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Specificity of Stroop Interference in Patients With Pain and PTSD

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The authors investigated processing of threat words in motor vehicle accident survivors using a modified Stroop procedure. Three samples were included: 28 participants with comorbid posttraumatic stress disorder (PTSD) and pain, 26 participants with pain without PTSD, and 21 participants without pain or any psychiatric conditions. Four word categories were used: (a) accident words, (b) pain words, (c) positive words, and (d) neutral words. This study examined whether processing biases would occur to accident words only in participants with PTSD or if these biases would also be noted in the No PTSD/Pain sample. Additionally, this study examined whether processing biases would be noted to pain words in the 2 pain samples, irrespective of PTSD. Overall, color naming was significantly slower in the PTSD/Pain group in comparison with the other groups. As well, the PTSD/Pain sample showed significant response delays to both accident and pain-related words, whereas patients with No PTSD/Pain showed delays to pain stimuli only.

Information-processing models have had a notable influence on the study of anxiety disorders, particularly posttraumatic stress disorder (PTSD; Foa & Kozak, 1986; Litz & Keane, 1989; Williams, Mathews, & MacLeod, 1996). As defined in the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM–IV;* American Psychiatric Association, 1994), PTSD includes symptoms of cognitive disturbance, such as hypervigilance to potentially threatening stimuli, intrusive thoughts and dreams about the trauma, and flashbacks. Current models of PTSD emphasize the primary role that cognitive processes, such as fear networks (e.g., Foa & Kozak, 1986), attentional biases (e.g., Litz & Keane, 1989), and trauma-related memory (e.g., Brewin, Dalgleish, & Joseph, 1996), play in the maintenance of PTSD symptomatology. For example, individuals with PTSD are hypothesized to have trauma-specific fear structures. When the person encounters a stimulus that is represented within the trauma-specific structure, the system is activated and fear or anxiety is evoked (Chemtob, Roitblat, Hamada, Carlson, & Twentyman, 1988; Foa & Kozak, 1986; Foa, Steketee, & Rothbaum, 1989; Lang, 1977). Additionally, some authors have postulated that the existence of such a fear structure sensitizes the individual to trauma-related stimuli so that these cues are perceived more easily and greater processing resources are allocated to them (Foa et al., 1989).

Drawing on these models, many investigators have relied on the modified Stroop paradigm to examine selective processing of fear-relevant information in patients with PTSD. In the original Stroop Color–Word Interference Test (Stroop, 1935), the participant is instructed to name the color of a printed word but to ignore the word itself. The Stroop paradigm has a substantial research history (e.g., MacLeod, 1991), with many variations across the years. Recently, investigators have modified the Stroop paradigm to evaluate cognitive interference in psychopathology. The modified Stroop procedure involves color naming emotional words, particularly words that are relevant to the specific disorder under study. Several studies have documented greater Stroop interference (i.e., longer response latencies) to trauma-relevant words in individuals with PTSD following rape (Cassiday, McNally, & Zeitlin, 1992; Foa, Feske, Murdock, Kozak, & McCarthy, 1991), combat exposure (McNally, English, & Lipke, 1993; McNally, Kaspi, Riemann, & Zeitlin, 1990), a ferry disaster (Thrasher, Dalgeish, & Yule, 1994), and motor vehicle accidents (MVAs; Bryant & Harvey, 1995). In each case, color-naming performance was slowed for words that were reflective of the specific trauma. A variety of control conditions were included in these studies, such as positive words, general threat words, and neutral words that are matched for usage frequency and length. On the basis of these studies, investigators have documented that Stroop interference is specific to trauma-relevant words among individuals with PTSD but typically is not noted among trauma survivors without PTSD.[1]

Although these studies represent an important step in understanding PTSD, the exclusive focus on trauma-relevant words may

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[1] An exception to this finding was reported by Litz et al. (1996), who observed that veterans with combat-related PTSD showed response delays to threat words, although this category involved a mixture of both military and general (education-related) words.

be too narrow. In particular, it is recognized that individuals with PTSD often have numerous comorbid problems (e.g., Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995). Among individuals who experienced a traumatic event that involved physical injury (i.e., MVAs, combat, physical assault), pain frequently accompanies PTSD (e.g., Benedikt & Kolb, 1986; Turk, Okifuji, Starz, & Sinclair, 1996). As noted by Blanchard et al. (1995), the severity of physical injury among individuals who had experienced a serious MVA significantly predicted the development of PTSD ($r = .30$) and the development of posttraumatic stress symptoms ($r = .31$). Similar findings have been noted among both Vietnam veterans (Helzer, Robins, & McEvoy, 1987; Pitman, Altman, & Macklin, 1989) and female crime victims (Kilpatrick et al., 1989).

Thus, comorbid conditions, particularly pain, have been understudied in research on PTSD. Although it is recognized that patients with comorbid PTSD and pain report greater pain levels, more emotional distress, and greater disability relative to pain patients without PTSD (e.g., Geisser, Roth, Bachman, & Eckert, 1996; Sherman, Turk, & Okifuji, 2000; Turk et al., 1996), it is unclear how the combination of PTSD and pain impacts cognitive processing. One could envision, for example, that patients with comorbid PTSD and pain would show response delays to both accident and pain cues. This finding would indicate that both trauma and pain cues are contained within the trauma-related fear structure in patients with these comorbid disorders, given the interrelationship of these cues in the etiology of both PTSD and pain (e.g., Mathews & MacLeod, 1994). Stated another way, given the relatedness of these two stimulus categories to current concerns (Williams et al., 1996), one could expect response delays in color naming in both stimulus categories. Alternatively, Stroop interference might be noted only for stimuli that are emotional reminders of the trauma, given that response delays appear to be uniquely associated with threat cues in clinical samples (Williams et al., 1996). Prior to describing our study, it is important to review the available literature involving the modified Stroop paradigm, both with pain patients and with individuals diagnosed with PTSD following an MVA.

To date, there have been several examinations of Stroop interference in patients with pain, with mixed results. Pearce and Morley (1989) selected pain-relevant words from the McGill Pain Questionnaire (MPQ; Melzack, 1975) and contrasted color-naming times for these stimuli with general negative emotional words and with conflicting color words. Individuals who had experienced chronic pain for at least 1 year ($n = 16$) were significantly slower in color naming pain words, relative to negative emotional words, although response latencies did not differ depending on the type of pain word (affective versus sensory). No interference effects were noted in the pain-free control group ($n = 16$). Similar findings were reported by McNeil, Sperry-Clark, Ciano-Federoff, Haught, and Broadman (1998), who contrasted response times to naming pain-relevant cues (derived from the MPQ) with neutral cues in a sample of 50 pain patients. However, Pincus, Fraser, and Pearce (1998) failed to replicate the findings of Pearce and Morley (1989) and McNeil et al. (1998) in two separate experiments using similar stimulus conditions and methodology. Using a different paradigm to assess attentional allocation, Asmundson, Kuperos, and Norton (1997) did not observe differences between pain patients and pain-free control participants in responding to dot-probes presented after pain (e.g., *throb, ache*) and injury-related (e.g., *accident, fall*) cues. Thus, it is unclear, on the basis of research to date, whether attentional interference is a consistent facet of pain.

In contrast, Stroop interference is a well-documented phenomenon in the PTSD literature, as discussed previously. Two studies have examined Stroop interference in participants with PTSD following an MVA. In the first, Bryant and Harvey (1995) contrasted 15 participants diagnosed with PTSD following an MVA, 15 participants diagnosed with simple phobia of driving following an MVA, and 15 low anxiety control participants. Four types of words were included: strong threat (e.g., *smash, death*), mild threat (e.g., *traffic, driver*), positive (e.g., *love, nice*), and neutral (e.g., *pause, blanket*). Bryant and Harvey noted that participants with PTSD showed greater Stroop interference to the strong threat words, relative to the other two participant groups. Contrary to the authors' expectation, participants with driving phobias performed similarly to the control participants. A subsequent study (Harvey, Bryant, & Rapee, 1996) used both a modified Stroop and a masked modified Stroop paradigm to examine processing of threatening information in patients with PTSD following an MVA. The masked Stroop paradigm has been used to examine preconscious processing and involves a very brief stimulus presentation interval (<20 ms) followed by a backward mask. Results indicated that participants with PTSD showed greater interference to threat words relative to neutral words in both the masked and unmasked procedure. Participants who had experienced an MVA but were not diagnosed with PTSD responded to the threat and neutral words equivalently, and control participants (who had never been involved in an MVA) responded significantly more slowly to the neutral words than to the threat words. Overall, these two studies indicate that individuals with PTSD following an MVA preferentially allocate attention to cues suggestive of the MVA. An interesting finding was that this attentional interference seems particularly notable in those individuals with MVA-related PTSD, as participants with driving phobias as a consequence of their MVA performed similarly to control participants.

This article is designed to extend the scope of these studies by examining how the presence of a comorbid condition, pain, affects Stroop interference in individuals with PTSD following an MVA. Participants included 28 individuals with comorbid PTSD and pain (PTSD/Pain), 26 individuals with pain who did not meet diagnostic criteria for PTSD (No PTSD/Pain), and 21 individuals without pain complaints or any psychiatric conditions (No PTSD/No Pain). Each participant had been involved in a serious MVA that involved threatened death or serious injury to themselves or another individual. In our study, the stimulus categories included accident-related (e.g., *wrecked, totaled*), pain-related (e.g., *throbbing, ache*), positive, and neutral words. Our study was designed to examine whether there would be specificity in cognitive interference such that the PTSD/Pain group would show Stroop interference to both accident and pain words, whereas the No PTSD/Pain group would show interference to only the pain words and the No PTSD/No Pain group would not show Stroop interference to these cues. In particular, we were interested in evaluating whether the well-documented effect of Stroop interference to trauma cues would be noted only for those individuals with PTSD, as evidenced by slower response times to color naming accident words. Alternatively, would Stroop interference for accident words also be noted for individuals who were suffering from pain but not diagnosable with PTSD, given the association between the acci-

Table 1
Description of PTSD/Pain, No PTSD/Pain, and No PTSD/No Pain Samples

Variable	PTSD/Pain (n = 28)		No PTSD/Pain (n = 26)		No PTSD/No Pain (n = 21)		
	M	*SD*	*M*	*SD*	*M*	*SD*	*p*
Age (years)	42.9_a	10.7	41.3_a	8.6	32.5_b	10.1	.001
Employed (% yes)	39.3		46.2		52.4		*ns*
Gender (% female)	75		81		48		*ns*
Time elapsed since MVA (months)	18.0	17.9	34.3	42.1	39.1	46.7	*ns*
Race							
% Caucasian	77		85		86		*ns*
% African American	20		10		4		
% Hispanic	3		5		—		
Litigation (% yes)	89_a		85_a		29_b		.0001
No. of psychiatric diagnoses	3.1	1.2	0.6	0.9			.0001
Fear during MVA (0–100)	86.9_a	28.8	65.7_a	36.4	57.1_b	32.6	.007
Helpless during MVA (0–100)	91.2_a	23.7	75.9_a	29.9	65.0_b	37.9	.01
Danger (0–100)	82.8_a	31.5	57.7_a	39.1	54.3_b	40.3	.01
Certainty would die (0–100)	56.3_a	45.7	21.9_b	35.6	24.1_b	35.5	.003
Use pain medication (% yes)	43		50				*ns*

Note. Means within each row with different subscripts differ significantly ($p < .05$). PTSD = posttraumatic stress disorder; MVA = motor vehicle accident.

dent and their ongoing physical complaints? If this finding was observed, it would suggest generalization of attentional biases across stimulus categories and support the contention that some conditions may be characterized by complex, disjointed fear structures that facilitate generalization of distress (Foa & Kozak, 1986). Given inconsistencies in previous research on Stroop interference in pain patients, we also were interested in evaluating whether Stroop interference would be noted to pain words in pain patients. Inclusion of positive affect words allowed consideration of the role of emotion in selective cognitive processing.

Method

Participants

Three groups of individuals were included, all of whom had been involved in a serious MVA: (a) individuals with PTSD/Pain, (b) individuals with No PTSD/Pain, and (c) individuals with No PTSD/No Pain. Individuals reporting pain (Groups a and b) were recruited from a university pain specialty service, a local trauma center, physical therapists, and specialists in rehabilitation and internal medicine. Pain-free participants (Group c) were recruited from a local trauma center, friendship networks,[2] and by the use of flyers distributed in community centers and in the local Department of Motor Vehicles. Individuals were included in the PTSD/Pain group if they met criteria from the *DSM–IV* for a principal diagnosis of PTSD. Individuals were included in one of the two pain groups if their pain symptoms were the result of injuries sustained during an MVA and had not responded to standard medical treatment after 1 month. In each case, pain caused significant lifestyle limitations, impairment, or significant distress, determined on the basis of behavioral restriction (e.g., unable to work), continued utilization of health care resources for pain relief, or consistent use of pain medication (at least 3 days per week). Among the final sample included in Groups a and b, the majority (83%) had pain associated with a musculoskeletal injury. As well, 91% had experienced pain for at least 3 months, thus fulfilling criteria for chronic pain (International Association for the Study of Pain, 1986).

To form the PTSD/Pain sample, 43 patients were evaluated initially by the use of the Clinician Administered PTSD Scale (CAPS; Blake et al., 1990) and the Anxiety Disorders Interview Schedule–IV (ADIS–IV; DiNardo, Brown, & Barlow, 1994). Advanced graduate students in clinical and counseling psychology served as interviewers and were trained by using methods described by DiNardo, Moras, Barlow, Rapee, and Brown (1993). Ten patients were excluded because the evaluation indicated a principal diagnosis other than PTSD,[3] 3 patients were excluded owing to current substance abuse or dependence, and 2 participants' data were lost owing to equipment failure, resulting in a final sample of 28 participants. For the No PTSD/Pain sample, 28 patients were evaluated initially, with 2 patients excluded because of current substance abuse or dependence. The final samples are described in Table 1. As can be seen, the No PTSD/No Pain sample was significantly younger than the other two samples, $F(2, 71) = 7.49$, $p < .001$, contained somewhat fewer women (albeit nonsignificantly), and was significantly less likely to be involved in MVA-related litigation, $\chi^2(2, N = 75) = 25.07$, $p < .0001$. In addition, the PTSD/Pain sample was evaluated closer in time to their MVA (although nonsignificantly), relative to the other two samples. As is typical of PTSD patients, this sample reported significantly more psychiatric disorders, relative to the No PTSD/Pain sample, $t(52) = 8.51$, $p < .0001$. Within the PTSD/Pain group, the most common additional disorders included major depressive disorder (MDD; n = 18, 64%), specific phobia (SpecPh; n = 15, 54%), generalized anxiety disorder (GAD; n = 9, 32%), and panic disorder with agoraphobia (PDA; n = 7, 25%). Within the No PTSD/Pain sample, the most common disorders included MDD (n = 5, 19%), SpecPh (n = 5, 19%), and GAD (n = 5, 19%). Reliability checks were conducted for 30% of CAPS and ADIS–IV interviews, with a second clinician making independent diagnoses based on the videotaped interviews. Agreement between diagnosticians, determined using kappa coefficients, was strong for MDD

[2] Friendship networks included friends and family members of participants in Groups a and b, as well as university clerical staff.

[3] Six of these individuals were given coprincipal diagnoses that included PTSD as one of these conditions; the remaining 4 patients were given another diagnosis as their principal condition.

(κ = .93), SpecPh (κ = .93), GAD (κ = .96), and PDA (κ = .96).[4] Perfect agreement was noted for PTSD.

Exclusionary criteria for all participants included neurological impairment, alcohol or substance abuse within the preceding 6 months, the presence of psychotic symptoms, acute distress or suicidal ideation, color blindness, under age 18 or over age 65, and IQ less than 70 (assessed with the Shipley Institute of Living Scale; Zachary, 1986). For the No PTSD/No Pain group, participants were required to be free of all psychiatric diagnoses. All participants were involved in an MVA that occurred at least 1 month preceding the evaluation and evoked strong feelings of fear, helplessness, horror, or the perception that one would die (Criterion A of the diagnostic criteria for PTSD in the *DSM–IV;* American Psychiatric Association, 1994). Participants were asked to rate their fearfulness during the MVA on a 0–100 Likert scale (0 = *no fear,* 100 = *extreme fear*). A similar scale was used to assess helplessness (0 = *no feelings of helplessness,* 100 = *extreme helplessness*), danger (0 = *no feelings of danger,* 100 = *extreme danger*), and certainty that they would die during the MVA (0 = *certain that I would not die,* 100 = *certain that I would die*). As noted in Table 1, the three groups reported relatively high ratings of fear, helplessness, and danger. The PTSD/Pain and No PTSD/Pain samples reported significantly more fear, helplessness, and danger during their MVAs than did the No PTSD/No Pain sample. Additionally, the PTSD/Pain sample reported greater certainty that they would die during their MVA, relative to the other two samples. Among the PTSD/Pain sample, 43% used pain medication at least 3 days per week. In the No PTSD/Pain sample, 50% regularly used pain medication. Individuals with PTSD, pain, or both, participated in exchange for a free psychological evaluation. Individuals without PTSD or pain were paid $20 for their participation.

Stimulus Materials and Apparatus

Four word categories were used in this experiment: accident-related words, pain-related words, positive words, and neutral words. To select the words, the following procedure was used. Twenty-seven words thought to represent each category were presented to 10 PTSD/Pain individuals and to 16 No PTSD/Pain individuals. All of these individuals had experienced a serious car accident and none of them participated in other parts of this study. These individuals were asked to rate each word on (a) how upsetting it was and (b) their estimate of how frequently the word is used or seen, on a Likert scale (0 = *not upsetting or infrequent,* 5 = *extremely upsetting or frequent usage*). Ten words that were rated high in threat by the PTSD/Pain group and low in threat by the No PTSD/No Pain group but similar in frequency for both groups were selected for the accident-related and pain-related word categories. The positive and neutral words had similar ratings of threat and frequency in both groups. Ten words were selected for each category (see Table 2) and presented three times, for a total of 120 randomized presentations. Word lists were equal on the average number of syllables, and reading difficulty was no higher than fifth grade.

Table 2
Stimulus Words

Accident-related	Pain-related	Positive	Neutral
totaled	throbbing	enjoyment	cabinet
trauma	cringe	nice	kitchen
accident	sore	smile	table
trapped	hurting	laughing	blender
siren	suffer	glad	fork
wreck	discomfort	lovely	spoon
helpless	pain	cheer	chair
scared	injury	delight	toaster
crash	ache	friendly	bowl
terrified	agony	amusing	dishwasher

The words were presented on a Gateway 486 computer at a distance of approximately 0.6 m from the participant's face. Each word was centrally presented on a CTX color monitor in uppercase letters about 2 cm tall. The words were presented for 1.5 s with a 5-s interstimulus interval. Each participant's reaction time for each trial was recorded by the computer (in milliseconds) through the use of a voice-activated microphone with adjustable sensitivity.

Procedure

After participants provided informed consent, we administered the CAPS and ADIS–IV. Each participant returned for a second appointment, in which they were seated in a comfortable chair in front of the computer monitor. The microphone was attached to the participant's collar, and the voice-activated mechanism was adjusted to the participant's vocal tone. Next, the participant was presented with a series of five color patches (white, red, blue, yellow, and green) and asked to name them by giving a distinct label to each hue. Participants were instructed to name the color of each word or patch being presented as quickly and accurately as possible, ignoring the meaning of the word. Participants were told to avoid anticipating any particular color, given that colors were randomly assigned and could appear in any order.

Twenty practice trials using number words (*one, two, three, four, five;* Cassiday et al., 1992) were presented. Practice continued until the participant correctly named at least 80% of the colors correctly. All of the participants achieved at least 16 correct of 20 responses during the practice interval. The participant was then presented with 120 experimental trials. The presentation of each stimulus initiated a timing cycle that was stopped by the participant's verbal response. Because of the 5-s interstimulus interval, a maximum response latency of 4 s was allowed. Trials in which no verbal response was detected were not included in response latency averages and were considered errors. An experimenter was present in the room throughout the entire procedure. Following the Stroop procedure, the experimenter asked the participant to complete the psychopathology and pain measures, and then the experimenter debriefed him or her.

Measures

Psychopathology measures. All participants completed a battery of questionnaires that are commonly used in research on PTSD. These included the Beck Depression Inventory (BDI; Beck, Ward, Mendelsohn, Mock, & Erbaugh, 1961), the State–Trait Anxiety Inventory—State and Trait subscales (STAI–S and STAI–T; Spielberger, Gorsuch, & Lushene, 1970), the PTSD Symptom Scale—Self Report (PSS–SR; Foa, Riggs, Dancu, & Rothbaum, 1993), and the Impact of Event Scale—Avoidance and Intrusion subscales (IES–A and IES–I; Zilberg, Weiss, & Horowitz, 1982). The BDI is a 21-item inventory designed to measure depressed mood and other symptoms of depression. The inventory has a split-half reliability coefficient of .93 and excellent psychometric properties (Steer & Beck, 1988). The STAI–S and STAI–T are 20-item scales designed to measure state and trait anxiety, respectively. Psychometric properties are strong in college and middle-aged samples (Spielberger, 1983). As expected, test–retest reliability is lower for the State subscale, relative to the Trait subscale. The PSS–SR evaluates the frequency of the 17 *DSM–IV* symptoms of PTSD and has good test–retest reliability and internal consistency (Foa et al., 1993). The 15-item IES assesses intrusive and avoidance symptoms of PTSD during the preceding week and has good internal consistency (Zilberg et al., 1982). Additionally, the severity of PTSD was computed on the basis of the CAPS by summing the total of the frequency and intensity rating for each of the 17 *DSM–IV* symptoms of PTSD. The

[4] Other diagnoses did not occur with sufficient frequency in the reliability sample to calculate kappa coefficients.

CAPS severity score is widely used in PTSD research as an index of severity of posttrauma symptoms (e.g., Weiss, 1997).

Pain measures. Participants completed several self-report pain measures, including the Pain Distress Scale (PDS; Jensen, Karoly, & Harris, 1991). The PDS is a 10-item measure of emotional responses to pain, with good internal consistency and test–retest reliability. The Oswestry Disability Index (ODI; Fairbank, Couper, Davies, & O'Brien, 1980), which includes 10 items assessing pain-related functional limitations, also was administered. The psychometric properties of this scale also are established (Fairbank et al., 1980). The Multidimensional Pain Inventory (Kerns, Turk, & Rudy, 1985) also was administered. This measure is an omnibus questionnaire from which the following measures were derived: pain severity in the preceding week, evaluated on a 0–6 Likert scale (0 = *none*, 6 = *quite severe*) and frequency of time typically spent in bed because of pain, evaluated on a 0–6 Likert scale (0 = *never*, 6 = *often*). No psychometric data are available for these two ratings.

Color-naming latency. The time elapsed between presentation of the stimulus and color-naming response (accurate to ±1 ms) was recorded for each target word. These response latencies were averaged across 30 presentations of each of the four word conditions, yielding four scores for each participant. As in previous studies in which researchers used the modified Stroop procedure, outliers of ±2 *SD*s were removed for each participant in each word condition, given the high likelihood that these were artifacts. Additionally, latencies shorter than 350 ms (caused by participants activating the voice-response relay prematurely) or other errors (e.g., naming the wrong color, reading the word aloud rather than naming the color) were removed. Approximately 3% of responses in the PTSD/Pain group, 3% of responses in the No PTSD/Pain group, and 2% of responses in the No PTSD/No Pain group were excluded.

Results

Psychopathology Measures

Each questionnaire was analyzed by the use of a one-way between-groups analysis of variance (ANOVA), with significant effects followed by using Tukey's honestly significant difference (HSD) procedure. As can be seen in Table 3, the PTSD/Pain group scored significantly higher on the BDI, the STAI–S, the STAI–T, the PSS–SR, the IES–A, the IES–I, and the CAPS severity score relative to the No PTSD/Pain and the No PTSD/No Pain groups. On the BDI, PSS–SR, IES–A, IES–I, and the CAPS severity score, the No PTSD/Pain group also scored significantly higher than the No PTSD/No Pain group. Thus, the PTSD/Pain group reported higher levels of depression, anxiety, and PTSD symptoms, relative to the No PTSD/Pain and No PTSD/No Pain groups. The No PTSD/Pain group reported significantly more depression and PTSD symptomatology, relative to the No PTSD/No Pain group. These data provide support for the group assignment criterion.

Pain Measures

Consideration of the pain measures (see Table 3) indicated that the PTSD/Pain and No PTSD/Pain groups scored significantly higher on the PDS, the ODI, pain severity, and time in bed relative to the No PTSD/No Pain group. This pattern of data also supports the group assignment criterion.

Color-Naming Latency

Color-naming latency data were examined with a 3 (group) × 4 (word category) ANOVA, with repeated measures on the second factor. Because the sphericity assumption was violated, $\chi^2(5, N = 75) = 72.03, p < .0001$, Greenhouse–Geisser correction was used. A significant Group × Word Category interaction was noted, $F(3.55, 216) = 2.81, p < .03$, and was followed via Tukey's HSD procedure, using comparison-specific error terms for effects involving the repeated factor. Comparison of the effect of group for each word category indicated that the three groups differed significantly from each other ($p < .05$), with the PTSD/Pain group showing the slowest response latencies, followed by the No PTSD/

Table 3
Comparison of PTSD/Pain, No PTSD/Pain, and No PTSD/No Pain Samples on Self-Report and Clinician Measures

	PTSD/Pain (n = 28)		No PTSD/Pain (n = 26)		No PTSD/No Pain (n = 21)			
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*(2, 73)	*p*
Psychopathology measure								
BDI (0–63)	24.71_a	11.78	13.21_b	8.11	4.33_c	3.67	31.26	.0001
STAI–S (20–80)	50.40_a	15.89	40.40_b	16.26	34.14_b	10.20	9.02	.0001
STAI–T (20–80)	53.46_a	12.75	41.38_b	12.59	35.33_b	8.99	14.24	.0001
PSS–SR (0–51)	32.38_a	11.32	14.54_b	11.11	3.00_c	3.72	54.08	.0001
IES–A (0–24)	15.17_a	5.43	6.38_b	5.24	1.48_c	3.06	48.29	.0001
IES–I (0–21)	14.75_a	5.32	6.21_b	5.40	1.86_c	2.76	43.94	.0001
CAPS severity score (0–136)	78.29_a	17.90	27.89_b	18.90	6.48_c	7.60	131.19	.00001
Pain measure								
PDS (0–40)	20.00_a	4.15	20.50_a	5.22	8.57_b	9.27	21.80	.0001
ODI (0–50)	22.40_a	6.39	19.54_a	7.06	2.14_b	3.18	72.42	.0001
Pain severity (0–6)	4.33_a	1.17	3.80_a	1.44	0.33_b	0.66	67.35	.0001
Time in bed (0–6)	2.54_a	1.98	2.00_a	1.79	0.04_b	0.22	16.66	.0001

Note. Means within each row with different subscripts differ significantly ($p < .05$). PTSD = posttraumatic stress disorder; BDI = Beck Depression Inventory; STAI–S = State–Trait Anxiety Inventory—State subscale; STAI–T = State–Trait Anxiety Inventory—Trait subscale; PSS–SR = PTSD Symptom Scale—Self Report; IES–A = Impact of Event Scale—Avoidance subscale; IES–I = Impact of Event Scale—Intrusion subscale; CAPS = Clinician Administered PTSD Scale; PDS = Pain Distress Scale; ODI = Oswestry Disability Index.

Pain group, and then the No PTSD/No Pain group in each word category (see Figure 1). Comparison of the effect of word category for each group indicated that in the PTSD/Pain sample, response latency was slower for the accident words, relative to both the neutral ($p < .05$) and positive categories ($p < .05$). Additionally, response latency was slower for the pain words, relative to both the neutral ($p < .05$) and positive ($p < .05$) categories in the PTSD/Pain sample. Within the No PTSD/Pain group, significantly slower response latencies ($p < .05$) were noted for the pain words, relative to each of the following categories: accident, neutral, and positive words. In the No PTSD/No Pain group, response latencies to the accident words were significantly slower than those noted to the positive words ($p < .05$), with no other differences noted between word categories.

Owing to observed differences among the samples with respect to age, self-reported depression, self-reported anxiety, and elapsed time since the MVA, the response latency data were reexamined by using a series of 3 (group) × 4 (word category) analyses of covariance (ANCOVAs), using age, BDI score, STAI–T subscale score, and interval since the MVA as covariates. ANCOVA results indicated a significant Group × Word Category interaction for age, $F(3.55, 216) = 2.81, p < .01$; BDI, $F(3.32, 198) = 2.96, p < .03$; STAI–T, $F(3.32, 198) = 2.96, p < .03$; and interval since MVA, $F(3.55, 216) = 2.81, p < .03$. In each case, the pattern of response latency results was unchanged. Additionally, to examine the influence of PTSD severity on response latency, a 3 (group) × 4 (Word Category) ANCOVA was conducted by using the CAPS severity score as the covariate. Again, a significant Group × Word Category interaction was noted, $F(3.55, 216) = 2.81, p < .03$, and the pattern of results was unchanged. These secondary analyses suggest that age, depression, anxiety, elapsed time since the MVA, and PTSD severity do not explain the key findings.

Discussion

The current study illustrates both generality and specificity of responding in patients with MVA-related PTSD and pain, when assessed using stimulus cues pertaining to both pain and trauma in a modified Stroop task. The PTSD/Pain sample showed overall generalized slowing in their responses to all word categories, relative to the No PTSD/Pain sample. Both of these samples showed slower responses relative to the No PTSD/No Pain participants. Additionally, interference on the modified Stroop task showed specificity with respect to trauma and pain. Participants with comorbid PTSD and pain showed response delays in color naming both accident and pain-related word cues, whereas participants with pain alone showed delays to pain cues only.

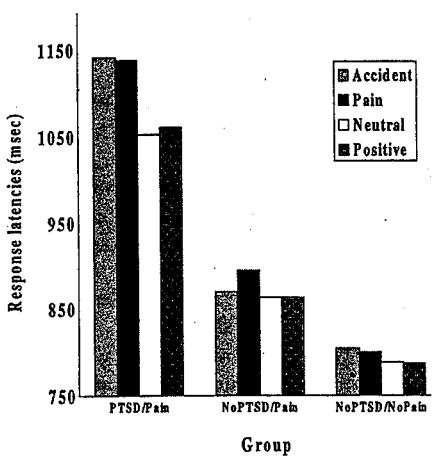

Figure 1. Mean response latencies (in milliseconds) for the four word types for PTSD/Pain, No PTSD/Pain, and No PTSD/No Pain samples. PTSD = posttraumatic stress disorder.

These results suggest an interesting combination of specificity and generalized responding of cognitive interference. On the one hand, the PTSD/Pain sample was notably slower across all word categories. Additional ANCOVAs indicated that this was not attributable to PTSD severity, depression, age, anxiety, or time elapsed since the MVA. Additionally, because approximately the same percentage of participants were taking pain medication in the PTSD/Pain and No PTSD/Pain samples, it is difficult to attribute this generalized slowing to sedation from pain medication. On the other hand, specific delays in color naming on the modified Stroop task were noted for only those word categories in which participants had ongoing current concerns. Thus, even though patients in the No PTSD/Pain category had experienced a serious MVA that had caused painful, lingering injuries, this group did not show color-naming delays for accident-related words. Despite speculation that certain conditions, such as PTSD, may be characterized by complex, disjointed fear structures (Foa & Kozak, 1986), these data indicate a degree of specificity within specific word categories with respect to cognitive interference. By the use of the modified Stroop task, similar specificity effects have been observed in patients with social phobia (McNeil et al., 1995) and in a sample of patients with a variety of anxiety disorders (Mathews & Klug, 1993). In particular, Mathews and Klug (1993) suggested that words that are judged to be related to relevant concerns will cause greater Stroop interference, irrespective of emotional valence. The present results support this claim, in part.

Unlike researchers in previous studies (Pincus et al., 1998), we did observe color-naming delays for pain words in patients with pain. It is possible that the pain words in this study captured emotional facets of pain, which would potentially explain the observed Stroop effect. This hypothesis appears unlikely, however, in light of previous studies that have reported no differences in response latency between affective and sensory pain words (Pearce & Morley, 1989). Clearly, more work is needed to ascertain what factors are relevant in pain-related Stroop interference.

Several additional issues deserve comment in the interpretation of these data. Like many patients with PTSD, the PTSD participants in this study received an average of two additional (nonprincipal) psychiatric diagnoses. It is possible that the additional diagnostic comorbidity seen in the PTSD/Pain sample accounts for the overall slower response latencies in this group. Similar data have been reported by Litz et al. (1996) with Vietnam veterans. Ideally, continued consideration of the impact of comorbid conditions on cognitive processing can help to elucidate how related psychological problems interact with PTSD. It is conceivable, for example, that some comorbid conditions, such as pain, exert a large impact on cognitive processing of trauma cues, whereas others, such as social phobia, do not. Second, it would have been useful to have assessed the perceived threat and frequency of the word cues from the participants of this study. It is possible that the

pain and accident words would have received higher frequency ratings from the PTSD/Pain and No PTSD/Pain samples, given their ongoing involvement with litigators and health care professionals. Specifically, one could hypothesize that the PTSD/Pain and No PTSD/Pain samples showed response delays to those cues that were overlearned, given the participants' more frequent exposure to these cues. Although the evidence that emotional Stroop interference is due to extended practice (or expertise) is not strong (Williams et al., 1996), participants' ratings of perceived threat and frequency of the word cues would have helped to clarify this point. As well, individual participants may have experienced specific words as not threatening, on the basis of the idiosyncratic details of their MVA. Although there is little evidence that frequency of word usage explains Stroop interference in emotional disorders (Williams et al., 1996), these additional data would have been helpful in interpretation of the obtained results. Finally, this study could have benefited from a PTSD/No Pain sample. This additional control group would have allowed a more thorough examination of specificity effects of Stroop interference.

In summary, the current study documents both a generalized slowing and specificity of Stroop interference in patients with PTSD and pain. It is interesting that individuals with both PTSD and pain showed response delays to both accident and pain words, whereas individuals with pain without PTSD showed response delays to pain words only, although the PTSD/Pain sample showed generalized slowing overall. Despite current speculation about how fear networks are organized within PTSD, this is the first empirical effort to examine cognitive processing in the presence of comorbid conditions. Contrary to prediction, generalization of Stroop interference was not noted within word categories. Rather, the PTSD/Pain group showed generalized slowing, upon which was superimposed specificity of responding within the accident and pain word categories. Future work should continue to expand researchers' understanding of the role of multiple disorders in information processing in anxious patients, particularly in light of available theories of information processing.

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