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ATTENTION AND MEMORY DYSFUNCTION IN PAIN PATIENTS WHILE CONTROLLING FOR EFFORT ON THE CALIFORNIA VERBAL LEARNING TEST-II

A Thesis

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Psychology
Applied Biopsychology

by

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Abstract

Previous studies have reported that deficits in attention are often a common complaint in individuals suffering from pain and attentional impairment in patients with pain has been demonstrated on a variety of neuropsychological measures. Much of the research to-date, however, has not taken into account extraneous factors that may contribute to observed cognitive deficits. Using the California Verbal Learning Test - II, attention and memory performance was examined in two clinical populations (pain and mild traumatic brain injury) while controlling for effort using the Word Memory Test. Controlling for effort led to different explanations of poor performance on attention variables. While mild deficits were expected, and could be accounted for by psychological factors (i.e. somatization), extremely poor performance was more likely related to poor effort. The findings of this study strongly support the necessity of measuring effort during neuropsychological and pain psychological evaluations.

Introduction

According to the International Association for the Study of Pain, pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage" (p. 566, Turk, Robinson, Loeser, Covington, & Lippe, 2001). It is a major cause of morbidity and lost production in workers in the United States and accounts for approximately 25 percent of all worker's compensation claims filed (Guo et al., 1995). Over the years, direct compensation costs have increased from around one billion dollars in 1979 to between 50 and 100 billion dollars in 1990 (Guo et al., 1995; Guo, Tanaka, Halperin, & Cameron, 1999; Meyers & Diep, 2000). As such, research examining the pathophysiology of pain and pain disorders has become increasingly important.

The pathophysiology of pain conditions is far from being known. Pain itself is a subjective multidimensional construct and because of this, the effects of pain in a variety of domains, including cognitive abilities, is sometimes hard to empirically assess. Complicating the issue further is the fact that some patients experience pain as a result of a traumatic brain injury. This makes it hard to differentiate among cognitive dysfunction that occurs as a result of brain injury, pain, or an interaction of the two. Because of this, there have been a number of studies that have examined the effect of pain in isolation, in a variety of cognitive tasks (for a review of these studies, see Nicholson, 2000; Eccleston, 1994, 1995; Grigsby, Rosenberg, & Busenberg, 1994; Iverson & McCracken, 1997; McCracken & Iverson, 2001; Schmand, Lindeboom, Schagen, Heijt, Koene, & Hamburger, 1998; Schnurr & MacDonald, 1995; Smith-Seemiller, Fow, Kant, & Franzen, 2003). In general, most of the studies found that chronic pain, independent from traumatic brain injury, had an adverse effect on cognitive functioning. This effect appears to be most salient on aspects of attention, memory, concentration, and speed of processing.

Iverson and McCracken (1997, 2001) examined the rate of specific cognitive complaints endorsed by pain patients who had not sustained a head injury in two separate studies. Looking at the combined rates, 23.4% to 29% of their samples reported problems with forgetfulness and approximately 18% had difficulty maintaining attention. Furthermore, 23.1% of patients reported being involved in minor accidents, 20.5% had difficulty finishing tasks (McCracken & Iverson, 2001) and 16.5% had difficulty with concentrating (Iverson & McCracken, 1997). In another study examining the cognitive complaints in chronic pain patients without a history of head injury, Smith-Seemiller, Fow, Kant, & Franzen, (2003) found that 67% of the chronic pain (CP) group indicated having problems with memory, 78% indicated that they have difficulty concentration, and 71% reported that it took them “longer to think.”

Grisart, Van der Linden, and Masquelier (2002) postulated a reason as to why attentional processes, in particular, are affected in chronic pain conditions. They hypothesized that patients with chronic pain conditions, such as fibromyalgia, often have difficulty attending to tasks that need to be executed because they allocate their attentional resources towards their pain. The results of their study showed that there was a significant decrease of the controlled explicit component of memory in chronic pain patients which suggests that there is a “higher attentional cost” of pain experience for pain patients compared to controls (Grisart et al., 2002). In a study investigating the attentional functioning in patients diagnosed with either fibromyalgia, rheumatoid arthritis, or musculoskeletal pain, 60 percent of the patients had at least one score in the clinically impaired range and all three groups of chronic pain patients had impaired functioning on tests of everyday attention (Dick, Eccleston, & Crombez, 2002). These findings are consistent with earlier findings that showed greater performance deficits on complex attention-demanding tasks in patients with severe chronic pain versus normal controls (Eccleston, 1994, 1995). These data indicated that memory test performance should be disrupted as a result of impaired attentional processes.

Understanding the impact of pain on attentional and memory functioning is complicated by the fact that some patients may exaggerate the severity of their pain or complain of pain when they may not have any (Mendelson, 1984). This has been shown to be the case when the patient is involved in litigation or there is a known incentive that motivates them to portray themselves in a way that makes them look more impaired than what can be accounted for by physical pathology alone (Brown, 2004). In a study examining cognitive validity indicators ordinarily used in the detection of feigned cognitive impairment in brain injury, approximately 29 percent of pain patients in litigation failed cognitive symptom validity indicators compared to the zero percent in the non-litigating group (Meyers & Diep, 2000). Iverson, King, Scott, and Adams (2001) compared the cognitive complaints of litigating pain patients with and without head injuries to groups of non-litigating patients. It was found that litigating pain patients reported more cognitive symptoms than the non-litigating pain patients. Furthermore, the pain patients in litigation reported more cognitive symptoms than head injury patients not involved in litigation

(Iverson et al., 2001). This means that the existence of some sort of external gain may be influencing the effort put forth by litigating patients when undergoing cognitive assessments. As a result, it becomes more difficult to discern the actual cognitive problems and limitations individuals with pain experience from those problems distorted by individuals exaggerating their cognitive impairment.

Green and colleagues were the first to address the importance of distinguishing between cognitive performance affected by good and poor effort in a sample of traumatic brain injury (TBI) patients. Specifically, they looked at the relationship between injury severity (as determined by Glasgow Coma Scale [GCS] score, Computerized Tomography [CT] or Magnetic Resonance Imaging [MRI] abnormalities, post-traumatic amnesia [PTA] duration, and loss of consciousness [LOC] duration) and olfactory ability as measured by the Alberta Smell Test (Green & Iverson, 1998a, 2001; Green, Rohling, Iverson, & Gervais, 2003). Two main sets of analyses were conducted in each of the studies. They first looked at the relationship of olfactory discrimination with injury severity while controlling for poor effort and the second set of analyses examined this same relationship in the context of poor effort. Poor effort was defined by an individual’s score less than the published/established cut-off on the Word Memory Test (WMT; Green, Allen, & Astner, 1996,2003) and Computerized Assessment of Response Bias (CARB; Conder, Allen, & Cox, 1992).

Two different explanatory models of the effect of injury severity and olfactory discrimination resulted. As expected, in analyses controlling for effort, there was a clear dose-response relationship between olfactory abilities and injury severity. In other words, olfactory discrimination decreased with increased injury severity. Patients with mild head injuries exhibiting good effort did not differ significantly from controls (patients with orthopedic injuries) and patients with severe head injuries had significantly worse deficits compared to patients with mild head injuries. However, these same results could not be applied to patients who failed effort tests, in fact, a paradoxical effect could be seen. Specifically, more impairment in smell test scores were seen in those patients with the least objective abnormalities of the brain but who exaggerated their impairment on testing with the WMT and CARB (Green & Iverson, 1998a, 2001; Green et al., 2003).

Rohling (2000) examined the effect of effort on a measure of cognitive impairment and self-reports of patients using a large sample (N = 655) referred for neuropsychological evaluations. Patients were divided into four groups: mild and severe traumatic brain injury groups showing good effort (labeled the genuine group) and mild and severe traumatic brain injury groups showing poor effort (exaggeration group). For self-reports of memory impairment, a significant group (genuine versus exaggerators) by injury severity (mild versus severe) existed. For example, mild TBI patients in the exaggerating group rated their memory as poor whereas severe TBI patients in the exaggerating group rated their memory as excellent (Rohling, 2000).

The effect of pain on various neurocognitive measures has also been studied. For example, in two studies, higher levels of reported pain were hypothesized to be associated with self-reported memory difficulties and self-reported levels of psychological distress during memory tasks (Allen, Green, & Eimer, 1999a, 1999b). It was shown that high reported pain levels in the good effort groups had no effect on memory ability.

In summary, although measures have been developed to detect exaggeration of impairment within the context of brain injury, little attention has been directed at re-examining the validity of research that has been conducted with pain patients regarding attention and memory complaints while controlling for exaggeration or poor effort. Considering this, it may be possible that researchers and clinicians are drawing inaccurate inferences about the cognitive dysfunction associated with pain conditions. Thus, in order to better understand the nature of cognitive impairments in pain conditions, it is important to specifically tease apart the effects of effort and effects of pain on tests of cognitive ability.

Structure of Memory Processes

Much of the research on memory processes focuses on the ability to learn and remember information. Although there are multiple memory systems that have been described (i.e. implicit and explicit memory), explicit (or controlled) memory is the type most often studied as a way to understand memory dysfunction (Lezak, Howieson, & Loring, 2004). Clinically, three kinds of memory are distinguishable from each other: sensory memory, short-term memory, and long-term memory (Lezak et al., 2004). Within these stages are specific processes responsible for various components of the learning and memory process.

An individual's ability to learn and ultimately remember what has been learned, is primarily and initially influenced by the active and complex process of attention. Generally, it is the selective and preferential process that functions to exclude certain aspects of a person's sensory field (Parente & Herrmann, 1996). If the information is actively rehearsed (via repetitive mental processes), the likelihood that the information will be permanently stored is increased (Baddeley, 1976). The process of storing information is called consolidation (Lezak et al., 2004); during this process, learning takes place. Once consolidated, the ability to maintain learned information over time is referred to as retention (Curtiss, Vanderploeg, Spencer, & Salazar, 2001). If the information is needed for some reason, it is retrieved from long-term memory stores. Although each component reflects unique aspects of the memory process, they are ultimately dependent on each other. The elaborate interrelatedness of these components makes it hard to study each in isolation.

The CVLT-II is one of the few measures that assesses, in some way, all of the memory processes described. It is the fourth most used instrument used in general neuropsychological practice and the second most used in terms of memory instruments (Rabin, Barr, & Burton, 2005). Generally, it examines the rate of learning, the effect of retroactive and proactive interference, as well as the strategy that the person uses in order to remember the information presented to them (Lezak et al., 2004). Therefore, the CVLT-II enables inference about the integrity of component memory processes such as learning, encoding, retention/storage, and retrieval (Curtiss et al., 2001; Murji, Rourke, Donders, Carter, Shore, & Rourke, 2003).

Since the CVLT-II yields a large number of scores (42; Delis, Kramer, Kaplan, & Ober, 2000), a number of researchers have examined ways to identify patterns of learning and memory performance using exploratory factor analytic and confirmatory factor analytic techniques in a variety of populations including TBI (Curtiss et al., 2001; Millis & Ricker, 1994; Wiegner & Donders, 1999), HIV-I infection (Murji et al., 2003) and children (Roman, Delis, Willerman, et al., 1998). In studies looking at TBI, four factor models have resulted from the pre-selection of fourteen CVLT variables thought to be most representative of learning and memory processes. These factor models include: attention span, learning efficiency, delayed recall, and inaccurate recall (Millis & Vicker, 1994; Murji et al., 2003; Wiegner & Donders, 1999). Taking from this existing research, Curtiss et al., (2001) developed indices of each of the memory processes (i.e. attention, encoding, consolidation, retention, and retrieval) using the variables analyzed in previous research in order to examine patterns of learning and memory in TBI patients. Therefore, adaptations of the indices developed by Curtiss et al. (2001) were utilized in this study to examine the effect of pain on memory processing abilities.

Purpose

Although the presence of cognitive dysfunction in the form of attention and memory problems has been reported in the literature, little, if any, research exists examining the specific attentional and memory problems encountered by pain patients while controlling for effort. This is particularly important for understanding the cognitive impairments observed in patients seen in the context of incentive and/or litigation. Therefore, a goal of this study was to examine the nature and severity of cognitive problems in pain patients while controlling for exaggeration and effort. The effects of pain on memory processes was examined using selected variables from the California Verbal Learning Test-Second Edition (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000) while controlling for effort using the Word Memory Test (WMT; Green, Allen, & Astner, 1996, 2003).

Hypotheses

Since literature exists reporting that pain primarily disrupts attentional processes, one goal of this study was to examine if pain patients differed from the normative sample (i.e. individuals without evidence of neurological disorder or brain dysfunction) on scores associated with attention and how they differed. Regardless of effort, it was expected that the scores of pain patients on CVLT-II variables of attention would be significantly lower compared to normal performance. Because deficits in attentional processing can ultimately impact subsequent “down-stream” memory processes (i.e. the ability to encode, consolidate, or retrieve information), possible deficits (i.e. lower scores) on these “down-stream” memory processes were also expected in the pain patients compared to the normative sample.

A second goal of this study was to examine the effects of effort on CVLT-II scores in two pain groups and a comparison group consisting of mild TBI patients. It was hypothesized that both good effort pain patients and mild TBI patients exhibiting good effort would not significantly differ from each other on variables of attention. Individuals suffering mild head injuries often report attention and concentration problems initially, although these symptoms typically resolve within six months of their injury (Alexander, 1992; 1995; Binder,1986, 1997; Dikmen, McLean, & Temkin, 1986; Dikmen, Temkin, Machamer, Holubkov, Fraser, & Winn, 1994; Dikmen, Machamer, Winn, & Temkin, 1995; Heilbronner & Taylor, 1994; Larrabee, 2005; Youngjohn, Burrows, & Erdal, 1999). However, a subset of head injury patients do experience residual cognitive problems, including attention problems, past the typical recovery period (Barth, Diamond, & Errico, 1996; Bazarian, Wong, Harris, Leahey, Mookerjee, & Dombovy, 1999; Binder, 1986, 1997; Evered, Ruff, Baldo, & Isomura, 2003; Karzmark, Hall, & Englander, 1995; Rees, 2003; Santa Maria, Pinkston, Miller, & Gouvier, 2001). Therefore, it was hypothesized that the individuals in the mild TBI group would have slightly lowered scores on measures of attention as well.

A differential pattern of performance was expected, however, for the poor effort pain group. Whereas attentional processing was expected to be the most affected in the good effort groups, with possible deficits being observed on “down-stream” memory processes, the poor effort group was expected to show a broader range of deficits. In other words, poor effort groups were expected to perform significantly worse on <u>all</u> of the memory processing indices compared to the good effort pain and mild TBI groups.

Methods

Participants

Retrospective data was obtained from patients seen for psychological pain or neuropsychological evaluations at a clinical psychology/neuropsychology practice located in southern Louisiana. In order to be included in the study, all patients had to have completed the California Verbal Learning Test - II (CVLT-II; Delis et al., 2000) and Word Memory Test (WMT; Green, Allen, & Astner, 1996,2003) during the course of their evaluations. Furthermore, so as to avoid the possible confounding effect of low education on the measures used, patients had to have at least ten years of education.

The pain groups (*n* = 20 each) were formed after review of the archival records of 158 patients who underwent a psychological pain evaluation and who had completed both the CVLT-II and WMT. A demographically - matched mild TBI group (*n* = 20) was chosen for the purposes of comparison to the two pain groups (see below for further inclusion and exclusion criteria). Medical records and assessment results were extensively reviewed in order to obtain the objective medical diagnostic test results, clinical diagnoses, and injury characteristics necessary for group assignment. The patients were referred by physicians, attorneys, and worker's compensation companies. All patients included in this study were seen in the context of a worker's compensation claim (*n* = 48), disability claim (*n* = 1) or personal injury suit (*n* = 11) and thus had known external incentive (i.e. worker's compensation benefits or disability benefits).

Good effort pain group. Patients were included in this group on the basis of two main criteria. First, patients in this group had to have exhibited good effort on the Word Memory Test as defined by scores equal to or greater than 82.5% on all three of the effort measures: Immediate Recognition (IR), Delayed Recognition (DR), and Consistency (CONS1) (Green, Allen, & Astner, 1996, 2003; Tan, Slick, Strauss, & Haultsch, 2002). The scores in this group ranged from 85% to 100% for each of the three effort measures with the averages being 95.5%, 98.4%, and 94.6% respectively.

Second, patients were included in this group if they reported and experienced pain-related complaints at the time of the evaluation as a result of an accident that they sustained. Demonstrable objective abnormalities of the spine as indicated by x-ray, computerized tomography (CT), magnetic resonance imaging (MRI), myelograms, electromyelography (EMG), nerve conduction studies (NCS), and/or surgery needed to be present in order to be included in the study. Overall, 20% of the good effort pain patients had positive findings on x-rays, 30% on CT, 85% on MRI, 15% on myelograms, and 15% on EMG/NCS. Sixty percent of the patients in this group underwent at least one surgery and 30% had a second surgery. Surgeries typically involved intervertebral fusions, laminectomy, discectomy, and removal of disc bulges.

A number of exclusionary criteria were also implemented. First, any individual who did not have a pain condition directly related to an accident was excluded from the study. In other words, individuals with primary diagnoses of fibromyalgia, complex regional pain syndrome, reflex sympathetic dystrophy, and myofascial pain, were excluded. Second, individuals self-reporting a head injury and/or exhibiting objective evidence of head trauma/injury that co-occurred with their pain physical pathology, were also excluded from this study. Third, pain patients with primary diagnoses involving any other areas besides the spine (cervical, thoracic, lumbar, or sacral) were excluded from the study. Primary diagnoses mainly included some type of spinal strain/sprain, disc herniations, bulges, and/or fractures, and nucleus pulposus. Overall, 30% of the good effort pain sample had self-reported cervical complaints, 20% had thoracic complaints, 95% had lumbar complaints, and 70% had sacral complaints.

Poor effort pain group. Patients were included/excluded from this group based on the same criteria established for the good effort pain group. First, individuals in this group had to obtain scores less than the established cut-off (82.5%) on either the IR, DR, or CONS1 effort sub-tests of the Word Memory Test (Green et al., 1996, 2003; Tan et al., 2002). Overall, 80% of the poor effort pain group obtained a score less than 82.5% on the IR trial, 70% scored below the cut-off on the DR trial, and 100% scored below the cut-off on the CONS1 trial. Sixty percent of the poor effort pain sample obtained scores less than the cut-offs on all three of the effort measures.

Demonstrable objective abnormalities of the spine as indicated by radiological testing was also required for inclusion into this group. Overall, 5% of the poor effort pain group had positive findings on x-rays, 40% on CT, 75% on MRI, 25% on myelogram, and 35% on EMG/NCS. Sixty-five percent of the poor effort group had undergone at least one surgery and 20% had a second surgery. Within this group, 35% had self-reported cervical complaints, 20% thoracic, 100% lumbar, and 50% sacral.

TBI patients. The mild TBI group, serving as the study's comparison/control group, consisted of patients referred for neuropsychological evaluation after suffering from an apparent traumatic brain injury. Patients were classified as having suffered a mild head injury if there was evidence that they sustained a blunt trauma to the head <u>and</u> they met the criteria set by the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitative Medicine (1993). These criteria include: 1) posttraumatic amnesia (PTA) not greater than 24 hours; 2) an initial Glasgow Coma Scale (GCS) of 13 to 15 after 30 minutes from the time of the injury/accident; and 3) loss of consciousness (LOC) of approximately 30 minutes or less. Any patient who did not meet <u>all</u> of the mild TBI criteria was excluded from the study. Of the fifteen individuals with documented GCS scores, one (5%) had a GCS of 13, 5 (25%) had a GCS of 14, and 9 (45%) had a GCS of 15. In terms of loss of consciousness, fifteen individuals (75%) reported a LOC of less than five minutes with the remaining five patients reporting a LOC ranging from ten to twenty minutes. Finally, no patients reported a PTA greater than 24 hours.

Some of the TBI patients exhibited positive neuro-radiological findings, therefore, further examination of the details of their injuries was warranted. Four individuals had positive findings on x-rays and CT - further examination of their medical histories revealed that two of these individuals had facial fractures and two had minor skull fractures, one basilar in nature and the other a small depressed skull fracture. Three individuals showed slightly abnormal activity on an EEG (mild diffuse slowing) which has been shown to sometimes occur secondary to sustaining a concussion (Lezak et al., 2004).

Measures and Variables

Measure of effort - Word Memory Test. (WMT; Green, Allen, & Astner, 1996, 2003) is based on the forced-choice paradigm which is extensively used in symptom validity tests (SVTs; Millis & Volinsky, 2001). It is a computerized forced-choiced task that is designed to measure both verbal memory and biased responding (Green, Iverson, & Allen, 1999) and requires both immediate and delayed recognition of twenty semantically-linked pairs of common words (i.e. dog/cat, man/woman). It contains three effort measures along with four sub-tests measuring memory ability (Green et al., 1996, 2003). To start, a list is presented to the patient twice with each pair being presented for six seconds. In the first effort task (Immediate Recognition; IR), the patient has to select original words from new pairs presented to them, each of which includes an original word and a new word. After thirty minutes, a delay recognition (DR) task is given where the patient needs to select each of the 40 original words from pairs with 40 new “trick” words (Green et al., 1999). The third effort measure, Consistency (CONS1) measures the consistency of the responses from the IR and DR conditions. The four remaining sub-tests measure memory ability (Green et al., 1996).

Studies have shown that the Word Memory Test is effective in detecting individuals putting forth sub-optimal effort. Green, Iverson, and Allen (1999) found that patients classified with definite traumatic brain injury had significantly higher scores on all three effort measures compared to individuals classified as having sustained mild head injuries. Furthermore, studies comparing the failure rates of SVTs in a group of non-head injury claimants showed that the WMT was more sensitive to response bias compared to two other tests used (Gervais, Rohling, Green, & Ford, 2004). As such, the cut-offs utilized in previous studies were used to classify patients into their pain groups. As mentioned previously, any individual scoring below 82.5% correct on the any of the three effort trials (IR, DR, or CONS1) were considered as exhibiting poor effort (Green et al., 1996, 2003; Tan et al., 2002).

Measure of memory - California Verbal Learning Test - II. (CVLT-II; Delis et al., 2000). The CVLT-II consists of a list of sixteen words that are organized into four meaningful categories. The list is read to the participant five times and then they are asked to recall as many of the items as they can. Then, a competing list of sixteen words is read to the person under the same condition and they try to recall as many words as they can from the second list. Next, the participant is asked to recall the original list first under a free recall procedure and then a recall condition in which the participant is cued using four semantic categories (Delis et al., 2000).

For the purposes of this study, a select number of CVLT-II variables were utilized. Each variable selected has been proposed in previous research to represent aspects of various memory processes. The CVLT-II variables used in this study were: total words recalled correctly from List A Trial 1 (Trial 1), total words recalled correctly from List B (List B), total words recalled from List A Trial 5 (Trial 5), Semantic Cluster Ratio, Percent Recall Consistency (Consistency), Learning Slope (Slope), total words recalled correctly for Trials 1 through 5 (Total Trials 1 -5), Long - Delay Free Recall (LDFR), Long - Delay Cued Recall (LDCR), Short - Delay Free Recall (SDFR), Short - Delay Cued Recall (SDCR), Recognition Hits (Hits), Free Recall Intrusions (FR), Cued Recall Intrusions (CR), and

False Positives (FP). Appendix A provides a description of the CVLT-II variables used to measure each of the memory processes examined in this study. Appendix B is an overview of the adapted Curtiss et al., (2001) formulas used to derive the memory processes measured in this study.

Results

Demographic Characteristics

Comparisons among the three clinical groups were made for demographic variables to ensure that the groups were appropriately matched on relevant demographic characteristics. Analyses of variance (ANOVA) were conducted to test for group differences on age, education level, and the amount of time that elapsed between the time of the injury and the evaluation. Chi-square analysis was performed to examine differences in regards to gender.

Overall, the three groups (two pain groups and the mild TBI group) averaged 35.3 months between injury and evaluation (*sd* = 29.7). There was no difference in time post-injury between the three groups (F [2,57] = .41, p = ns, *partial* eta^2 = .01). There were also no group differences in age (F [2,57] = 2.19, p = ns, *partial* eta^2 = .07) or education level (F [2,57] = 1.06, p = ns, *partial* eta^2 = .04). However, there was a significant difference with respect to gender among the groups; overall, there was a higher proportion of males in the three groups than females (χ^2 [df = 1] = 9.60, $p < .01$) but there was no difference between the groups regarding the proportion of men in each group. Table 1 provides the detailed results and descriptive statistics of the demographic variables.

Table 1. *Demographic characteristics of the current sample by group*.

Group		Age (years)	Education (years)	Months since injury (mos)	Gender (% male)
Poor Effort Pain	Mean	41.3	12.8	38.9	0.80
	(sd)	(9.5)	(1.9)	(41.9)	
Good Effort Pain	Mean	45.1	12.3	36.6	0.65
	(sd)	(7.6)	(1.4)	(25.1)	
Good Effort Mild TBI	Mean	39.0	13.1	30.5	0.65
	(sd)	(10.8)	(2.0)	(17.9)	
Total Sample	Mean	41.8	12.7	35.3	0.70
	(sd)	(9.6)	(1.8)	(29.7)	

Note. mos = months; TBI = traumatic brain injury; sd = standard deviation.

Normative Sample Comparisons

The standardized scores (z-scores) for the fifteen CVLT-II variables examined in this study were recorded for each patient from the standardized CVLT-II scoring print-out. The z-scores from the print-out are demographically-corrected for age and gender and are based on the normative sample from the test. In general, negative z-scores are indicative of below average performance. However, the original z-scores for three variables (FR Intrusions, CR Intrusions, and False Positives) are reverse scaled in that positive scores are indicative of more errors being made by the individual. For the purposes of the study, the three error variables were reverse scored (multiplied by -1) so that the results of the analyses could be easily interpreted. Next, a multivariate analysis of variance (MANOVA) was conducted to examine group differences on the fifteen standardized variables. Follow-up ANOVAs were examined to identify the specific variables the groups differed on. Post-hoc comparisons were performed using the Tukey honestly significant difference procedure (Tukey HSD) to examine how the groups differed.

Preliminary assumption testing for the MANOVA was conducted to check for normality, linearity, and homogeneity of variance-covariance matrices. In terms of multivariate normality, the maximum Mahalanobis distances value obtained (38.15) was slightly above the chi-square critical value associated with fifteen dependent variables (χ^2 critical value = 37.7 at $p < .001$; Tabachnik & Fidell, 2001). However, examination of potential outliers revealed only one person who obtained this value. Therefore, this individual was left in the data file. The assumption of equality of variance was violated for three variables: Recognition Hits, Free Recall Intrusions, and False Positives. Therefore, a more conservative alpha level ($p = .025$; Pallant, 2005) was used for determining significance for those variables in the univariate F-tests. There were no serious violations found when testing for linearity and homogeneity of covariance matrices.

There was a statistically significant difference between the three groups on the fifteen dependent variables (F [30,86] = 2.05, $p < .01$, *Wilk's* $\Lambda = .34$, *partial* $eta^2 = .42$). Follow-up analyses of variance (ANOVAs) revealed significant differences between the groups on the following variables: Slope, Total Trials 1 - 5, LDCR, Trial 5, SDFR, SDCR, LDFR, Recognition Hits (at the adjusted alpha level of .025), and FR Intrusions (at the adjusted alpha level of .025). The FP variable showed a trend towards significance (*p* = .033 using the adjusted alpha level of .025).

Tukey honestly significant difference (HSD) post-hoc comparisons were conducted on the significant variables. With the exception of the FR Intrusions variable, the poor effort pain group obtained significantly lower scores than the good effort pain and mild TBI groups. The good effort pain group and mild TBI group did not statistically differ from each other. On the FR Intrusions variable, the poor effort pain scored significantly lower than the good effort pain group but did not differ from the the mild TBI. The mild TBI group also did not differ from the good effort pain group. Table 2 summarizes the results and descriptive statistics associated with the MANOVA. A graphical representation of the mean z-scores for each of the fifteen variables as a function of group can be seen in Figure 1.

Table 2. *Results and descriptive statistics from the multivariate analysis of variance examining differences on the fifteen standardized CVLT - II variables as a function of group.*

	poor effort pain	good effort pain	good effort mTBI			
Variable	M (sd)	M (sd)	M (sd)	*F*	*p*	*partial eta*^{2}
Trial 1	-1.10 (1.20)	-0.98 (0.85)	-0.83 (1.07)	.35	ns	.01
List B	-1.08 (0.57)	-0.63 (0.89)	-0.83 (0.96)	1.50	ns	.05
Semantic Cluster	-0.23 (0.70)	-0.10 (0.70)	-0.25 (0.79)	.24	ns	.01
Consistency	-0.75 (1.08)	0.03 (1.08)	-0.17 (0.99)	2.96	ns	.09
Slope	-0.70^a (0.85)	0.28^b (0.98)	0.03^b (0.79)	6.69*	.002	.19
Total 1-5	36.8^a (10.1)	45.9^b (8.70)	46.2^b (9.38)	6.44*	.003	.18
LDCR	-1.75^a (1.00)	-0.53^b (1.09)	-0.33^b (0.88)	12.09**	.000	.30
Trial 5	-1.45^a (1.11)	-0.43^b (0.86)	-0.53^b (0.94)	6.70*	.002	.19
SDFR	-1.63^a (1.01)	-0.32^b (0.89)	-0.50^b (0.89)	11.48**	.000	.29
SDCR	-1.60^a (1.13)	-0.45^b (0.99)	-0.48^b (0.92)	8.34**	.001	.23
LDFR	-1.78^a (1.09)	-0.48^b (1.04)	-0.30^b (1.01)	11.81**	.000	.29
Recog Hits	-2.53^a (1.94)	-0.90^b (1.54)	-0.38^b (1.58)	10.09**	.000†	.26
FR Intrusions	-1.70^a (1.73)	-0.45^b (1.15)	-0.78^{ab} (1.22)	4.36*	.017†	.13
CR Intrusions	-1.13 (1.40)	-0.73 (1.36)	-0.23 (0.83)	2.70	ns	.09
FP	-1.48 (1.74)	-0.53 (1.28)	-0.38 (1.11)	3.61	.03†	.11

Note. mTBI = mild traumatic brain injury; LDCR = Long-Delay Cued Recall; SDFR = Short-Delay Free Recall; SDCR = Short-Delay Cued Recall; LDFR = Long-Delay Free Recall; Recog Hits = Recognition Hits; FR = Free Recall; CR = Cued Recall; FP = False Positives.

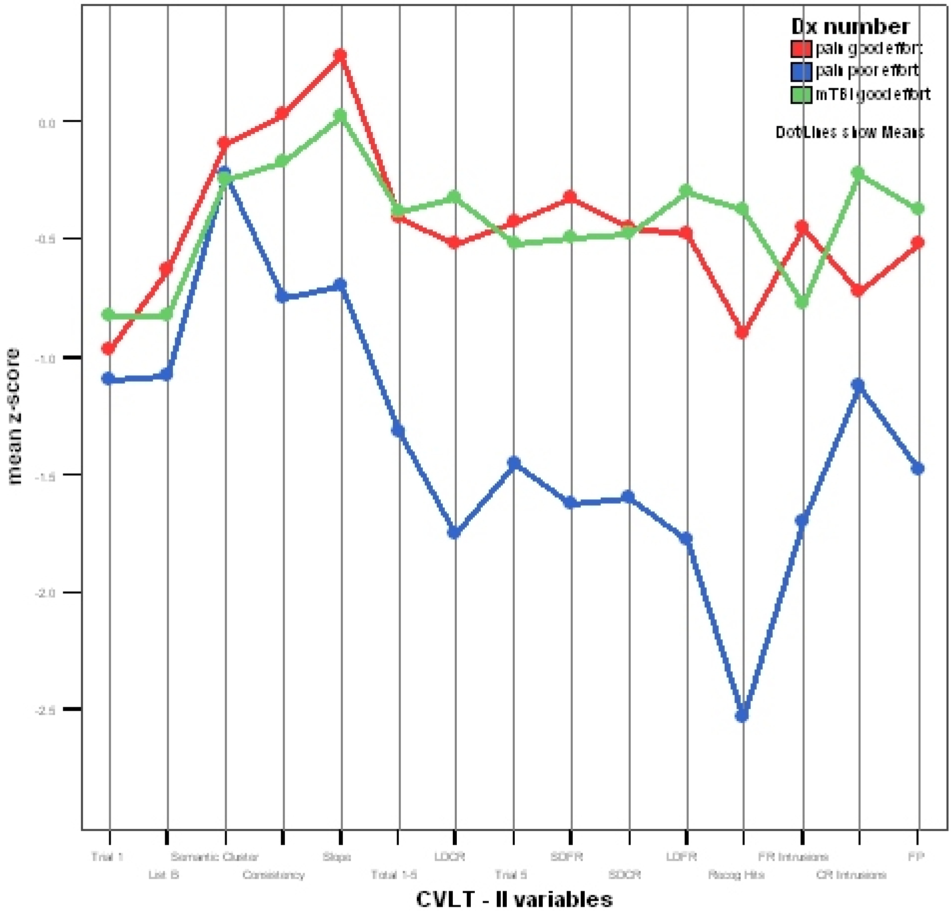
$df = 2, 57$

† an adjusted alpha level of $p \leq .025$ was used.

* $p \leq .025$; ** $p \leq .001$.

^{ab} row means with the same letter are not significantly different from each other.

Figure1. *Mean z-scores on the fifteen standardized CVLT-II variables as a function of group.*



Note. The standardized value for the Total Trials 1-5 (T-score) was converted to a z-score for the purposes of the figure only. The z-score was calculated by subtracting 50 from the individual's T-score and dividing by 10.

It was hypothesized that all three clinical groups would show deficits on variables associated with attention and concentration (List A Trial 1 and List B). Further, it was postulated that possible “down-stream” effects on memory processes would also be seen for these groups. Using the results from the post-hoc comparisons, the three groups were combined in various ways in order to conduct one-tailed, single-sample t-tests evaluating whether the means of the three groups on the fifteen standardized variables were significantly different from normal (with normal equaling a mean of 0 for all variables except the Total Trials 1-5 variable which has a mean of 50).

Overall, 15 one-tailed single-sample t-tests were conducted. An adjusted alpha level of $p \leq .002$ ($p \leq .025$ divided by 15) was used to control for Type I error inflation. Post-hoc tests from the MANOVA indicated that the three groups did not statistically differ from each other for these variables: List A Trial 1, List B, Semantic Cluster Ratio, Consistency, and CR Intrusions. Therefore, one-sample t-tests for these variables were conducted using the overall combined sample. Three variables, List A Trial 1, List B, and CR Intrusions, were significant using the adjusted alpha level. Specifically, the results indicated that the three clinical groups scored significantly lower than normal on variables of attention (List A Trial 1 and List B). Additionally, the three clinical groups scored significantly lower than normal on a variable that represents errors made on cued-recall trials. This indicates that the three groups made significantly more errors than normal. Table 3 summarizes the results.

Table 3. *Results from the one-tailed single-sample t-tests using the fifteen standardized CVLT-II variables*.

Variable		Mean (sd)	*t* - value	*p* - value
Combined Sample[a]				
Trial 1		-0.97 (1.04)	-7.22*	.000
List B		-0.84 (0.83)	-7.85*	.000
Semantic Clustering		-0.19 (0.72)	-2.06	ns
Consistency		-0.3 (1.09)	-2.12	ns
CR Intrusions		-0.69 (1.26)	-4.24*	.000
mTBI + good effort pain combined				
Total Trials 1 - 5		46.1 (8.90)	-2.80	ns
Slope		0.15 (0.89)	1.07	ns
LDCR		-0.43 (0.15)	-2.73	ns
Trial 5		-0.48 (0.89)	-3.37*	.002
SDFR		-0.41 (0.88)	-2.93	ns
SDCR		-0.46 (0.94)	-3.10	ns
LDFR		-0.39 (1.02)	-2.41	ns
Recognition Hits		-0.64 (1.37)	-2.95	ns
mTBI and good effort pain separately				
FR Intrusions	mTBI	-0.78 (1.22)	-2.84	ns
	good effort pain	-0.45 (1.15)	-1.76	ns
FP	mTBI	-0.38 (1.11)	-1.51	ns
	good effort pain	-0.53 (1.28)	-1.83	ns

Note. mTBI = mild traumatic brain injury; CR = Cued Recall; LDCR = Long-Delay Cued Recall; SDFR = Short-Delay Free Recall; SDCR = Short-Delay Cued Recall; LDFR = Long-Delay Free Recall; FR = Free Recall; FP = False Positives.

[a] t-test was conducted based on combined sample of mild TBI, good effort pain, and poor effort pain.

* $p \leq .002$ ($p = .025$ divided by 15)

The mild TBI and good effort pain groups were combined for the variables found to show significant group differences (Slope, Trials 1 - 5, LDCR, Trial 5, SDFR, SDCR, LDFR, and Recognition Hits). Therefore, a t-test for the combined (mild TBI and good effort pain) group was conducted for each of these variables. With the exception of Trial 5 (*p* = .002), the combined group did not score significantly lower than normal on the above-listed variables. This indicates that the performance on variables representing "down-stream" memory processes was relatively normal for both the mild TBI and good effort pain groups. Based on the fact that the combined good effort group performed normally on these variables, and the MANOVA indicated that the poor effort pain group scored significantly lower than the two groups on all of these variables, it can be assumed that the poor effort pain group scored significantly lower than normal on these variables.

Since the mild TBI group was not significantly different from the good effort and poor effort pain groups on FR Intrusions, t-tests for the mild TBI group and good effort pain group were conducted separately. Two separate t-tests were conducted for FP as well because this variable showed a trend towards significance. Both sets of t-tests indicated that the mild TBI and good effort pain groups did not score significantly different from normal. As mentioned above, it can be assumed that the poor effort pain group scored significantly lower than normal on these variables.

Group Analyses on Memory Index Scores

In order to compare the three groups on the various memory process indices, the memory process index scores were generated with the formulas presented in Appendix B using the standardized z-scores calculated from the overall sample means and standard deviations. Then, a repeated measures analysis of variance (ANOVA) was conducted to compare scores on the memory process indices (Attention Span, Encoding, Consolidation, Retention, Retrieval, Control) as a function of group (good effort pain, poor effort pain, and good effort mild TBI). The analysis revealed a significant main effect for group (*F* [2,57] = 5.97; $p < .01$, *partial* $eta^2 = .17$) but no significant effect for index or the group by index interaction. This signifies that the groups statistically differed from each other but within group differences did not occur across the indices. Specifically, the poor effort pain group scored lower ($M = -.36$, *S.E.* = .13) than the good effort pain group ($M = .11$, *S.E.* = .13) and mild TBI group ($M = .25$, *S.E.* = .13) across the memory process indices.

Since only a main effect was observed on the repeated measures analysis, a one-way MANOVA was conducted to further examine on which memory process index the groups differed. Preliminary assumption testing conducted to check for normality, linearity, and homogeneity of variance-covariance matrices was non-significant; thus, no assumptions were violated. There was a statistically significant difference between the three groups on the combined index scores (*F* [12,104] = 2.34, $p < .05$; *Wilk's* $\Lambda = .620$; *partial* $eta^2 = .213$). This indicates that 21% of the multivariate variance of the index scores was associated with the group the individual was in. Analyses of variance on each dependent variable were conducted as follow-up tests to the MANOVA. The ANOVAs on the Consolidation, Retention, Retrieval, and Control indices were all significant ($p < .05$) while the ANOVAs on the Attention Span and Semantic Cluster indices were not significant. Table 4 contains the descriptive statistics for each of the six indices for the three groups.

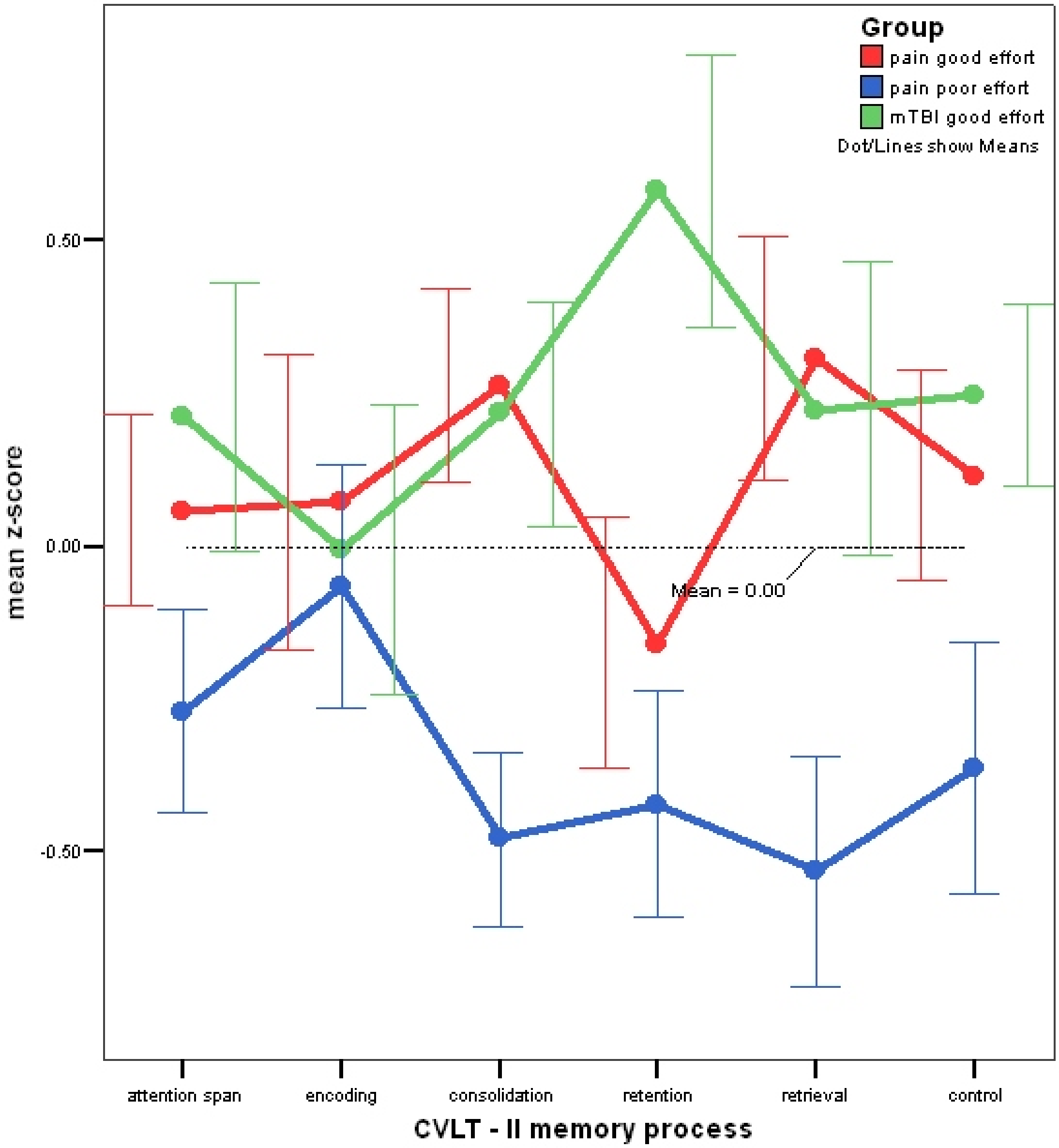
Table 4. *Results and descriptive statistics from the multivariate analyses of variance examining differences on the six memory process indices as a function of group.*

Index		poor effort pain	good effort pain	good effort mTBI	*F*	*p*	*partial eta*^{2}
Attention Span	M	-0.27	0.06	0.21	1.82	ns	.06
	(sd)	(0.75)	(0.70)	(0.98)			
Encoding	M	-0.07	0.07	-0.01	.095	ns	.003
	(sd)	(0.89)	(1.08)	(1.07)			
Consolidation	M	-0.48^{a}	0.26^{b}	0.22^{b}	6.46^{**}	.003	.185
	(sd)	(0.64)	(0.72)	(0.83)			
Retention	M	-0.42^{a}	-0.16^{a}	0.58^{b}	6.45^{**}	.003	.185
	(sd)	(0.83)	(0.92)	(1.00)			
Retrieval	M	-0.53^{a}	0.31^{b}	0.22^{b}	4.86^{*}	.011	.146
	(sd)	(0.84)	(0.88)	(1.08)			
Control	M	-0.36^{a}	0.12^{ab}	0.25^{b}	3.27^{*}	.045	.104
	(sd)	(0.92)	(0.77)	(0.67)			

Note. mTBI = mild traumatic brain injury; M = mean; sd = standard deviation.
df = 2,57
^{ab} row means with the same letter are not significantly different from each other.
* $p \leq .05$. ** $p \leq .01$.

Post-hoc comparisons using the Tukey HSD test were conducted for each of the significant ANOVAs. On the Consolidation index, the poor effort group performed significantly worse than both the good effort pain group and mild TBI group. On the Retention index, both pain groups performed significantly worse than the mild TBI group. On the Retrieval index, the poor effort pain group scored significantly worse than the good effort pain and mild TBI groups. Finally, the poor effort pain group scored significantly lower on the Control index compared to the mild TBI group whereas the good effort pain group did not statistically differ from either group. Figure 2 is a graphical representation of these patterns of performance.

Figure 2. *Patterns of performance on the CVLT-II memory process index scores as a function of group.*



Note. Memory process index scores were calculated using adaptations of the indices developed by Curtiss et al., (2001)

Secondary Analyses

The effect of effort on CVLT-II scores was clearly evident in that the poor effort pain group scored significantly lower on most of the individual variables and memory indices. Although the good effort groups showed relatively normal performance on variables representative of “down-stream” memory processes, significantly lower than normal attention scores were still observed for the two good effort groups. Because of this, exploratory statistics were conducted to examine possible contributory factors to below average scores on attention variables in the good effort groups.

First, a validation of methodological manipulation was performed to ensure that patients in the good effort group were, in fact, only patients exhibiting good effort. It was possible that the Word Memory Test did not accurately classify some individuals and as such, individuals that should have been placed in the poor effort group were instead placed in the good effort group (i.e. that person was a false negative). In order to do this, patients’s scores on three measures frequently used to detect poor effort in TBI were examined to see if any individuals scored below the established cut-off indicative of poor effort. The measures used included the: Portland Digit Recognition Test (Binder & Willis, 1991; Binder, 1993), the Test of Memory Malingering (TOMM, Tombaugh, 1996,1997), and the Reliable Digit Span calculated from the Digit Span subtest of the Wechsler Adult Intelligence Scale - III (RDS; Greiffenstein, Baker, & Gola, 1994).

On the PDRT, cut-offs of less than 19 on “Easy” trials, less than 18 on the “Hard” trials, or less than a total score of 39 are indicative of poor effort (Binder, 1993). In the good effort sample, nobody obtained scores below these cut-offs. On the TOMM, nobody in the good effort group scored less than the established cut-offs of less than 45 on Trial 2 or Retention (Tombaugh, 1996, 1997). Finally, three individuals obtained a score of 6 on RDS which is below the established cut-off of 7 (Mathias, Greve, Bianchini, & Houston, 2002). However, a score in this range does not necessarily reflect intentional poor effort because other factors, such as fatigue, psychological disturbance, or medication side effects may be present (Etherton, Bianchini, Ciota, & Greve, 2005). These results indicate that patients in the good effort group were classified appropriately.

Exploratory analyses were conducted to examine the relationship between psychological factors and premorbid intellectual functioning with attention scores. In order to do this, the combined good effort pain and mild TBI group were split into two groups based on performance on the variables associated with attention (List A Trial 1 and List B). The "Normal Attention" group consisted of individuals that obtained a z-score of greater than -1.0 on both the Trial 1 and List B variables. The "Poor Attention" group was comprised of individuals having a z-score of equal to or less than -1.0 on these variables. Once done, cross-tabulations and mean comparisons were conducted to examine group differences ("Normal Attention" versus "Poor Attention") on scores representing psychological factors and scores representing premorbid intellectual functioning.

Group comparisons of psychological factors were done by examining scores on four Minnesota Multiphasic Personality Inventory - 2 (MMPI-2; Butcher, Dahlstrom, Graham, Tellegren, & Kaemmer, 1989) scales. The MMPI-2 scales examined were: Hypochondriasis (Scale 1), Depression (Scale 2), Hysteria (Scale 3), and Psychasthenia (Scale 7). These scales have been found to be elevated in individuals with persisting symptomatology (Arbisi & Butcher, 2004; Larrabee, 1998; Lebovits, 2000; Slesinger, Archer, & Duane, 2002). Table 5 provides the means and standard deviations for each of the scales as a function of group. The table also includes the percentage of individuals in each group that had normal, moderate, and elevated scores on each of the four scales.

Table 5. *Percentage of patients showing normal, moderate, and elevated scores on the Hypochondriasis, Depression, Hysteria, and Psychasthenia scales of the MMPI-2.*

MMPI - 2 Scale		Normal Attention	Poor Attention
		n = 9	n = 14
Hypochondriasis		69.0 (12.3)	79.5 (11.3)
	< 65	22%	14%
	65 - 80	56%	43%
	> 80	22%	43%
Depression	M	74.3 (18.8)	76.9 (13.2)
	< 65	33%	14%
	65 - 80	22%	43%
	> 80	44%	43%
Hysteria	M	73.4 (10.4)	77.3 (14.1)
	< 65	22%	21%
	65 - 80	56%	36%
	> 80	22%	43%
Psychasthenia	M	68.3 (16.1)	70.4 (15.9)
	< 65	33%	43%
	65 - 80	33%	29%
	> 80	33%	21%

In general, a higher percentage of patients in the “Poor Attention” group showed moderate to high elevations on Scales 1,2, and 3 whereas the “Normal Attention” group showed mainly moderate elevations only on Scales 1 and 3. On Scale 1, the “Poor Attention” group was found to have significantly higher scores than the “Normal Attention” group (F [1,21] = 4.43, $p < .05$, $eta^2 = .17$). This indicates that the lowered attentional ability seen in this group could be attributable to hypochondriacal factors more so than actual impairment caused by physical pathology.

Finally, comparisons were conducted to examine possible differences on eight measures of premorbid intellectual functioning as a function of attention group. Scores on seven measures of intellectual functioning from the Wechsler Adult Intelligence Scale - III (WAIS-III; Wechsler, 1997) were examined. These included: the Full Scale IQ (FSIQ), Verbal IQ (VIQ), Performance IQ (PIQ), Verbal Comprehension Index (VCI), Perceptual Organization Index (POI), Working Memory Index (WMI), and Processing Speed Index (PSI). Finally, scores on the Reading subtest of the Wide Range Achievement Test- III (WRAT-3; Wilkinson, 1994) were also compared. See Table 6 for the means and standard deviations for each measure as a function of attention group. As can be seen, there were no significant differences between the two groups on any of the measures. The Working Memory Index showed a trend towards significance (F [1,22] = 3.60, $p = .07$, $eta^2 = .15$) with the “Poor Attention” group obtaining a lower score than the “Normal Attention” group. This result, however, was somewhat expected given that the WMI itself is a measure of attention.

Table 6. *Means and standard deviations of the Wechsler Adult Intelligence Scale - III IQ and index scores and the Wide Range Achievement Test - 3 Reading scores as a function of attention group.*

Index Score		Normal Attention	Poor Attention
		n = 9	n =14
WAIS-3 FSIQ	M (sd)	94.1 (11.9)	90.4 (9.5)
WAIS -3 VIQ	M (sd)	94.4 (14.6)	92.4 (13.1)
WAIS-3 PIQ	M (sd)	95.8 (10.6)	90.8 (9.8)
VCI	M (sd)	98.0 (17.9)	92.1 (11.6)
POI	M (sd)	99.6 (14.4)	95.3 (15.6)
WMI	M (sd)	94.2 (9.0)	87.0 (8.9)
PSI	M (sd)	93.0 (14.0)	91.3 (14.4)
WRAT-3 Reading	M (sd)	91.3 (12.2)	92.8 (10.9)

Note. WAIS-3 = Weschler Adult Intelligence Scale - Third Edition; FSIQ = Full Scale IQ, VIQ = Verbal IQ; PIQ = Performance IQ; VCI = Verbal Comprehension Index; POI = Perceptual Organization Index; WMI = Working Memory Index; PSI = Processing Speed Index; WRAT-3 = Wide Range Achievement Test - Third Edition.
None of the above mean comparisons were significant.

Discussion

Previous studies have reported that deficits in attention and concentration are often a common complaint in individuals suffering from pain, particularly chronic pain (Dick, Eccleston, & Crombez, 2002; Eccleston, 1994, 1995; Grigsby et al.,1994; Iverson & McCracken, 1997; McCracken & Iverson, 2001; Nicholson, 2000; Schmand et al.,1998; Schnurr & MacDonald, 1995; Smith-Seemiller et al., 2003). Furthermore, studies have demonstrated attentional impairment in patients with pain on a variety of neuropsychological measures (Eccleston, 1994; 1995; Grisart et al., 2002) However, much of the research to-date has not taken into account factors besides pain (such as effort) that may contribute to cognitive deficits seen and reported in pain patients. Therefore, in order to fully assess the impact that pain may have on cognitive abilities such as attention, it is important to address other factors that may influence cognitive abilities along with pain, including effort.

Considering this, the present study aimed to accomplish two main goals. One goal was to examine the nature and severity of deficits on variables of attention and memory in two clinical populations (pain and mild TBI). It was expected that all of the clinical groups would show significantly below average scores on variables of attention regardless of effort. The second goal sought to examine differential patterns of performance between the clinical groups on theoretically-derived memory indices as a function of effort. In other words, although all groups may have shown below average scores on certain variables, it was expected that the poor effort pain group would obtain the worst scores on attention and memory measures when compared to the good effort groups. Furthermore, it was expected that both the good effort pain and mild TBI groups would not significantly differ from each other.

In the current study, all three of the clinical groups showed deficits (i.e. below average) performance on the two CVLT-II variables chosen to reflect attention. Although the three groups did not differ from each other, results from a single-sample t-test indicated that scores in these groups were significantly lower than normal. The combined sample performed at almost one standard deviation below normal on these variables (refer to Table 3 for the mean z-scores associated with the two attention variables). For these particular variables, effort, as well as other factors appeared to be affecting scores on these variables.

The influence of effort on scores was apparent for variables representing "down-stream" memory processes. The most extreme scores were seen in the poor effort pain group (refer to Figure 1). Z-scores for the poor effort pain group ranged from a high of -.70 (Slope) to a low of -2.53 (Recognition Hits). On the other hand, both the good effort pain group and mild TBI group, although technically below average on a majority of "down-stream" variables, were not statistically different from normal. Mean z-scores for the combined group ranged from .15 (Slope) to -.64 (Recognition Hits). Therefore, these results suggest that the more extreme a score an individual gets, the more likely it is a reflection of poor effort exhibited by the individual rather than physical pathology alone.

Examining the results from the group analyses on the calculated memory index scores also provided support for the hypothesis that the poor effort pain group would perform significantly worse than the good effort groups. With the exception of the Attention

Span index and Encoding index, in which the three groups did not differ from each other, significant group differences existed for the remaining four index scores. In general, the good effort pain and mild TBI groups scored above the sample's mean whereas the poor effort pain group scored significantly below the sample's mean (see Figure 2).

Contributing Factors to Persistent Symptomatology

Why is it important to examine the potential role of effort in measuring the relationship between pain and cognitive complaints? Given the extent of disability benefits and other forms of incentive allocated to pain patients every year, it is clinically important to be able to identify the etiology, including the psychology and pathophysiology, of pain-related disorders. Assessing these issues involves a comprehensive examination of objective evidence, self-reported symptom complaints, as well as psychosocial factors in combination so that a better understanding of the causality of pain conditions can be identified.

Although many pain patients in this study had radiological findings, research has shown that physical pathology alone cannot fully account for the magnitude of disability often seen in pain patients (Bianchini, Greve, & Glynn, in press; Etherton, Bianchini, Ciota, Heinly, & Greve, 2005; Linton, 2000). Pain itself is an inherently subjective phenomenon (Bianchini et al., in press; Binder, 2005; Gatchel, 2004; McGuire & Shores, 2001; Turk et al., 2001) and the existence or presence of physical pathology usually does not definitively mean that an individual will experience deficits in various domains or present with significant pain symptomatology. Furthermore, the presence of objective physical findings does not ensure that a patient's report of their cognitive impairments is valid (Greve, Bianchini, & Ameduri, 2003). In addition, some individuals may have objectively documented evidence of spinal pathology and be asymptomatic (Nicholson & Martelli, 2004; Turk et al., 2001).

Related to this complexity between objective physical findings and pain, the symptoms endorsed by the patients included in this study were chronic and persistent in nature. Chronic pain is commonly defined as “pain that persists for longer than the expected time frame for healing” (p. 134, Meyers & Diep, 2000). The patients in this study had a considerable length of time between the date of their injury and the date they were evaluated with the average for the entire sample being approximately three years (*M* = 35.3 months, *sd* = 29.7 months). It would not be expected then that patients would continue to have significant impairments as a result of pain from an injury or accident incurred many years ago (Binder, 2005). Therefore, this suggests that residual complaints experienced are more likely attributable to a variety of factors beyond physical ones.

The influence of non-physical factors in persisting symptomatology has been extensively researched in the context of mild traumatic brain injury. Although research has shown that the cognitive symptoms reported by individuals suffering a mild brain injury usually resolve within approximately six months (Alexander,1992; 1995; Binder,1986, 1997; Dikmen et al., 1986, 1994, 1995; Heilbronner & Taylor, 1994; Larrabee, 2005; Youngjohn et al., 1999), there remains a subset of individuals that have persisting complaints (Barth et al., 1996; Bazarian et al., 1999; Binder, 1986,1997;Evered et al., 2003 Ingebrigsten,1998; Karzmark et al., 1995; Rees, 2003; Santa Maria et al., 2001). This persisting symptom presentation, often referred to as post-concussion syndrome

(PCS), is often characterized by self-reported somatic (i.e. headaches, dizziness), cognitive (i.e. having a difficult time concentrating, forgetting), and psychological (i.e. irritability, depression) complaints (Alexander, 1995; Bazarian et al., 1999; Bernstein, 1999; Larrabee, 2005; McAllister & Archiniegas, 2002; Santa Maria et al., 2001). Many of the persistent cognitive symptoms typically endorsed by individuals with PCS, such as problems with information processing speed, attention, and memory, are also symptoms that are frequently endorsed by individuals with chronic pain (Binder, 2005; Iverson & McCracken, 1997; McCracken & Iverson, 2001; Nicholson & Martelli, 2004; Smith-Seemiller et al., 2003). Therefore, it is reasonable to consider that some of the mechanisms, both conscious and unconscious, responsible for persistent symptomatology in PCS may also be the same for chronic symptoms experienced in pain patients.

Conscious mechanisms contributing to persistent symptomatology. What other factors then, besides pain, can account for persisting symptomatology? Extensive research exists providing evidence for the influence of conscious psychological mechanisms in persisting symptoms. In other words, it has been shown that some individuals purposely exaggerate their physical, psychological, and cognitive symptoms for the sake of obtaining some sort of external incentive (i.e. worker’s compensation benefits, disability benefits, relief from military duty (American Psychiatric Association, 2000; Meyers & Diep, 2000).

In both TBI and pain, it has been found that individuals involved in litigation often times report more disabling symptoms than individuals not involved in litigation (see Binder & Rohling, 1997; Green et al., 2001; Iverson et al., 2001; Larrabee, 2003; Lees-

Haley & Brown, 1996; Mittenberg, Patton Canyock, & Condit, 2002). In this context, there is a greater incentive to appear more disabled than the person actually is (Bianchini et al., 2005) and as such, the individual will employ strategies that make them appear more impaired on psychometric measures of cognitive and psychological abilities. In the current sample, all of the patients had known external incentive and many were involved in litigation; 52% of the sample was being represented by an attorney at the time of the evaluation and 20% of the sample had been referred by either a defense or plaintiff attorney for an independent medical evaluation. Therefore, the presence of incentive most likely provided motivation for some individuals to put forth sub-optimal effort on the tests they were evaluated on.

Psychological mechanisms contributing to persistent symptomatology. Effort aside, there were still patients in this sample that showed deficits on variables of attention. Analyses showed that "Normal Attention" patients were not different from "Poor Attention" patients regarding premorbid intellectual functioning. Furthermore, none of the patients in this group were misclassified as good effort patients when in fact they should have been in the poor effort group. Therefore, examination of differences on psychological factors was warranted.

Because pain is a subjective state, there are a number of affective factors that have the potential to affect assessment results (Gatchel, 2004). Research using the MMPI-2, one of the most commonly used standardized self-report psychological measures (MMPI-2; Butcher et al., 1989; Arbisi & Butcher, 2004; Lebovits, 2000; Slesinger et al., 2002) has shown that chronic pain patients typically endorse responses related to depressive (Scale

2) and anxiogenic complaints (Scale 7) (Brox, Storheim, Holm, Friis, & Reikeras, 2005; Linton, 2000; Mendelson, 1984; Sleslinger et al., 2002). Estimates range from 30% to over 50% of chronic pain patients who endorse severe levels of depression (Geisser, Robinson, Miller & Dade, 2003; Romano & Turner, 1985). In terms of anxiety, pain-related fear and concerns about the potential of being harmed again commonly causes an individual stress (Gatchel, 2004). Together, these symptoms by themselves may decrease one's ability to concentrate (Binder, 2005; Geisser et al., 2003). Given this, it was possible that individuals in this study in the good effort group with significantly below normal performance on attention variables would have elevations on scales 2 and 7 of the MMPI-2. Results showed however, that although the "Poor Attention" group showed higher levels of depression than the "Normal Attention" group, this difference was not statistically different. Neither group showed elevations on anxiety.

Along with the emotional distress that many chronic pain patients experience, persistent symptomatology may also be manifested via unconscious psychological mechanisms in some individuals. One type of unconscious mechanism is referred to as somatization which is the psychological process that underlies somatoform disorder, including pain disorder (DSM-IV TR, American Psychiatric Association, 2000; Brown, 2004; Brox et al., 2005; Gatchel, 2004). This occurs when an individual has psychological symptoms that are manifested physically because "the physical symptoms are easier to accept as causing current unhappiness and discontent than admitting that some psychological reason is contributing to it" (p. 204, Gatchel, 2004). Elevations on Scale 1 (Hypochondriasis) and 3 (Hysteria) of the MMPI-2 have been associated with somatization via cluster and factor analytic techniques (Arbisi & Butcher, 2004; Larrabee, 1998; Lebovits, 2000). In the current study, the "Poor Attention" group had significantly higher scores on the Hypochondriasis scale compared to the "Normal Attention" group (F [2,21] = 4.43, $p < .05$, $eta^2 = .17$). The effect size of .17 is considered a large effect (Cohen, 1988) and implies that 17% of the variance in hypochondriasis was dependent on the attention group that an individual was in. This indicates that below average scores on attention in the good effort group can be attributed to elevations on this scale. In other words, the cognitive and physical problems reported and measured in this group are more likely to be the result of psychological factors versus ongoing physical pathology.

Limitations

Despite the positive results obtained in this study, several methodological limitations are present in the studies' design. First, there was a selection bias in that selection of the sample was not completely randomized. The goal of this study was to examine the attention and memory problems in pain patients while controlling for effort. In order to do that, a number of inclusionary and exclusionary rules were implemented for group assignment in order to control for the potential confounding effects of education level and demographic variables. Furthermore, due to the limited availability of mild TBI patients with CVLT-II and WMT scores, some of the TBI patients had secondary pain complaints as a result of the blunt trauma they had sustained. Second, all of the patients in the study had known external incentive and/or were in the process of litigation. It is possible that some of the variance in patterns of performance seen in patients' scores could be related to stresses associated with the process of litigation (Binder & Rohling, 1997). Related to this, the study did not have a comparison group comprised of individuals with no incentive. However, although having a no-incentive comparison group would have been beneficial, having a sample made up entirely of individuals with incentive provides support for the fact that poor performance on cognitive measures may be more related to psychosocial factors rather than neurologically or physically-based ones. Third, all of the patients in the sample had chronic symptomatology present. Ideally, a comparison group of patients evaluated shortly following their accident would have provided information regarding the extent of psychological influence on their deficits.

Summary

This is one of the first studies examining the effect of pain on attention and memory processes while controlling for effort. The findings of this study strongly support the beliefs of Green and colleagues expressing the necessity of measuring effort during neuropsychological and pain psychological evaluations. In this study, controlling for effort led to different explanations of poor performance on attention and memory variables. While mild deficits were expected, and could be accounted for by psychological factors (i.e. somatization), extremely poor performance was more likely related to poor effort and/or malingering.

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Appendixes

Appendix A

California Verbal Learning Test-II (CVLT-II; Delis et al., 2000) variables used to measure specific memory systems.

Short - term memory variables

Attention Span

1. List A Trial 1. Number of words recalled from List A, Trial 1.
2. List B. Number of words recalled from List B.

Long - term memory variables

Encoding

1. Semantic Clustering. The summed value of the Semantic clustering (chance adjusted) scores for each of the individual trials and divided by T where T equals the number of Trials that had at least two or more correct responses (Delis et al., 2000).

Consolidation

1. Percent Recall Consistency. Refers to the percentage of target words recalled on one of the first four trials that are also recalled on the next trial.
2. Total Learning Slope. The average number of new words acquired per trial of List A. This reflects the rate of learning (Roman, Delis, Willerman, et al., 1998)
3. Sum of Trials 1 - 5. The total number of words recalled from List A Trials 1 through 5.

Retention

1. Long - Delay Cued Recall (LDCR). The number of words recalled from List A when cued after a 20 minute delay.
2. List A, Trial 5. The number of words recalled from List A, Trial 5.

Retrieval

1. Short - Delay Free Recall (SDFR). The number of words recalled from List A, after a brief delay and exposure to the interference list (List B).
2. Short - Delay Cued Recall (SDCR). The total number of words recalled from List A when cued after a brief delay and exposure to the interference list (List B).
3. Long - Delay Free Recall (LDFR). The total number of words recalled from List A after a 20 minute delay.
4. LDCR. The total number of words recalled when cued after a 20 minute delay.
5. Recognition Hits. The number of List A target words the individual endorses as correct on the recognition trial.

Control (Error)

1. Free Recall Intrusions (FR). The number of non-target words reported within each free recall trial summed across free recall trials (Roman et al., 1998).
2. Cued Recall Instrusions (CR). The number of non-target words reported within each cued recall trial summed across cued recall trials.
3. False Positives (FP). The number of distractor items on the recognition test which the individual incorrectly reports as having been on List A.

Appendix B

Overview of CVLT-II formulas used to derive short- and long-term memory processes

Short - term memory process

Attention Span = (List A Trial 1 + List B) / 2

Long - term memory process

Encoding = Semantic Clustering Ratio score

Consolidation = (Percent Recall Consistency + Learning Slope + Total Trials 1-5) / 3

Retention = Long-Delay Cued Recall / List A Trial 5

Retrieval = [(Short-Delay Free Recall / Short-Delay Cued Recall) +
(Long-Delay Free Recall / Long-Delay Cued Recall) +
(Long-Delay Cued Recall/ Recognition Hits)] / 3

Control (errors) = (Free Recall Intrusions + Cued Recall Intrusions + False Positives) / 3

Note. Formulas adapted from Curtiss et al., 2001.
For the current study all index scores were converted to z-scores calculated from the means and standard deviations of the current sample.

Vita

Kelly L. Curtis was born in Libertyville, Illinois and received a Bachelor of Science in Psychology from the University of Illinois at Urbana-Champaign in May 2000. In August of 2003, Kelly began the Applied Biopsychology Doctoral program at the University of New Orleans. Currently, she conducts research with Dr. Kevin W. Greve and is the research assistant for a clinical psychology/neuropsychology practice located in Metairie, Louisiana. Recently, she has become interested in investigating the contributory factors to persistent symptomatology in both traumatic brain injury patients and pain patients. She plans to continue this line of research for her dissertation.