect this rate.

Studies of Physiologic Responding to Nontrauma-Related Stimuli Not all physiologic symptoms of PTSD involve heightened responses to stimuli related to the traumatic event. The condition is thought to comprise nonspecific hyperarousal as well, including insomnia, irritability, hypervigilance, and exaggerated startle response (Table 1). With regard to exaggerated startle, which is criterion D.5 for PTSD, Shalev and colleagues[37] have extended the psychophysiologic study of PTSD to responses to the presentation of 15 consecutive, sudden, loud tone stimuli. Shalev's subjects included Israeli male and female, military and civilian, trauma victims in the following categories: 14 PTSD, 14 non-PTSD anxious, 15 non-PTSD mentally healthy with past traumatic experiences, and 19 non-PTSD mentally healthy with no trauma history. The PTSD group showed significantly larger heart rate, skin conductance, and a trend toward large eye blink responses to the tones than did every non-PTSD group.

Belgian investigators[38] have reported augmentation of contingent negative variation (an electroencephalographic phenomenon) following exposure to traumatic events. They have rendered forensic reports incorporating physiologic findings to the Belgian courts in approximately 25 cases involving traumatized litigants (M. Timsit, personal communication, 1992).

Other Biologic Studies A variety of other psychobiologic investigative techniques are producing useful insights into PTSD, although none has been as thoroughly researched as psychophysiology. Pharmacologic challenge with the chemicals lactate[39] or yohimbine[40] has been found to produce a greater frequency of panic attacks and flashbacks in combat veterans with PTSD than in non-PTSD subjects. However, because this technique is invasive, it is unlikely to be suitable for forensic evaluations. The

same consideration applies to techniques that measure changes in pain sensibility[41] or blood adrenalin levels[42] induced by a trauma-related film. A characteristic pattern of stress hormones in the urines of PTSD subjects has been reported by one research group[43] but not replicated by another.[44] Potential blood tests for PTSD are emerging[45–49]; however, the findings have not yet been replicated in studies utilizing trauma-exposed, non-PTSD control subjects, nor extended to civilian PTSD samples. Although sleep studies[50, 51] hold promise for identifying electrophysiologic abnormalities in PTSD, they are arduous (requiring that the subject spend one or often several nights in a sleep laboratory) and in a more preliminary stage of development.

Interpretation of Psychophysiologic Test Results Psychophysiologic test results may be interpreted by comparing the subject's response to a stimulus of interest with the responses of comparison subjects, e.g., those used in the above studies. For illustrative purposes, Figure 1 presents in graphic form the industrial accident subject's skin conductance responses during imagery of his accident (black bar) and of his personal combat experience in Vietnam (white bar). Juxtaposed against this subject's responses are the mean skin conductance responses of several clinical PTSD comparison groups (black bars appearing to the left of subject's bars) and non-PTSD comparison groups (white bars appearing to the right of subject's bars).

Two kinds of interpretation will be considered for psychophysiologic test data, referred to below as "criterion" and "classificatory."

"Criterion" interpretation represents a more conservative interpretation of psychophysiologic test data. As noted above, DSM-III-R PTSD Criteria D.5 and D.6 (Table 1) lend themselves to direct physiologic measurement. Determining whether either of these criteria is met may be accomplished by evaluating the degree to which the subject's test result deviates from the responses shown by non-PTSD subjects during imagery of their personal traumatic events. For "criterion" testing, therefore, only a normal, i.e., non-PTSD, comparison sample is required. For example, combining the data from the 48 subjects in non-PTSD groups 1, 3, 4, and 5 shown in Figure 1 provides an estimate of the mean skin conductance response during personal traumatic imagery in normal subjects of .14 μS (*SD* .33). Using these estimates, the probability (p) that the industrial accident subject's skin conductance response during imagery of his accident is normal may be calculated using the mean shift outlier test[52] at $p = .06$ (one-tailed, $t = 1.6$, $df = 47$). On the other hand, his skin conductance response during personal combat imagery (.11 μS) is below the mean of normal responders and therefore clearly not abnormal.

An abnormal skin conductance (or heart rate or electromyographic) response using the above method could be interpreted as evidence that the subject meets DSM-III-R PTSD criterion D.6 (Table 1). However, because this criterion is neither necessary nor sufficient

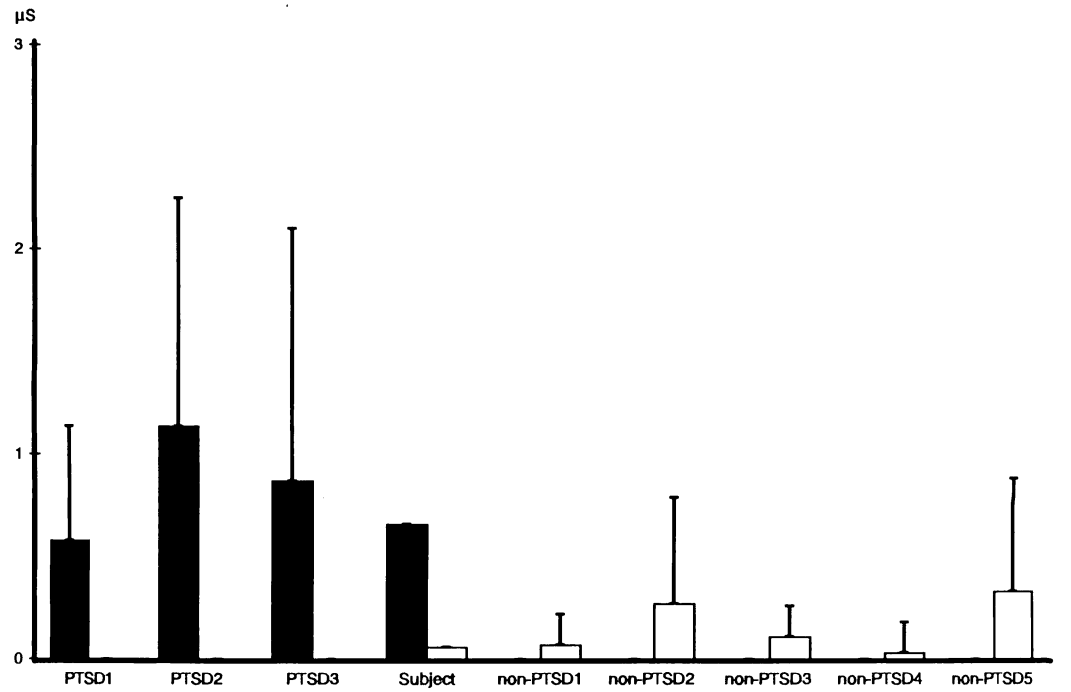

Figure 1. Skin conductance responses of industrial accident subject and comparison samples during script-driven personal traumatic imagery. For the subject, the black bar indicates his response during script-driven imagery of his clinical PTSD (industrial accident) event; the white bar indicates his response during imagery of his non-PTSD (Vietnam) combat event. (See text for explanation.) For the comparison samples, the black bars indicate group mean responses of subjects clinically diagnosed as PTSD during imagery of their personal traumatic events; the white bars indicate group mean responses of subjects clinically diagnosed as non-PTSD during imagery of their personal traumatic events. Lines above bars indicate standard deviations. Key to comparison samples: PTSD1: 25 male Vietnam combat veterans (mean age 41)[30-32]; PTSD2: 8 male World War II and Korean War combat veterans (mean age 65)[33]; PTSD3: 9 male and 4 female Israeli civilians (mean age 34)[34]; Non-PTSD1: 16 male Vietnam combat veterans (mean age 40)[30, 32]; Non-PTSD2: The 16 male Vietnam combat veterans in Non-PTSD1, attempting to simulate PTSD-like responses[35]; Non-PTSD3: 7 male Vietnam combat veterans with non-PTSD anxiety disorders (mean age 39)[31]; Non-PTSD4: 12 male World War II and Korean War combat veterans (mean age 69)[33]; Non-PTSD5: 6 male and 7 female Israeli civilian trauma victims (mean age 28).[34]

for the diagnosis of PTSD, at least as defined in DSM-III-R, this would not be tantamount to indicating that the individual has PTSD.

"Classificatory" interpretation represents a bolder interpretation of psychophysiologic data, in that it attempts to arrive at a probability of the subject's belonging to the category of persons with the PTSD diagnosis, rather than only determining that a single PTSD criterion is present. Classificatory interpretation requires a pair of comparison samples, one with PTSD and one without. A statistical discriminant function[53] is derived from the combination of physiologic response scores (e.g., heart rate, skin conductance, electromyogram) that maximally separates the PTSD and non-PTSD comparison samples. Application of this discriminant function to the subject's responses yields a probability that he or she belongs to the PTSD category. Any calculated probability may be con-

verted to the odds of the subject's having PTSD. For example, applying a discriminant function derived from the 46 subjects in PTSD groups 1, 2, and 3 versus the 48 subjects in non-PTSD groups 1, 3, 4, and 5 (Fig. 1) to the above subject's responses during imagery of his industrial accident yields a PTSD probability of $p = .50$ (odds of PTSD = 1:1), whereas the probability of PTSD yielded by substituting his responses during imagery of his combat experience is $p = .25$ (odds of PTSD = 1:3).

Interpreting the Test Result within the Context of Other Information Results of a medical test do not stand on their own; they must be considered within the context of other information. According to Bayes' theorem,[54] the overall odds of a disorder being present may be calculated by multiplying the odds yielded by as many independent sources of information as are available. In the evaluation of PTSD, sources of information about the probability of PTSD in addition to the results of a psychophysiologic test include the apparent severity of the traumatic event, the rate of PTSD in the population of individuals experiencing such an event, and the results of the clinical evaluation, psychometrics, and other tests. As an example, a physiologic test result may yield odds for PTSD of 5:1. However, if all the other information available suggests that the odds of PTSD are remote, say only 1:10, Bayes' theorem indicates that the overall odds for PTSD are still only 1:2, despite the presence of a strongly positive test.

Caveats in the Expression of Expert Opinion Gutheil and Appelbaum[55] have suggested that what an expert has to offer is more an analysis of a question than an opinion. Litigators, however, often believe that a jury is more impressed by answers. In presenting the result of a psychophysiologic test, the expert should offer whatever interpretation is justified to a reasonable degree of medical probability (or other relevant jurisdictional standard). However, the expert should also be prepared to describe the rationale and limitations of the test, which include the quality and extent of the studies in which it has been validated and the representativeness of the comparison samples. The test result should not be presented as a final word, but rather as one piece of information bearing on the question at hand, which needs to be considered within the context of the other available data.

Psychophysiologic Test Results as Evidence

Admissibility of Novel Scientific Evidence Before the jury may hear evidence that purports to be "expert" or "scientific," the judge must rule on its admissibility. Courts generally allow considerable leeway in expert testimony about medical diagnoses. An expert who employs psychophysiologic testing as an element of a multimethod assessment for PTSD may present it as part of his or her clinical evaluation with a reasonably good expectation of having it deemed admissible by the court. However, the relative novelty of the method may present an obstacle. Also, because some of the dependent measures employed in psychophysiologic testing are

shared by lie detector tests, some courts might be wary. These matters are discussed in greater detail below.

Federal Rules of Evidence The admissibility of expert and scientific testimony is addressed in Federal Rules 403, 702, and 703. Rule 403 allows all relevant evidence, unless "its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury." Rule 702 permits "a witness qualified as an expert by knowledge, skill, experience, training, or education" to testify to "scientific, technical, or other specialized knowledge" if such testimony "will assist the trier of fact to understand the evidence or to determine a fact in issue." Rule 703 permits a qualified expert to base his or her testimony on otherwise inadmissible data that entered into the formation of his opinion, "if of a type reasonably relied upon by experts in the particular field." However, a Proposed Amendment to Federal Rule 702 posits the additional requirement that "Testimony providing scientific, technical, or other specialized information, in the form of an opinion or otherwise, may be permitted only if . . . the information is reasonably reliable."

The Frye Test Since 1923, many courts have subjected novel scientific evidence to the *Frye* analysis. In *Frye v. United States*,[56] the D.C. Circuit Court excluded from a criminal trial expert testimony involving the polygraphic measurement of blood pressure. The court held,

> Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.[56, p.1014]

"The particular field in which it belongs" is usually taken to mean the relevant scientific community.

While *Frye* remains the majority rule,[57] it has been abandoned or substantially modified in many jurisdictions.[58] Both commentators and courts have pointed out its weaknesses. To begin with, the circumstances under which courts will apply the *Frye* test are inconsistent, in part due to the indistinct boundary between the "expert" and "scientific" categories. For example, courts have liberally allowed psychiatrists to offer expert opinions regarding the future dangerousness of convicted criminals, despite the scanty scientific foundation for such predictions. However, when a defense expert attempted to present CAT scan results as objective evidence of brain abnormality in the defendant in *United States v. Hinckley*,[59] the judge became wary and held lengthy hearings before finally admitting these results (D. Bear, personal communication, 1982). Ironically, courts seem more suspicious of scientific data than clinical impressions and are more likely to exclude testimony when they regard it as "scientific" rather than merely "expert," although sometimes the two elements may be inseparable.

The manner in which the *Frye* test is to be applied is also ambiguous.[57] Courts have differed as to whether the standard should apply to the theory underlying the scientific evidence, the methodology that operationalizes the theory, the technical procedure employed in a specific instance, or a combination of the above. When women first attempted to present evidence on battered-spouse syndrome in support of self-defense claims in murder trials, the courts were skeptical. In *Ibn-Tamas v. United States*,[60] the court disallowed such evidence because it found the expert's methodology to fall short of general scientific acceptance. However, in *New Jersey v. Kelly*,[61] the New Jersey Supreme Court overturned a woman's conviction on the grounds that the trial judge had improperly excluded testimony on this syndrome. The higher court based its finding that the syndrome had gained acceptance in the scientific community in part on the fact that there existed "at least five books and almost seventy scientific articles about the battered-woman's syndrome."[61, p.380] Thus, while the first court focused on the question of acceptance of the methodology, the second court counted noses to gauge the syndrome's scientific popularity. Inconsistency in the application of the *Frye* test can lead at times to the admission of unsound methods and at other times to the exclusion of useful evidence. The *Frye* standard has even been cited[62] (but see reference 63) as implying that no clinical psychiatric or psychological evidence meets legal standards.

The arbitrary and restrictive impact of the *Frye* test has led to its abandonment in a number of jurisdictions. Recently, in *United States v. Jakobetz*,[64] the Second Circuit reiterated its rejection of *Frye*, citing the test's "overly conservative approach" to admissibility and its "susceptibility to manipulation in order to exclude novel scientific evidence."[64, p.794] That court, echoing the sentiments of *Frye*-test critics, favored replacing the test with the Federal Rules approach, concluding that the judge should engage in a Rule 403-type balancing test, considering such factors as the care with which a scientific method has been employed, and its inherent rate of error, in order to determine whether the probative value of the proffered evidence is outweighed by the danger of unfair prejudice. The Third and Fifth Circuits recently rendered virtually opposite opinions on the applicability of *Frye* to scientific evidence in toxic tort litigation.[65] In the Fifth Circuit case, *Christophersen v. Allied Signal Corp.*,[66] the Circuit Court upheld the District Court's exclusion of an expert's opinion because it was not based on a "well-founded methodology."[66, p.1106]

Admissibility of Psychophysiologic Testing for PTSD Considered from the standpoint of *Frye*, the *theory* that physiologic symptoms are a component of PTSD must be regarded as generally accepted by the relevant scientific community by virtue of their inclusion as diagnostic criteria for PTSD in the DSM-III-R (Table 1), which is the current standard for psychiatric diagnosis. One of the reasons Criterion D.6 was introduced into DSM-III-R was the in-

vestigations conducted between 1982 and 1987 reviewed above that documented measurable increased physiologic responding in persons with PTSD. That the *methods* described above are accepted as suitable means for evaluating the presence of the DSM-III-R physiologic PTSD criteria is supported by their publication in a number of peer-reviewed psychiatry and psychology journals, the absence of any significant published criticism disputing them, and the recognition accorded them by other authorities.[25,67] A weaker argument for the acceptance of the use of psychophysiologic test results to calculate the probability of the PTSD diagnosis derives from the acceptance of the psychophysiologic research studies reviewed above, combined with the acceptance of the use of data from such studies in medical decision making strategies.[54]

Considered from the current Federal Rule 703 standpoint, the proposition that psychophysiologic testing for PTSD is reasonably relied upon by experts in the field would appear to pose the lowest hurdle for admissibility. There is a strong argument that direct laboratory measurement of physiologic phenomena is at least as reasonably relied upon as the other currently available sources of data, i.e., claimant self-report or anecdotal behavioral observation.

Ultimately, the decision whether to admit a psychophysiologic test result for PTSD will come down to the judge's perception of its reliability and probative value. A favorable determination of admissibility is more likely when the test result is presented as one element within the context of an expert's overall opinion.

Contrast with Lie Detection The introduction of a psychophysiologic test result as a sophisticated form of "syndrome evidence"[9] that a traumatic event has actually occurred, e.g., in an alleged rape victim, comes uncomfortably close to a reverse lie detector test. By "reverse," it is meant that the occurrence of greater physiologic arousal during imagery of an alleged traumatic event might be construed as supporting the veracity of the victim's claims. However, large physiologic responses have been reported[68] in at least one PTSD research subject during imagery of an alleged event of doubtful authenticity. This illustrates the importance of using psychophysiologic assessment as one component of a complete evaluation, including where possible external corroboration of the traumatic event.

As long as it is understood that the intention of physiologic testing is to assess symptomatology, not truthfulness, the fact that polygraphic measures are employed should not be of concern. Medical tests of cardiac and pulmonary function also employ "polygraphic" measures. Furthermore, the *per se* judicial exclusion of lie detector results itself appears to be weakening. Even if an analogy were to be made between psychophysiologic testing for PTSD and polygraphy, this would not automatically lead to the former's exclusion. In *United States v. Piccinonna*,[69] the court held that polygraph evidence could be admitted, where the parties stipulated in advance as to the circumstances of the test

and the scope of its admissibility, for impeaching or corroborating the testimony of a witness at trial under conditions of adequate notice. Citing the advancement in polygraphic technology, the court called for "flexibility within the legal system so that the ultimate ends of justice may be served."[69, p.1537]

Current Status The Veterans Health Administration is currently pursuing a large-scale investigation at fifteen VA Medical Centers, regarding the application of psychophysiologic laboratory assessment to the evaluation of PTSD in Vietnam veterans.[16] Application to forensic cases cannot be far behind. To date, we are not aware of a case in which psychophysiologic test evidence has been offered during a civil or criminal trial to support or refute a PTSD claim. However, we are currently assessing several tort litigants in our laboratory toward this end.

To advance the forensic robustness of psychophysiologic testing for PTSD, further research is needed, especially in the areas of noncombat-related PTSD, responses of symptomatic subjects who do not meet the DSM-III-R "A" criterion, responses of female subjects, and susceptibility of physiologic measures to simulation.

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