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# Information Processing In Chronic Pain: The Role Of Depression

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# INFORMATION PROCESSING IN CHRONIC PAIN: THE ROLE OF DEPRESSION

by

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## ABSTRACT

Over the last three decades, chronic pain has become conceptualized as a multidimensional phenomenon, in that cognitive and emotional factors have become acknowledged as important contributors to the experience and expression of chronic pain. Although this general theoretical understanding of chronic pain has become widely accepted, there has been relatively little research to date which attempts to delineate the specific ways in which cognitive operations may be influenced by various dimensions of chronic pain. The present dissertation represents an attempt to expand upon the empirical knowledge regarding cognitive processing in chronic pain. Specifically, the present project has been designed to examine the relative influence of chronic pain and depression on attention, short-term memory, and long-term memory. In general terms, it was expected that processing of pain and emotion-relevant stimuli would each be biased in a direction which was congruent with the pain or emotional status of the subjects.

Two pilot studies were run to determine the relevant parameters of phenomena under consideration. Pilot Study I was designed to investigate the relationship of depressed mood to sensory and affective dimensions of chronic pain. Using psychometric methodology, it was found that depressed mood was more strongly associated to the affective than to the sensory dimension of chronic pain. Pilot Study II was designed as a preliminary examination of the selective effect of chronic pain and depressed mood on state-specific attentional processes, as exemplified by a modified Stroop task. That Pilot Study II did not yield the predicted results was explained in terms of diagnostic criteria and potential uncontrolled methodologically-related variance.

Results obtained in Pilot Study I informed much of the design and methodology employed in the principal study.

Subjects in the principal study were selected on the basis of rigorous diagnostic criteria to form the following four groups: pain-depressed, pain-nondepressed, nonpain-depressed, and nonpain-nondepressed. The principal study was comprised of three components. Phase I was a modified Stroop task, which used methodology modified on the basis of results obtained in Pilot Study II. Phase II was an autobiographical memory task, and Phase III was an incidental recognition task. In general, it was found that chronic pain and depression each exerted a unique biasing influence on each of the cognitive processes investigated in the three phases of the principal study. Results of the present project were discussed in terms of their theoretical and clinical implications.

## DEDICATION

This dissertation is dedicated to all of the subjects who participated in the project. In spite of pain, depression and inconvenience, they helped me. I hope that I may now begin to help them.

## Acknowledgements

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Table of Contents

## List of Tables

## List of Figures

# CHAPTER ONE

## Introduction

### Overview and Rationale

The present project is an investigation of the degree to which pain and depression influence cognitive processing in individuals with chronic pain. The specific cognitive processes to be examined here include attention, as represented by a modified Stroop task, and memory, as represented by an autobiographical memory task and a recognition memory task.

The research to be described here draws its inspiration from two sources: the recent recognition of psychological factors in pain, and research on specific cognitive processes in depression. First, recent developments in pain theory have explicitly recognized the role of psychological variance in the phenomenology and expression of pain (Melzack & Wall, 1988; Merskey and Spear, 1967a; Price, 1988; Sternbach, 1978). Consideration of the role of psychological factors has been especially fruitful in the study of chronic pain, where the experience of pain may persist long after the precipitating lesion has healed, or sometimes may exist in the absence of a physical lesion (e.g. Sternbach, 1989). In particular, the role of depression has been recognized as a clinically significant component of the chronic pain experience (Dworkin & Gitlin, 1991; Romano & Turner, 1985).

Although the relationship of chronic pain to psychological variance in general, and to depression in particular has been well described, there has been little empirical emphasis on the ways in which cognitive processes may be influenced by different components of the

chronic pain experience. Hence, the second source of inspiration for the present research lies in recent advances in the understanding of cognitive processes in depression, where multiple lines of research have generally converged in agreement that mood-relevant biases occur in depression at different stages of information processing, including attention, judgement, autobiographical memory, recall memory, and recognition memory (see Williams, Watts, MacLeod & Matthews, 1988 for a review).

The present project therefore represents an initial attempt to integrate the chronic pain and depression literatures. By adapting some of the theoretical and methodological approaches which have proven useful in understanding cognitive biases in depression, it is expected that a preliminary understanding will emerge of the relative contributions of emotion and pain to cognitive processing in chronic pain.

The introduction will proceed by reviewing the historical development of pain theory, with a particular emphasis on the contemporary understanding of multiple determinants of pain. Current research on the particular role of depression in chronic pain will then be considered. The rich literature on cognitive processes in depression will be reviewed, especially in the areas of attention, judgement, and memory. This will be contrasted with the relatively meagre literature on the same processes in chronic pain. Two pilot studies will then be presented. The first will provide evidence that depression and sensory pain are distinct components of the chronic pain experience, thus providing a rationale for the empirical separation of these components in subsequent studies. The second pilot study will utilize a modified

Stroop task to provide preliminary evidence that pain and depressed mood may each exert a unique biasing influence on attention in individuals suffering from chronic pain. The principal study will then be presented. This study represents a more rigorous investigation of the relative contribution of pain and depression to biases in attention, autobiographical memory, judgement, and recognition memory in chronic pain. Finally, the results of this project will be integrated with the current literature in a way which will suggest directions for future research.

## Historical Developments in Pain Theory

**Unidimensional Pain Theories.** Historically, pain has proven to be a difficult phenomenon to investigate empirically because its subjective nature defies ready quantification and communication. Until recently, theoretical formulations of the pain experience have largely been unidimensional in focus, either conceptualizing pain as a purely affective experience, or as a purely sensory experience (Craig, 1989). The first recognizable theory of pain was proposed by Aristotle, who considered pain an affect which was the obverse of pleasure. In this view, pain served a signal function, like other emotional states, so that the experience of pain was a cue to escape or remove the eliciting stimulus. Aristotle considered pain distinct from a sensory experience, because its qualities could not be referred from an external stimulus, unlike classical sensory experiences such as sight, or hearing, which clearly have their source in an external referent (Hardy, Wolff, & Goodell, 1952).

Apparently, pain continued to be seen as an affect until the 17th century, when sensory-specificity theories of pain began to predominate.

Descartes' dualistic theory of human experience can be seen as seminal in the development of sensory-specificity pain theory. In this view pain is reduced to a simple, linear sensory nerve transmission from the skin surface to the brain. For Descartes, only higher-order cognitive functions such as reason were distinct from these mechanistic principles (Heidbreder, 1933). In 1842 Johannes Muller published his "doctrine of specific nerve energies" which provided physiological support for the notion that all sensations, including pain, could be understood as electrical-conduction phenomena which were decoded by localized brain tracts. In the late 19th century, a physician named Max Von Frey expanded the cutaneous sensation into four characteristics: touch, cold, warmth, and pain, each with a modality-specific cutaneous receptor for which physiological evidence had been found (Boring, 1942). With the advent of rapid increases in medical knowledge in the 20th century, chemical and surgical methods of pain control began to emerge which were dramatically more effective than anything than had been available previously. These developments continued to lend credence to the view that pain was a unidimensional sensory experience (Craig, 1989).

Multidimensional Pain Theories. In spite of the generalized historical ascendancy of sensory-specificity pain theories, there have been several instances of early writers who have suggested that an adequate explanation of the pain experience requires equal consideration of both sensory and affective factors. For instance, Marshall (1894) proposed that affective and sensory systems operate in parallel during painful stimulation. Similarly, Strong (1895) recognized that negative affect is an inseparable consequence of pain. By the mid twentieth century, it was becoming apparent that sensory-specificity theories

could not provide a complete explanation for certain pain-related phenomena, such as: a) the highly variable relationship between extent of injury and intensity of pain, b) the observation that innocuous stimuli can sometimes provoke intense pain, c) the lack of relationship between the location of an injury and the location of pain, and d) the presence of chronic pain for which no anatomical basis can be found (Melzack & Wall, 1988).

To account for these apparently anomalous phenomena, multidimensional theories of pain have recently begun to emerge. A number of such theories have been proposed, all of which share the general assumption that psychological and physiological factors must interact in order to provide a complete account of all pain-related phenomena. Perhaps the most influential of these theories has been the gate-control theory, first proposed by Melzack and Wall in 1965, and elaborated in subsequent publications (Melzack & Casey, 1968; Melzack & Torgerson, 1971; Melzack & Wall, 1988; Wall, 1978). The gate-control theory proposes that nociceptive input may be controlled by a "gating" mechanism involving presynaptic as well as postsynaptic inhibition in the dorsal horn substantia gelatinosa of the spinal cord. After passing through this gating mechanism, painful stimulation is projected on to a sensory-discriminative channel and a motivational-affective channel. These channels are assumed to operate in parallel, and may be interactively influenced by higher-order central nervous system processes, which allow for cognitive processing and evaluation of the pain experience.

Price (1988) has also proposed a multidimensional theory of pain which recognizes a sensory-discriminative system, an affective-

motivational system, and a cognitive-evaluative system. Price argues that the affective-motivational and cognitive-evaluative systems are intimately related and pertain to the meanings which are derived from a painful sensation. These meanings are then influential in determining the level of motivation and the intensity of affect which an individual experiences in attempting to avoid pain-relevant harm. In Price's words:

> This three-component explanation of pain does not exclude either the sensory or affective dimension of pain, as has been done previously. It explicitly recognizes that pain sensation, arousal, meanings, and emotional responses exist simultaneously and moment-by-moment as an integrated experience. Thus, there is no reaction to pain....the various dimensions of pain have interdependent relationships (1988, pp. 5-6)

Leventhal and his colleagues have proposed a similar theory to account for the involvement of psychological factors in general physical disturbance, including pain (Leventhal & Everhart, 1979; Leventhal, Meyer, & Nerenz, 1980; Leventhal & Nerenz, 1982; Leventhal, Nerenz & Steele, 1984). In developing this model, Leventhal has posited several assumptions which bear on the present thesis. First, painful stimulation is processed along two separate but parallel channels, one focused on objective information (including the sensory aspects of symptoms, and information regarding potential harmfulness of symptoms), and the other focused on affective information. Second, sensory and emotional information is processed simultaneously, rather than consecutively. However, these two channels interact with each other at

different stages of information processing. This raises the third assumption, namely that discrete stages occur in the processing of illness-relevant information. Leventhal, Nerenz and Steele (1984) have identified five stages of processing, the first two of which are assumed to operate at the preconscious level, and the latter three which are conscious. These stages include: a) perception of the stimulus (i.e. symptom); b) integration of the perception with memory traces of related concepts; c) awareness of the symptom; d) coping with the symptom, which includes both planning and executing a response; and e) evaluation of the coping response.

These three theories are probably best seen as generalised, overarching, heuristic models. As such, they are not specifically testable. Instead, they can serve to provide direction to research and to suggest specific, testable hypotheses. However, it may be constructive to consider both areas of overlap between these positions, as well as individual, testable components within each model as a way of developing the general thesis that cognitive processing plays a significant role in chronic pain. For example, all of the models outlined above agree with the notion that pain is a multidimensional phenomenon, comprising at the least two general components, namely sensory and affective information. There is, however, some disagreement about whether affective and evaluative factors are to be considered separately, or whether they are inseparably dependent. According to gate-control theory (Melzack & Wall, 1965), the evaluative function is determined by central control processes which allocate cognitive resources. Price (1988) sees the affective-motivational systems as distinct, but interdependent. Leventhal and Everhart (1979)

propose that physiological input is simultaneously processed along a sensory and an affective channel. Similarly, Brennan, Barett, and Garretson (1987) found that the affective and evaluative dimensions of the McGill Pain Questionnaire were not effectively separable in assessing psychologically-distressed chronic pain patients. However, the sensory and affective/evaluative dimensions were found to be clearly distinct. Perhaps the most compelling arguments regarding this issue have been forwarded by Fernandez and Turk (1992) who reviewed studies of pain evaluation which used multivariate statistical analyses, signal detection analysis, and paired scaling methods. In their review, Fernandez and Turk (1992) found substantial evidence for the separation of pain into sensory and affective dimensions, but little consistent evidence for the evaluative dimension. Fernandez and Turk (1992) also noted that, although the sensory and affective components of pain are distinct, they are also highly interdependent. However, based on the extant information in this area, the present thesis will investigate sensory and affective dimensions of pain, since they appear to be the most reliably distinguished factors. The evaluative dimension of pain will not be considered, as the evidence for its validity appears more equivocal.

Leventhal's model is particularly useful in its recognition of the different stages of information processing which can affect the experience and expression of physical symptoms. For example, the supposition that perception of symptoms can occur at a preconscious level suggests that cognitive tasks which are thought to assess automatic processing, such as the Stroop task (see Williams, Watts, MacLeod, & Matthews 1988 for a review), may be profitably utilized to

assess the direction of cognitive processing in those suffering from physical symptoms. Leventhal's theory also suggests that at a preconscious level, symptom perception is integrated with existing memory networks prior to engaging in appraisal processes. This notion is consistent with Bowers's (1981) network theory of human memory. This theory, which is discussed in more detail below, was developed to account for the effect of mood on memory, such that mood is represented as a memory node which activates a network of related concepts. It seems reasonable to extend this theory to the area of physical symptoms, and hypothesize that perception of physical symptoms may also activate a network of related concepts. As such, it is possible that tasks such as the autobiographical memory task, which have typically been used to assess the influence of depression on memory networks, could also be used to assess the influence of pain on memory networks. These issues will be expanded below.

Chronic Pain as an Exemplar of Multidimensional Pain Theory. As discussed above, chronic pain which persists either after an injury has healed or in the absence of discernible physical injury has been one of the pain-related phenomena which have suggested that pain is not a unitary sensory experience. A theory which proposes that extent of injury and intensity of pain are isomorphic provides no rationale for explaining the persistence of pain in the absence of injury. It is in the case of chronic pain that it is perhaps most evident that multiple determinants must be considered in providing a complete explanation of the phenomenon. Recently, Flor, Birbaumer and Turk (1990) have developed a comprehensive model of chronic pain which proposes that chronic pain is a function of four elements, namely a) a physiological

diathesis; b) precipitating aversive stimuli, including internal and/or external factors; c) precipitating responses, which would include maladaptive information-processing and affective reactions; and d) maintaining responses, which would encompass social, respondent, and operant learning factors.

It is with the third of these elements that the present thesis is concerned. If the experience of chronic pain is, in part a function of biased information-processing, it would be important to examine the particular determinants of this phenomenon, as well as the areas of cognitive processing affected by chronic pain. In considering the potential determinants of information-processing biases in chronic pain, one would predict that both affect and sensation would play a role, based on the multidimensional theories of pain outlined above. Depression is the most likely affect to be considered in research on cognitive processes in chronic pain, since much previous research suggests that depression may be a significant component of chronic pain (e.g. Romano & Turner, 1985).

In considering the areas of cognitive processing likely to be affected by chronic pain, one must consider the literature on cognitive research on depression. A recent comprehensive review of the literature on cognitive processes in the affective disorders by Williams et al. (1988) demonstrated consistent effects of depression on specific stages of information-processing, including attention, long-term memory, and short-term memory. Thus it will be these stages that will be examined in the present thesis in relation to chronic pain and depression.

As a way of providing a rationale for examining depression-related effects in chronic pain, the following sections will therefore examine major findings regarding the role of depression in chronic pain, as well as the effect of depression per se on information-processing biases.

## The Role of Depression in Chronic Pain

Depression appears to be the predominant negative affect associated with chronic pain. Although some writers have noted the presence of anxiety in chronic pain (Large, 1980; Merskey & Boyd, 1978; Sternbach, 1976), recent analyses have suggested that such anxiety symptoms may represent a component of a depressive subtype, rather than a discrete entity in itself (Garron & Leavitt, 1983; Krishnan et al., 1985).

The Incidence of Depression in Chronic Pain. Although depression is a relatively common experience in chronic pain, its true incidence has not yet been confirmed. Many of the studies that have been published thus far have methodological weaknesses and inconsistencies which prevent strong inferences regarding the rate and level of depression among chronic pain populations. However, given allowances for the methodological problems associated with previous studies, it remains likely that a significant proportion of chronic pain patients suffer from depression.

Gupta (1986) reviewed the extant literature on chronic pain and depression and pointed out weaknesses in nosology, in sampling methodologies, and in demographics. Between 1963 and 1982, the incidence of depression among the studies which he reviewed ranged from 100% to 10%; however, among these studies, depression was variously diagnosed by clinical impression, by psychiatric diagnostic criteria,

and by questionnaire. Romano and Turner (1985) reviewed a similar body of literature, and found a similar range in the reported rate of depression among chronic pain samples. Romano and Turner (1985) noted that only two studies could be located to that date which utilized DSM-III criteria or Research Diagnostic Criteria to diagnose depression. One of these two studies reported that 25% of a sample of chronic pain patients were suffering from a major depressive episode, while the other reported a rate of unspecified depression of 87%. In agreement with Gupta (1986), Romano and Turner (1985) noted problems in assessment of pain and depression, in selection of patient samples, in the use of control groups, and in development of theoretical models which could account for the relationship between chronic pain and depression. They pointed out that although depression is often seen conjointly with chronic pain, because of methodological problems it cannot be concluded that depression is more common in chronic pain than in other chronic conditions or in the general population. Romano and Turner (1985) also argued that depression is probably not a monolithic phenomenon in chronic pain, but instead is likely to develop via a number of etiological pathways and time lines.

Recently Dworkin and Gitlin (1991) presented a summary of 28 contemporary studies which used more rigorous DSM-III or DSM-III-R criteria for diagnosing depression in chronic pain. Among these studies, the incidence of current major depressive episode ranged from 1.5% to 57.1%. The studies reviewed by Dworkin and Gitlin (1991) encompassed a heterogeneous population of pain patients, and included samples from inpatient neurosurgery, outpatient psychiatry, rheumatology, inpatient and outpatient pain programs, and a laparoscopy

clinic. Unfortunately, Dworkin and Gitlin (1991) did not comment on potential methodological problems among these studies, so it is difficult to determine whether these figures represent a true picture of the incidence of depression in chronic pain.

Perhaps the most accurate representation of the incidence of chronic pain and depression in the general population has been presented recently by Magni, Caldieron, Rigatti-Luchini and Merskey (1990). This group analyzed data collected between 1971 and 1975 for the first National Health and Nutrition Survey, wherein 3023 American subjects between 25 and 74 provided information on a number of health variables. From these data it was determined that 14.4% of the population suffered from chronic musculoskeletal pain. Of the chronic pain group, 18% suffered from probable depression, using a conservative cutoff score on the Centre for Epidemiologic Studies Depression Scale. Among the general population, 8% were found to be depressed, thus suggesting that the incidence of depression among chronic pain sufferers is likely to be higher than that found in the general population.

Although a number of serious methodological problems can be found in the extant descriptive research concerning the relationship between chronic pain and depression (Gupta, 1986; Romano and Turner, 1985), some inferences can be drawn from the research reported above. First, it is likely that depressed mood is an important component of chronic pain. Second, it is somewhat less clear whether diagnosable major depression is common in chronic pain, although the studies presented by Dworkin and Gitlin (1991) suggest that major depression is likely to be found among some chronic pain populations. Third, it appears that the rate of depression is probably higher among chronic pain patients than in the

general population (Magni et al., 1990), although it is not apparent that depression is more prevalent in chronic pain than in other chronic medical conditions (Romano & Turner, 1985).

Theoretical Accounts of the Chronic Pain-Depression Relationship. Because depression is a frequent concomitant of chronic pain, a number of theories have been put forward to account for the relationship. Perhaps the earliest identifiable theory was outlined by Freud (1955), who considered chronic pain in the absence of identifiable organic pathology to be a conversion reaction, wherein an individual may defend against emotional conflict by converting affect to somatic pain. In this view, the choice of pain location and intensity can be related to the precipitating psychological trauma, and therefore can symbolically represent the trauma. The thesis that chronic pain is a defense against unconscious depressive conflict has been most recently reiterated by Blumer & Heilbron (1982), who suggested that a "pain-prone disorder" should be nosologically subsumed under the category of general depressive disorders. They based this claim on examination of a select group of chronic pain patients who demonstrated evidence of neurovegetative symptoms of depression. However, this thesis has been convincingly challenged on methodological, empirical, and theoretical grounds (Romano & Turner, 1985; Tauschke, Merskey, & Helmes, 1990; Turk & Salovey, 1984).

Recent research on the central nervous system biochemistry of depression has encouraged some researchers to suggest that both depression and chronic pain may share a common physiological basis. It is well documented that serotonin is implicated in depression (DeLeon-Jones, 1982; Goodwin, Cowdry & Webster, 1978). It is also known that

when serotonin is depleted, there is a decrease in NREM sleep and an increase in somatic complaints and perceived pain (Moldofsky, 1982; Schakel & Horne, 1987). Another line of support for the biochemical hypothesis has been obtained from drug trials which have shown that tricyclic compounds are effective in ameliorating some chronic pain symptoms (Carette, McCain, Bell & Fam, 1986; Caruso et al., 1987; Hameroff et al., 1982; Pilowsky, Hallet, Bassett, Thomas & Penhall, 1982). In spite of the theoretical coherence of the biochemical hypothesis, some serious threats to its validity exist. Many of the studies have been methodologically flawed (Romano & Turner, 1985), and although it has been hypothesized that tricyclics exert their analgesic effects by blocking the re-uptake of serotonin at the synaptic cleft (Goldenberg, Felson & Dinerman, 1986) the mode of action of tricyclic compounds continues to remain unproven (Boissevain & McCain, 1991; Merskey, 1989).

Several cognitive-behavioural models of depression have been recently proposed to account for the relationship between chronic pain and depression. Like the biochemical model discussed above, cognitive-behavioural models draw their inspiration from the clinical success of cognitive-behavioural treatment of depression and chronic pain. From a behavioural perspective Fordyce (1976) has probably been the most influential chronic pain researcher. He has argued that depression in chronic pain is due to a loss in positive reinforcers. Although Fordyce's model is quite persuasive, it has not specifically acknowledged the existence or potential importance of cognitive processes in the chronic pain-depression relationship.

Perhaps in response to the explanatory and practical limitations

inherent in operant models of chronic pain, several researchers have begun to note the additional role of cognitive factors in the relationship between chronic pain and depression. This trend has been especially noticeable in the application of cognitive therapy to the treatment of chronic pain (Holzman, Turk & Kerns 1986; Miller, 1991; Tunks, Bellissimo & Roy, 1990; Turk, Meichenbaum & Genest, 1983). The cognitive-behavioural transaction model developed by Turk and his colleagues (Holzman et al., 1986; Turk et al., 1983; Turk & Rudy, 1986) has been especially influential in promoting psychological treatment approaches to chronic pain. In this view, chronic pain is a function of the reciprocal effects of sensory, cognitive, affective, and behavioural factors. Because this model assumes that chronic pain is likely to be exacerbated by dysfunctional cognitive strategies, Turk et al. (1983) have proposed a four-stage treatment program which includes a) assessment, reconceptualization, and education, b) functional skills acquisition; c) rehearsal and application; and d) maintenance and follow-through. Research has demonstrated that cognitive-behavioural approaches represent an effective means of treating chronic pain (see Keefe & Williams, 1989 for a review).

It has been widely acknowledged that cognitive approaches to chronic pain have been informed by the cognitive theory of depression developed by Beck (Beck, 1967; Beck, 1976; Beck, Rush, Shaw & Emery, 1979). Drawing from Beck's theory, several writers have suggested that cognitive distortions and biases in information-processing may be implicated in the relationship between chronic pain and depression (e.g. Ciccone & Grzesiak, 1984; Romano & Turner, 1985; Turk & Rudy, 1986; Flor, Birbaumer & Turk, 1990). Ingram et al. (1990) have published a

study which is particularly supportive of the notion that chronic pain is associated with cognitive distortion. In this study, 20 depressed and 20 nondepressed chronic pain patients were contrasted with 20 normal controls on their responses to both the negative Automatic Thoughts Questionnaire (ATQ: Hollon & Kendall, 1980), and the Positive Automatic Thoughts Questionnaire (ATQ-P: Ingram & Wisnicki, 1988). It was found that the nondepressed pain patients and the normal controls were indistinguishable on their responses to the negative ATQ, but that the depressed chronic pain patients reported significantly more negative automatic thoughts than the other two groups. On the ATQ-P, the three groups differed significantly, with the nondepressed pain patients reporting the highest number of positive automatic thoughts, followed by the normals, and the depressed pain patients, respectively. Ingram et al. (1990) interpreted these results as suggesting that depressed chronic pain patients have a negative cognitive bias. They also speculated that the increase in positive cognition manifested by the nondepressed chronic pain patients represents a cognitive coping mechanism which may serve to insulate individuals from the distress associated with chronic pain. Ingram et al. (1990) argued that these results provide support for the general notion that cognitive biases are implicated in the experience of chronic pain, and therefore that cognitive-behavioural interventions are likely to be useful with such patients.

The results of the Ingram et al. (1990) study suggest that depressed chronic pain patients may be similar to depressed nonpain subjects. However, both their choice of dependent variables and the absence of a depressed nonpain group prevent their results from shedding

light on the ways in which cognitive biases in chronic pain may be uniquely different from depression. In this sense, it appears that little research has yet been conducted on information-processing effects in chronic pain. Some of the issues which are yet to be explored in this area include: a) the boundaries of information-processing biases in chronic pain; b) the role of depression in such biases; c) the areas of cognition in which such biases may operate (e.g. attention, memory, judgement, etc.); and d) the ways in which cognitive biases in pain-related depression may be compared with biases in depression alone. As an introduction to this general topic, the following section will selectively review relevant research on cognitive aspects of depression. This will be followed by a review of the relatively small literature on cognitive biases in chronic pain.

## Cognitive Biases in Depression

In an influential summary of the extant literature regarding information-processing in affective disorders, Williams et al. (1988) examined the effects of mood on different stages of processing. In general, Williams et al. (1988) have noted that mood appears to exert a selective influence on cognitive processes, so that individuals who suffer from affective dysfunction may find that they notice mood-relevant stimuli in the environment, that their memory is biased in a way that enhances recognition and recall of mood-relevant materials, or that they judge harmless or ambiguous stimuli to be threatening. These phenomena may be seen as specific cases of general selective attention issues noted by other researchers (e.g. Broadbent, 1982, Johnston & Dark, 1986). Each of these cognitive stages will be examined individually.

Depression and Attention. Various modifications of the Stroop test have been one of the most consistently utilized task in investigations of attentional processes in affective disturbance. In its classic form (Stroop 1935, 1938), the subject is presented with three cards: a word card on which colour names were printed in black ink; a colour card, on which geometrical figures (typically Xs or Os) are printed in different ink colours; and a colour-word card, in which the names of colours are printed in incongruous colours. The invariable result with this test is that colour naming speed is significantly retarded for the colour-word card in comparison to the other two (Jensen & Rohwer, 1966). A number of theoretical explanations have been proffered to account for this phenomenon, including strength of semantic association to colours (Proctor, 1978) response competition (Reisberg, Baron, & Kelmler, 1980) and conceptual encoding delays (Seymour, 1977). However, as a recent review has pointed out (Macleod, 1991), while no one comprehensive theory has yet emerged which is capable of accounting for the Stroop interference effect, the most likely explanatory candidate is one which acknowledges that interference is due to the relative strength of word and colour associations when these different associative pathways are activated. In this model, the strength of interference effects may be modulated by attention, which may be selectively deployed at the intersections of colour and semantic associative pathways. Hence, in the view of MacLeod (1991), the Stroop effect is the combined result of attentional bias and associative memory networks.

Although the Stroop test has been widely applied in the study of basic cognitive processes and abilities (Jensen & Rohwer, 1966; MacLeod,

1991), more recently it has been applied in the investigation of cognitive processes in affective states. The paradigm in the affective studies is similar to the classic form of the Stroop test, in that subjects are asked to name the colours in which a series of words are printed, and to attempt to ignore the semantic content of the word. However, the test is modified so that in one of the conditions subjects are asked to name the ink colour of words which are salient to the affective state in question. The research on state-specific Stroop effects was initiated by Geller and Shaver (1976) who demonstrated that a self-focus manipulation produced a significant interference effect in the colour naming of self-relevant words.

Emotional Stroop effects have been investigated by Gotlib and his colleagues, who have generally found that depressed mood exerts an interference effect on the colour naming of depression-related words. In 1984 Gotlib and McCann observed that mildly depressed university students demonstrated an interference effect on depression-related words relative to nondepressed students. They also found that this interference effect could not be replicated by a mood induction procedure, thus suggesting that the effect may be due to stable depressive schemata, rather than to transient mood. However, Gotlib and Cane (1987) have subsequently obtained results which contradicted the schema hypothesis. In a longitudinal investigation with clinically depressed psychiatric patients they found that the interference effect could only be demonstrated at the time that patients were depressed. When the previously-depressed patients had recovered, they demonstrated the same response pattern as never-depressed individuals. Other researchers have obtained results which have expanded upon those

reported by Gotlib and his colleagues. For instance, Williams and Nulty (1986) found that previous depression was associated with a mood-congruent interference effect, so that this interference effect was strongest for subjects who were depressed at both testing occasions, and weakest for subjects who were nondepressed at both testing occasions. Subjects who were depressed at time 1, but nondepressed at time 2 showed an intermediate level of interference, thus suggesting that at least some attentional variance may have been influenced by a relatively durable schema. Recently Kleiger and Cordner (1990) found that the strongest mood-congruent interference effect was shown by subjects who were mildly dysphoric. Subjects who were moderately dysphoric showed a less marked interference effect.

Although the results reported above appear persuasive, the validity of depression-related Stroop effects has been controversial, largely because they do not appear to be restricted to depression. For example, state-relevant interference effects have been demonstrated in test anxiety (Ray, 1979), in social and physical anxiety (Matthews & MacLeod, 1985), in spider phobia (Watts, McKenna, Sharrock, and Tresize, 1986), in suicide attempts (Williams & Broadbent, 1986b), in emotional repressiveness (Dawkins & Furnham, 1989), and in health concerns (Cook, Jones, & Johnston, 1989). These conflicting results have led Williams et al. (1988) to suggest that attentional interference, as represented by the Stroop task, is a phenomenon related to anxiety, rather than to depression per se. Apparent corroboration of this hypothesis has recently been obtained by Hill and Knowles (1991) who found that depression-related Stroop interference effects disappeared when the variance contributed by state and trait anxiety scores was partialled

out of the analysis. Although this is a provocative thesis, a number of potential confounds militate against outright dismissal of depression-related Stroop effects. First, as pointed out by MacLeod (1991), the Stroop task may not tap attentionally-based encoding per se. Rather, it may represent the interactive influence of attention and semantic memory. Second, in many of the studies which have been conducted thus far little effort has been made to ensure the validity of stimulus-selection procedures, thus leading to questions about whether the test stimuli actually tap state-specific content. Third, in many cases, assignment of subjects has been based on psychometric, rather than interview-based diagnostic considerations. To ensure that such confounds are minimized in the present research, these concerns will be specifically addressed in the design of the principal studies.

Depression and Autobiographical Memory. Williams et al. (1988) have noted that depression-related cognitive biases appear to be most reliably obtained in tests of effortful memory processes. The theoretical account which is most widely invoked to explain the effect of mood on memory is the Human Associative Memory Network model developed by Bower and his colleagues (Anderson & Bower, 1978 Bower, 1981; Bower, 1987). According to this model, memories are arranged hierarchically within semantic networks, with each event comprised of a cluster of descriptive propositions, or memory nodes, connected by associative pathways. When one instance of a concept is activated, the entire conceptual network may become activated through association with the activating exemplar. In this model, emotions may occupy the status of unique nodes, with each emotion allocated to a specific location within the associative network. This implies that when joy, fear,

sadness, or anger are experienced they can facilitate the retrieval of memorial material specific to each emotion. As reviewed by Bower (1987), the evidence thus far has been generally supportive of the network model. Mood-dependent memory effects have been widely observed, but they appear to be most clear-cut in the case of clinically depressed subjects, rather than in situations where mood has been induced.

A number of depression-congruent memory effects have been observed (see Blaney, 1986 for a review). However, because it is beyond the scope of the present project to review this entire literature, the present thesis will focus only on autobiographical memory and recognition memory. Although these two outcome variables comprise only a fraction of the research conducted on depression and memory, each may be seen as representative of one the two main stages of cognitive storage, so that research on recognition memory can be seen as exemplifying shorter-term memory effects, whereas research on autobiographical memory exemplifies relatively long-term memory effects.

Researchers have generally adopted one of two paradigms in examining the effect of mood on autobiographical memory. The first paradigm may be referred to as a probability model, in which memories are cued by neutral words and the dependent measure is the proportion of negative versus positive memories retrieved. The expected outcome using this methodology is that depressives will have a higher probability of recalling negative memories to neutral cues. The second paradigm is a reaction-time model in which memories are cued by positive and negative words, and the dependent measure is the time taken to retrieve memories for each word type. With this methodology, it is expected that depressives would take longer to retrieve memories to positive cues and

less time to retrieve memories to negative cues in comparison to nondepressed subjects.

Research on autobiographical memory on depression was initiated by Lloyd and Lishman (1975) who demonstrated that when cued by neutral words and asked to retrieve either positive or negative memories, depressed patients retrieved negative personal memories more quickly than positive memories. In this study, however, the memories which subjects retrieved were not recorded, so as Williams et al. (1988) have pointed out, it was not possible to determine whether patients may have interpreted neutral experiences as depressing, or whether the memories were actually negative. This study also failed to control for the possibility that depressed patients may actually have had more genuinely depressing experiences than nondepressed subjects. These confounds have subsequently been controlled in a series of probability studies conducted by Teasdale and his colleagues. Using a within-subjects design, this group has found that the temporary induction of happy and depressed moods in normal volunteers resulted in mood-memory interactions. Specifically, it has been found that induction of depressed mood results in faster recall times for negative memories (Teasdale & Fogarty, 1979) and the increased probability of recalling of negative memories, as rated by the subjects when in a neutral mood (Teasdale, Taylor, & Fogarty, 1980). Conversely, these studies also found that induction of a happy mood results in faster recall times for positive memories, and the increased likelihood of recalling positive memories. Since random assignment presumably controlled for pre-induction levels in depressed mood, this research demonstrates that biased recall is a function of mood, rather than experience. Further,

since ratings of memories were conducted when subjects were in a nondepressed state, this research also demonstrates that the recalled memories were actually negative, rather than simply misinterpreted in a negative direction. Subsequent research has demonstrated the generality of these findings across different mood-induction methodologies (Teasdale & Taylor, 1981), and within a sample of clinically-depressed subjects (Clark & Teasdale, 1982). Teasdale and his colleagues have noted that their findings are consistent with Bowers's (1981) network theory of human memory, wherein mood is represented as a memory node which activates a network of related concepts. Drawing on network theory, one would clearly predict that the activation of a particular mood would increase the accessibility of mood-relevant material. Clark and Teasdale (1982) have also pointed out that their findings offer support for Beck's (1967, 1976) cognitive theory of depression, so that the increased accessibility of negative memories in depression is likely to lead to rumination on past negative experiences, negative interpretations of current experiences, and negative predictions about the future.

More recently Williams and his colleagues have extensively investigated autobiographical memory phenomena in clinical populations using reaction-time methodology. Investigating a group of recent suicide attempters, Williams and Broadbent (1986a) found that when compared to control groups of hospitalized patients and nonhospitalized normals, the suicide attempters showed no difference on latency to recall negatively-cued memories, but were significantly slower than the control groups in retrieval of positively-cued memories. Williams and Broadbent (1986a) also found that more of the memories retrieved by the

suicide group were general, rather than time- or location-specific. In the Williams and Broadbent (1986a) study subjects were requested to provide a specific autobiographical memory to each cue word. A subject's response was coded as general if they were unable to give specific details of a date, day of the week, or time of day when an event occurred. Examples of specific responses would be: "last Tuesday...", or "during the summer when I was 16...". Examples of general responses would be "when I was in school...", or "I always seem to...". Using this coding scheme, interrater reliabilities have been found to range between 0.87, and 0.93 (Williams & Dritschel, 1988).

Later, Williams and Dritschel (1988) were able to demonstrate that the phenomenon of state-specific memory generality continued to persist among recovered subjects who had been suicidal between 3 and 14 months prior to testing, thus suggesting the presence of a relatively durable cognitive style in the retrieval of personal memories. These results have also been replicated on a more clearly depressed sample by Williams and Scott (1988). In this study it was found that in comparison to nonhospitalized normals, depressives took significantly more time to retrieve positive memories and significantly less time to retrieve negative memories. In agreement with previous studies, depressives also provided more general responses than the control group. A group X valence interaction was also obtained, with depressives providing more specific negative than positive memories, while controls provided more specific positive than negative memories.

Williams and his colleagues have suggested that the generality effect may be due to deficits at both the encoding stage and the retrieval stage. Williams and Dritschel (1988) have proposed that

individuals prone to emotional disturbance may be hyperalert to emotional cues in the environment, and therefore use these cues as a strategy for encoding memories. Williams and Dritschel have proposed that such an emotionally-based encoding strategy is likely to lead to more general memories than an encoding strategy based on structural environmental cues. They reason that this is because emotional cues such as another person's perceived praise or criticism are more likely to be categorized as members of a series of similar stimuli, and will therefore be less discriminable from each other than memories which are based on factual detail, and thus presumably possess a greater number of unique features. On the other hand, Williams & Scott (1988) have suggested that at the retrieval stage individuals suffering from depression may also have a motivational deficit which prevents them from conducting a thorough search of memory traces, and thus may only reach a relatively superficial level when attempting to retrieve a personal memory. This superficial level of memory may not contain enough structural detail to allow specification of time or location of the memory.

Recently Richards and Whittaker (1990) have adapted the reaction-time methodology for the examination of autobiographical memory processes in anxiety. They found no differences between groups on memory generality, thus suggesting that this phenomenon may be specific to depression. Through multiple regression analyses, Richards and Whittaker (1990) also demonstrated that depression is related to an increased latency for positive memories, whereas anxiety is related to a reduced latency for anxiety-related memories.

Taken together, the research conducted by the Teasdale group and the Williams group suggests that depression does exert an effect on long-term autobiographical memory. Depressed subjects consistently demonstrate a greater propensity than nondepressed subjects to retrieve negative memories to neutral cues, regardless of whether the depressed mood is induced (Teasdale, Taylor & Fogarty, 1980) or clinical (Clark & Teasdale, 1982). It has also been found that depression is related to an increased retrieval latency for positively-cued memories (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Richards and Whittaker, 1990), and possibly to a reduced retrieval latency for negatively-cued memories (Williams & Scott, 1988). Finally, it has been consistently observed that depressed mood is associated with an overall tendency to recall general, rather than specific memories (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Williams & Scott, 1988), although the evidence for a mood-specific generality effect has thus far been equivocal. In summary, it appears that depression has a clearly biasing effect on autobiographical memory. The following section will examine the impact of depression on recognition memory.

Depression and Recognition Memory. Although depressives have shown mood-specific memory biases on recognition tasks, they tend to show more impairment on free recall than on recognition memory (Calev & Irwin, 1985). Typically, free recall tasks require subjects to recall as many previously-presented stimuli as possible, without contextual cues. In contrast, a recognition task requires subjects to select previously-presented stimuli from an array of stimuli which includes both target and distractor stimuli. Williams et al. (1988) have attributed this difference to the relatively poor discriminatory power

of recognition tasks, as well as to the relative lack of effort required by recognition tasks. However, some studies have been published which suggest that other factors may influence recognition biases in depression. First, the emotional tone of the material to be recalled may affect recognition processes. For example, Dunbar and Lishman (1984) found that while there was no difference between depressed and nondepressed subjects on overall recognition rates, depressed subjects tended to recognize unpleasant material more readily than pleasant material. Conversely, nondepressed subjects tended to recognized pleasant material more readily than unpleasant material. Similarly, this study demonstrated that depressed subjects were also biased against recognizing nondepressive material.

Second, Matthews and Southall (1991) have demonstrated that mood-specific recognition memory may also be affected by prior elaboration of material. In their study, depressed and nondepressed subjects were exposed to a semantic priming task prior to being tested for recognition of previously presented primes. Matthews and Southall (1991) found that there was a trend for depressives to correctly recognize more negative words than did the nondepressed group. However, the depressed group had a significantly higher false positive rate (i.e. incorrect recognitions) for negative material, whereas the nondepressed group had a higher false positive rate for positive material. Matthews and Southall (1991) attributed the false-positive interaction to the effects of mood-congruent elaboration during the encoding stage of processing. This finding is in agreement with the suggestion made by Williams et al. (1988) that depression-congruent biases are most likely to be observed when cognitive effort is implicated in information-processing. A

similar finding was obtained by Watts, Morris and MacLeod (1987) who used neutral, rather than mood-congruent stimuli in their study. They found that when elaboration of stimuli was enhanced by vocal repetition of stimuli, depressives showed a higher rate of false alarms than nondepressives. When no vocal elaboration of stimuli took place, nondepressed subjects showed a higher false alarm rate than depressives.

A number of conclusions are suggested by the results of these studies. First, recognition accuracy is not likely to be affected by depression (Cole & Zarit, 1984; Davis & Unruh, 1980; Watts & Sharrock, 1987), rather, depression appears to exert a biasing effect on recognition such that previously unpresented stimuli are likely to be incorrectly identified (Matthews & Southall, 1991; Watts et al., 1987). Second, recognition biases may be more likely to emerge when material to be recognized is mood-congruent (Dunbar & Lishman, 1984; Matthews & Southall, 1991). Finally, recognition biases may depend upon the degree of effortful processing or prior elaboration performed upon the material to be recognized (Matthews & Southall, 1991; Watts et al., 1987).

Parenthetically, a brief discussion should be made of signal detection theory, and the potential role of signal detection analyses in detecting bias in recognition memory. Signal detection theory was developed as a way of understanding the strategies used by subjects in psychophysics experiments where the task involved a decision regarding the presence or absence of a weak visual or auditory signal against a background of "noise" (Green & Swets, 1966). However, applications of the theory have been expanded to include other paradigms where decisions are to be made regarding the presence or absence of a target stimulus (see MacMillan & Creelman, 1991 for a thorough discussion of this

approach). In signal detection analyses, two principle indices are utilized. The first index assesses sensitivity to previously encountered stimuli. This index is usually denoted by the symbol d', and is computed by taking into account both hits (correct recognitions) and false alarms (incorrect recognitions). The index of sensitivity can range from 0 to 4.65, with greater numbers representing greater sensitivity to previously-presented stimuli. For example, when there is perfect sensitivity to previously-presented stimuli, the proportion of hits would be 1.0, and the proportion of false alarms would be 0. In such an instance, d' would be about 4.65.

A second index commonly used in signal detection analysis is the index of response bias, or the tendency to consistently favour one type of stimulus over another, regardless of whether a specific stimulus has been previously encountered. Different indices of response bias have been used in previous research, usually denoted c, c', or beta. Although these indices use slightly different calculations, they all support similar conclusions. Like d', the calculation of c is based on both hits and misses. However, c can range from -2.33 to +2.33, with negative values emerging when the false alarm rate is higher than the hit rate, and positive values emerging when the hit rate is higher than the false alarm rate. Thus an incorrect bias toward a stimulus class will result in a low or negative value of c, because of the relative elevation in false alarms, or incorrect recognitions.

In terms of recognition memory research, therefore, if a bias is present for a particular class of stimulus, (depressive stimuli, for example), one would expect that the index of response bias, or c would be lower for depressive stimuli than for other stimulus types.

Similarly, if recognition memory is more accurate for a certain class of stimulus, one would find elevations of the sensitivity index, or *d'* for that stimulus type relative to other stimulus types. In the present project, the general assumption is that pain and depression will exert biasing influences on cognitive processing of state-relevant stimuli. Therefore, predictions regarding recognition memory will suggest that *c* will be low for state relevant stimuli, but that *d* will be relatively invariant across stimulus classes. These hypotheses will be outlined in more detail below.

## Cognitive Biases in Chronic Pain

The previous section has demonstrated that depression appears to be related to certain information-processing biases. More specifically, attentional biases have been found in depression, especially when the attentional process in question may be partially dependent on semantic memory, as in various modifications of the Stroop task (Gotlib & McCann, 1984; Gotlib & Cane, 1987; Klieger & Cordner, 1990; Williams & Nulty, 1986). Depression has also been clearly implicated in long-term memory processes, as exemplified by both probability and reaction-time versions of autobiographical memory tasks (Clark & Teasdale, 1982; Teasdale & Fogarty, 1979; Teasdale & Taylor, 1981; Williams & Broadbent, 1986a; Williams and Dritschel, 1988; Williams and Scott, 1988). Recognition memory may also be affected by depression, but such effects appear to be most likely to emerge in situations where mood-congruent material has undergone prior processing (Dunbar & Lishman, 1984; Matthews & Southall, 1991). Finally, depression appears to exert an influence on various judgement processes (Williams et al., 1988), although it has not

yet been demonstrated whether such an effect holds for judgement of ambiguous stimuli.

Because it has been theorized that affect is an integral component of pain in general, and because depression may be particularly prominent in the specific case of chronic pain, it appears reasonable to ask first, whether some of the depression-related biases discussed above may also be demonstrated in chronic pain, and second, if such biases emerge, to what degree might pain and depression differentially contribute to such biases. The present section will therefore review the extant literature on such processes in chronic pain as a prelude to providing a rationale for further research in this area.

Chronic Pain and Attention. To date, only one study has examined the effect of chronic pain on a modified Stroop task. Pearce and Morley (1989) developed a version of the Stroop task which utilized four conditions, namely a simple conflicting-colour task, a task utilizing negative emotion words, one using words drawn from the sensory subscale of the McGill Pain Questionnaire, and one using words drawn from the affective/evaluative subscale of the McGill Pain Questionnaire. Pearce and Morley (1989) administered these tasks to 16 patients recruited from a pain clinic and to 16 age and sex-matched nonpatient control subjects. Besides the Stroop task, subjects in this study also completed the McGill Pain Questionnaire and a short form of the Profile of Mood States (POMS), a scale which provides information on a number of affective states, including fatigue, tension, vigour, despondency, anger, and confusion. Results showed that the pain group was slower than the controls on the sensory and affective/evaluative conditions. This suggests that the pain group showed a state-specific attentional bias

toward the state-relevant stimuli. No between-group differences emerged on either the conflicting-colour task or the negative-emotion task. Although the POMS showed that the pain group was more fatigued, more tense, and less vigorous than the nonpain group, the groups were equivalent in terms of their despondency score, thus suggesting that the pain group may not have been more depressed than the control group.

Although this study is provocative in that it suggests that state-specific attentional biases may occur in chronic pain, it fails to address a number of important issues. First, and perhaps most significantly, Pearce and Morley (1989) did not directly assess the level of depression in their sample. Indeed, because there was no between-group difference on the POMS despondency subscale, it is possible that either the chronic pain group had a relatively low level of depressed mood or that the control group had a relatively high level of depressed mood. In either case, the design of the study makes it impossible to distinguish the relative contribution of mood and pain to attentional biases. Second, there is some question as to whether Pearce and Morley (1989) selected the most appropriate control group for their study. In order to control for the effect of exposure to the general medical environment, it has become accepted to recruit hospital employees as a control group for medical patients (Marbach, Schwartz, & Link, 1992). The basis for choosing a hospital-employee control group for a medical experimental group is that both groups are likely to be equivalent on such potentially confounding variables as familiarity with the medical environment and familiarity with medical terminology. Further, if the specific role of depression in chronic pain is of empirical interest, it would also have been worthwhile to include a

control group of individuals who suffered from depressed mood, but who did not experience pain. Finally, it is not clear whether Pearce and Morley's (1989) stimulus-selection procedures resulted in a valid sample from each verbal domain. Pearce and Morley (1989) did not report frequency-of-usage indices for their stimulus samples, nor did they select stimuli from a single grammatical category (i.e. nouns or verbs). These anomalies suggest that the tasks may not have been matched on a number of important characteristics. Based on these considerations, future attentional research in chronic pain should provide stricter controls on mood assessment, control group selection, and stimulus selection.

Chronic Pain and Memory. As in the case of chronic pain and attention, it appears that little research has been conducted to investigate the influence of chronic pain on memory. In a review of research on memory for pain, Erskine, Morley and Pearce (1990) found relatively little empirical literature available. Most research in the area has examined memory for pain intensity, rather than memory for pain-specific content, or biases in memory for pain-specific material. Overall Pearce et al. found that recall for pain intensity is moderately accurate, and that memory for acute pain is more accurate than memory for chronic pain. The following are examples of the research reviewed by Erskine et al. (1990). First, Eich, Reeves, Jaeger and Graff-Radford (1985) tested 25 myofascial pain patients and found that over a seven-day period, memory for previous numerical pain ratings was biased by the present intensity of pain, so that when patients were experiencing high levels of pain they tended to overestimate their previous levels of pain, and when subjects were experiencing low levels of pain, they

tended to underestimate previous pain levels. Second, similar results were obtained by Roche and Gijsbers (1986), who compared rheumatology patients with subjects who had undergone temporary ischaemic pain induction. In this case, pain ratings were assessed by the McGill Pain Questionnaire, a verbal pain measure. Roche and Gijsbers (1986) found that over a seven day period, pain scores on both the sensory and combined non-sensory subscales of the MPQ increased for the rheumatology group and decreased for the ischaemic group, again suggesting that the experience of pain can exert a biasing influence on memory for state-relevant material.

Although somewhat limited, the results of these two studies suggest that the influence of pain on state-specific memory may be similar to the influence of mood upon state-specific memory. Consistent with Bowers's (1981) network theory of human memory, both pain and mood may be represented as memory nodes which activate a network of related concepts. As in previous research on recognition memory and mood, one would clearly predict that the activation of a pain state would increase the accessibility of pain-relevant material, thus increasing the likelihood of false positives on a pain-relevant memory task (Dunbar & Lishman, 1984; Matthews & Southall, 1991; Watts et al., 1987). It is interesting to note that these results appear to be consistent across both numerical (Eich et al., 1985) and verbal pain ratings (Roche & Gijsbers, 1986). Although provocative, these results do not permit one to determine the relative contribution of mood and pain to memory biases, nor do they allow the examination of the influence of pain on autobiographical memory.

More recently, the results two studies by Pearce et al. (1990) suggest that pain may enhance the accuracy of short-term recall for state relevant stimuli. In the first study, 25 chronic pain patients and 25 nonpain controls were asked to learn auditorially presented sensory pain, negative, and neutral words. A significant interaction effect was observed. In comparison to controls, pain subjects had greater immediate recall for pain and negative words relative to neutral words. After a five minute delay, the pain subjects recalled more pain words than negative or neutral words. In the second study, normal subjects were subjected to either a painful stimulus (cold pressor test) or a non-painful stimulus (warm water bath), immediately following which they were asked to learn the same list of sensory pain, negative, and neutral words used in the first study. Subjects were then exposed to either a congruent sensory stimulus (i.e. cold-cold or warm-warm), or to an incongruent one (i.e. cold-warm or warm-cold) prior to being asked to recall the verbal stimuli. In this study, a state-congruity effect was not found. Instead evidence was found for a general state-dependent learning effect, since the overall recall accuracy of subjects was enhanced when the state was the same at encoding as at recall (i.e. either cold-cold or warm-warm). Taken together, Pearce et al. (1990) suggested that the results of their two studies suggest that state-specific enhancement of congruent stimuli "may be more related to the status of being a chronic pain patient than to the state of being in pain" (p. 187). This statement suggests that both the chronicity of pain and its attendant emotionality may be influential in selective memory processes. Unfortunately, the design of Pearce et al.'s first study did not permit the use of mood as a between-subjects variable,

thus preventing an investigation of the specific role of affect in cognitive processing in chronic pain. Finally, although Pearce et al. demonstrated that chronic pain appears to be related to enhanced recall for pain-relevant adjectives, their study did not permit assessment of potential biases in memory processes. However, it is important to acknowledge that this study does support the general notion that chronic pain exerts a directional influence in memory.

Chronic Pain and Autobiographical Memory. To date, only one study has been conducted on the role of pain in autobiographical memory. Eich, Rachman and Lopatka (1990) adapted Teasdale's probability model of autobiographical memory (e.g. Clark & Teasdale, 1983) for use with 25 female undergraduates who suffered from recurrent menstrual pain. Ratings of pain and mood were obtained by 100 mm visual analogue scales. In this study, subjects' personal memories were cued with neutral stimuli on two occasions: once when they were suffering from pain, and once when they were pain-free. It was found that subjects were more likely to retrieve negative memories when pain was present and more likely to retrieve positive memories when pain was absent. Multiple regression analyses revealed that negative affect contributed most of the variance to memory unpleasantness, thus leading Eich et al. (1990) to conclude that autobiographical memory in pain is wholly mediated by mood, rather than by pain per se.

Again this result is interesting, but it leaves several important questions unanswered. First, the subjects in this study suffered from intermittent, rather than chronic pain. This may have caused the pain component of their experience to be less influential than mood in biasing the autobiographical memory process. In contrast, pain may

assume greater significance for individuals whose pain is unremitting. Second, the mood which was assessed by Eich et al. (1990) was likely to be less severe than the depression which is reported among chronic pain sufferers, again suggesting that this design might have constituted a relatively weak test of the effect of pain-relevant mood on autobiographical memory. Finally, the probability model of autobiographical memory does not permit the investigation of memory generality as reported by Williams (Williams & Broadbent, 1986a; Williams and Dritschel, 1988; Williams and Scott, 1988), which may be a potentially useful variable to consider in chronic pain.

In considering the potential influence of chronic pain on autobiographical memory, it may be instructive to recall Williams's theoretical explanation for the phenomenon of memory generality in emotionally-disturbed subjects (Williams & Dritschel, 1988; Williams & Scott, 1988). This group suggested that autobiographical memory generality may be due to deficits at both the encoding and retrieval stage. At the encoding stage it was proposed that depressives' memory traces may be laid down according to emotional, rather than factual cues, thus leading to relative indiscriminability between memories. At the retrieval stage, it was suggested that depressives may lack sufficient energy or motivation to conduct a thorough search of the memory store, thus leading to relatively superficial memory descriptions. How may this theory be applied to autobiographical memory in chronic pain? First, it is likely that depressed chronic pain patients will show a pattern of memory generality which is similar to that shown by depressives. This would be so because depression is likely to be related to encoding and retrieval deficits irrespective of

the presence of chronic pain. Second, it is possible that among those subjects who experience pain without depression, the deficit will only operate at the retrieval level. There is no reason to predict that nondepressed chronic pain patients will use emotional cues to encode memories, but it is more likely that the experience of pain could be sufficiently distracting to prevent a thorough search of the long term memory store, which would in turn prevent the retrieval of stimulus details which would allow discrimination of specific memories.

Chronic Pain and Recognition Memory. A major theme of the present thesis is that chronic pain and negative mood may cause a bias in memory for state-congruent stimuli. As discussed above, Pearce et al. (1990) have already suggested that chronic pain may enhance accuracy of memory. Previous research on recognition memory in depression has suggested that negative mood may bias recognition memory, thereby increasing the false-alarm rate, or invoking a relaxed acceptance criterion for state-congruent distractor stimuli (Dunbar & Lishman, 1984). To date, one paper has been published which has investigated the biasing effect on memory of chronic pain and negative affect on state-relevant stimuli. Edwards, Pearce, Collett, and Pugh (1992) investigated state-congruity memory effects of chronic pain and depression on sensory and affective pain descriptors. In this study, four groups of subjects were assessed: chronic pain with depression, chronic pain without depression, depression without pain, and control subjects with neither pain nor depression. The Beck Depression Inventory (BDI: Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) was used to classify patients into depressed and nondepressed categories. Subjects were auditorially presented with three lists, each comprising four sensory, four affective, and four

neutral words. After each list presentation, subjects were asked to provide a free recall of the words. Following the presentation of the three lists, subjects were auditorially presented the original 36 target words and an equal number of distractor adjectives. On the recall task, it was found that pain subjects without depression were more accurate in their recall for sensory words than for affective or neutral words. Similarly, it was also found that depressed subjects without pain were more accurate in their recall for sensory adjectives than for affective or neutral adjectives. However, it was found that depressed chronic pain subjects were not distinguishable in their recall of sensory, affective, and neutral words. Thus the results of the Edwards et al. (1992) study provide only modest support for the notion that memory accuracy may be differentially affected by pain or depression status. In terms of recognition memory, Edwards et al. (1992) found significant main effects for pain and depression on $\underline{d}'$. Post-hoc analyses showed that nonpain and nondeprepressed subjects were more accurate in their recognition across all stimulus types relative to chronic pain and depressed subjects. No significant group or interaction effect was found on Beta, thus suggesting that pain or depression did not differentially bias recognition memory.

The results of the Edwards et al. study provide only equivocal support for the notion that chronic pain and depression may bias recognition memory. These results stand in contrast to previously-cited research on depression, which has perhaps more consistently shown that negative mood may be a biasing influence on recognition memory. However, it is possible that methodological variance may have contributed to the relatively weak results obtained in the Edwards et

al. (1992) study. First, Edwards et al. (1992) presented stimuli in an auditory format, rather than in a visual format. This may have had an unintended and unmeasured effect on encoding or recall processes, as most previous research on recognition memory in depression has utilized visually-presented stimuli. Second, Edwards et al. (1992) used affective pain descriptors rather than depressive descriptors in an attempt to detect a depression-mediated bias. It may be the case that words which are specific to the subjects' affective status are required to detect such a bias. Certainly, research on attentional processes with the Stroop task suggest that this may be the case (cf. Williams et al., 1988). Edwards et al. (1992) classified subjects as depressed or nondepressed based on psychometric criteria. In order to form groups which are clearly distinct in terms of emotional status, it may be important to invoke precise diagnostic criteria as well as questionnaire scores. Finally, it will be recalled that depression researchers have demonstrated that prior effortful processing may be implicated in recognition memory biases (Matthews & Southall, 1991; Watts et al., 1987). Although Edwards et al. (1992) instructed their subjects to learn the word lists, it is not clear whether these instructions invoked sufficient processing of the material to activate contiguous memory nodes, as one would expect in a memory bias effect.

Because of these potential sources of variance, the results obtained by Edwards et al. (1992) do not definitively rule out the possibility that depression and chronic pain exert biasing effects on recognition memory. Based on their results, as well as on results obtained in depression research, a number of predictions may be made concerning the relationship between chronic pain and recognition memory.

First, depression is likely to be an influential component of any observed biases in recognition memory among chronic pain patients. Second, as in depression, chronic pain patients are more likely to demonstrate an increased false alarm rate for previously-presented stimuli (Matthews & Southall, 1991; Watts et al., 1987), rather than to manifest an enhanced recognition accuracy (Cole & Zarit, 1984; Davis & Unruh, 1980; Watts & Sharrock, 1987). Third, recognition biases may be most likely to emerge when material to be recognized is mood- or pain-congruent (Dunbar & Lishman, 1984; Matthews & Southall, 1991). Finally, recognition biases may depend upon whether the material to be recognized has undergone prior effortful processing or elaboration (Matthews & Southall, 1991; Watts et al., 1987). These predictions are based, of course, on a direct extrapolation from depression research, and are consistent with the conceptualization of both pain and mood as memory nodes capable of activating related memorial material, as in Bowers's (1981) network theory of human memory. However, whether this model holds directly for short-term recognition memory processes in chronic pain must remain for the moment an unanswered question.

## Summary and Implications for Present Research

This chapter has provided a number of lines of evidence which converge in providing a theoretical rationale for the prediction that affective and sensory factors may contribute to information-processing biases in chronic pain. First, it was shown that a complete account of chronic pain phenomenology cannot be provided by unidimensional, sensory-specificity pain theories (e.g. Heidbreder, 1933; Boring, 1944). Instead, multidimensional pain theories such as those suggested by Melzack and Wall (1965), Price (1988), or Leventhal et al. (1985) appear

to offer more complete explanations of pain phenomena which persist in the absence of an identifiable physiological lesion. Common to these theories was the acknowledgement that affect and sensation must be considered simultaneously in order to provide a comprehensive explanation of chronic pain (Fernandez & Turk, 1992). Because there is wide agreement that depression is a significant affective component of chronic pain (Dworkin & Gitlin, 1991; Gupta, 1986; Romano & Turner, 1985), it was reasoned that cognitive research in depression might be able to inform a theoretical account of possible cognitive processes in chronic pain. To that end, cognitive research in depression was selectively reviewed. The research that was reviewed demonstrated that depression is likely to be associated with biases in attention, in autobiographical memory, and in recognition memory.

The extant research on cognitive processes in chronic pain appears to be quite limited, but that which is available suggests that pain can influence attentional processes (Pearce & Morley (1989) and autobiographical memory (Eich, Rachman, & Lopatka, 1989). To date no research has been conducted on chronic pain and recognition memory, or on judgement biases in chronic pain. However, because it is assumed that similarities in cognitive processing may exist between depression and chronic pain, it is predicted that effects similar to those found in depression will also be found in chronic pain.

Hypotheses Drawing on the literature reviewed above, the following hypotheses are proposed as a means of assessing the relative contribution of depression and pain to cognitive processing in chronic pain:

1. Relationship Between Depression and Chronic Pain: Since it has been demonstrated that pain is comprised of a sensory component and an affective component, it is expected that among chronic pain patients, measures of depression will relate more strongly to measures of the affective dimension of pain than to the sensory dimension of pain. Such a finding would provide justification for further examination of the role of depression in cognitive processing in chronic pain, as it would demonstrate patterns of shared variance between chronic pain and depression. Such a finding would also provide further validation for the separation of chronic pain into sensory and affective components.

2. Attentional Biases: In general, it is expected that subjects will show state-relevant attentional biases on a modified Stroop task, so that for example, subjects with chronic pain will produce longer colour-naming times for pain-relevant words in comparison to positive, negative, or neutral stimuli. This hypothesis can be refined in the following fashion:

   A) Depressed chronic pain subjects will show longer colour naming times for sensory pain, affective pain, and depressive stimuli in comparison with positive or neutral stimuli.

   B) Nondepressed chronic pain subjects will show longer colour naming times for sensory pain stimuli in comparison with affective pain, depressive, positive, or neutral stimuli.

   C) Depressed subjects without pain will show longer colour naming times for depressive stimuli relative to other classes of stimuli.

   D) Nondepressed, nonpain subjects will show relatively little variation across different classes of stimuli.

3. Autobiographical Memory: Using a reaction-time autobiographical memory paradigm, the following hypotheses are proposed:

A) Depressed chronic pain subjects will take less time to retrieve memories to sensory pain, affective pain, and depressive cues relative to positive cues.

B) Nondepressed chronic pain subjects will take less time to retrieve memories to sensory pain cues and positive cues relative to affective pain and depressive cues

C) Depressed nonpain subjects will take less time to retrieve memories to depressive cues relative to other classes of cues.

D) Nondepressed nonpain subjects will take less time to retrieve memories to positive cues relative to other classes of cues.

3a. Generality of Autobiographical Memories: Based on research by Williams and his colleagues (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Williams & Scott, 1988), it is expected that all depressed subjects, regardless of pain status, will be more likely to retrieve general, rather than specific memories on the autobiographical memory test. In line with previous research it is expected that depressives will have more difficulty recalling specific positive memories than negative memories. Thus, it is expected that depressed subjects in the present research will have a higher proportion of general memories for positive cues in comparison to depressive or pain cues.

4. Recognition Memory: Because it is assumed that pain and depression exert a biasing effect on cognitive processes the following hypotheses are suggested:

A) It is expected that subjects experiencing pain and depression

will tend to overestimate the prevalence of state-relevant stimuli on a recognition task. In other words, subjects experiencing pain and depression will provide a higher false-alarm rate for pain and depression-relevant stimuli relative to other classes of stimuli.

B) Subjects experiencing pain will provide a higher false alarm rate for pain-relevant stimuli.

C) In contrast, it is expected that depressed subjects will provide a higher false-alarm rate for depressive stimuli in comparison to other stimulus classes.

D) Finally, it is expected that subjects experiencing neither pain nor depression will be relatively accurate in their recognition across stimulus types.

E) It will be recalled that one of the principal assumptions underlying the present project is that pain and depression will exert biasing influences on cognitive processing of state-relevant stimuli. This assumption suggests, therefore, that c will be low for state relevant stimuli, but that d will be relatively invariant across stimulus classes. More specifically, the interaction term for the sensitivity criterion (d') is not expected to attain significance. Instead, it expected that state-specific biases will be reflected in a more relaxed criterion for acceptance of state-relevant stimuli. This relaxed criterion will be reflected in a lower absolute value of c for those stimuli which are relevant to a subject's pain or affective status. For example, for subjects with both pain and depression, it could be expected that c will be lower for depression and pain-relevant stimuli than for positive stimuli. Similarly, depressed subjects

could be expected to produce a lower value of $\underline{c}$ for depression stimuli than for pain or positive stimuli.

In order to provide a valid test of these hypotheses, certain conditions must be met. First, if one is concerned with the relative contributions of negative affect and sensory pain to cognitive processes, research concerned with these questions must be designed to cleanly separate the influence of depression and pain. Second, a stringent test of these hypotheses will require a demonstration that verbal stimuli are valid representatives of the domains from which they are drawn, and that stimuli are equivalent on such dimensions as length, frequency of usage, and imagery.

The studies to be presented in subsequent chapters will address these hypotheses in a stepwise fashion. The first of the two pilot studies to be presented in the next chapter will provide evidence that affect and sensation are distinct but overlapping components of chronic pain, and that depression is more strongly related to the affective component of pain than to the sensory component. The second pilot study is a preliminary Stroop task designed to investigate which parameters influence attentional biases in chronic pain. The third chapter will present a study which includes three experiments designed to examine the relative contribution of depression and pain to attention, autobiographical memory, recognition memory, and judgement of ambiguous stimuli. The stimulus selection in this study was rigorous both in terms of validity and between-group equivalence. The relative contribution of mood and pain was separated by including four groups of subjects: a chronic pain depressed group, a chronic pain nondepressed group, a depressed no-pain group, and a nondepressed no-pain group.

# CHAPTER TWO

## Pilot Studies

### Pilot Study I: Research Objectives and Overview of Design

Pilot Study I is designed to investigate the relationship between depressed mood and the sensory and affective dimensions of chronic pain. As discussed above, previous research has noted the presence of both sensory and affective factors in chronic pain (Ciccone & Grzesiak, 1984; Keefe & Williams, 1989; Melzack & Wall, 1988; Price, 1988; Turk & Rudy, 1986). It has also been noted that depression appears to be a significant component of chronic pain (Dworkin & Gitlin, 1991; Gupta, 1986; Magni et al., 1990; Romano & Turner, 1985). If, as this literature suggests, sensory and affective components of chronic pain are distinct, it would be expected that depression would be more strongly related to the affective dimension of chronic pain than to the sensory dimension. Such a finding would provide justification for proceeding with an investigation of the role of depression in information processing in chronic pain, since it would demonstrate that depressed mood is related to a particular aspect of the chronic pain experience.

Subjects in the present study were administered pain measures and a depression measure. The two types of pain measurement each assessed sensory and affective dimensions of pain. If the interrelationships between these measures emerge as predicted, this will provide preliminary justification for the further study of the influence of depression in cognitive processing in chronic pain.

## Method

Subjects. Fifty chronic pain subjects were recruited from the outpatient roster of the Rheumatic Diseases Unit of University Hospital. The sample comprised 43 females and 7 males. Mean age was 49.92 (SD=11.13). A variety of rheumatologic diagnoses were included in the present sample, including rheumatoid arthritis (n=13), osteoarthritis (n=10), and fibromyalgia (n=27).

## Materials

McGill Pain Questionnaire The McGill Pain Questionnaire (MPQ: Melzack, 1975, listed in Appendix A) is a checklist of 78 verbal pain descriptors arranged into 20 subclasses in terms of increasing intensity. Subjects are requested to check only the single most descriptive word in each subclass, and to disregard any subclass which contains no appropriately descriptive words. Descriptors are given a numerical score according to their rank position in each subclass. Based on factor-analytic research, subclass scores are used to calculate scores on a number of subscales, including Sensory, Affective, Evaluative, Miscellaneous, a Total Pain Rating Index (PRI-T), and the number of words chosen (NWC). For the present project, Sensory and combined Affective/Evaluative scores were calculated as exemplars of the two elements of chronic pain under consideration. Melzack (1975) reported validity data obtained from patient samples with different pain conditions, and the MPQ has been widely validated in subsequent research (Reading, 1984; Holroyd et al., 1992).

Visual Analogue Scales. Two 100 mm visual analogue scales were utilized in the present study, each designed to assess one of the two main dimensions of chronic pain. The VA sensory pain scale was anchored

by the descriptors "No Pain" and "Very Severe Pain". The VA affective pain scale was introduced by the description: "Considering all the ways your pain affects you, how would you rate its severity over the past week?", and was anchored by the descriptors "Not Troublesome At All" and "Extremely Troublesome". Subjects responded to the two scales by placing a vertical mark across the line at a position which subjectively corresponded to their sensory pain levels and to their affective reactions to their pain. Previous research has demonstrated the validity of VAS methodology in pain measurement (see Chapman, Casey, & Dubner, 1986 for a review).

Centre for Epidemiologic Studies Depression Scale. Depressed mood was assessed by the Centre for Epidemiologic Studies Depression Scale (CES-D: Radloff, 1977, listed in Appendix B). The CES-D is a twenty-item instrument which assesses depth of depressed mood by requiring respondents to indicate the frequency of depressive cognitions and behaviours over the week prior to testing on a four-point scale ranging from 0 (rarely or none of the time: less than one day in the past week) to 3 (most or all of the time: 5 to 7 days in the past week). The CES-D has been standardized on both patient and non-patient groups and has been shown to have adequate reliability and validity (Radloff, 1977).

## Procedure

Subjects were approached by their attending physician to determine their interest in participating in the present study. Subjects were excluded if their first language was not English. After selection of subjects, the questionnaires and VA scales were explained to the subjects, their informed consent was obtained, and they were provided with a letter of explanation (listed in Appendix C). Subjects were

instructed to complete the measures within the week following recruitment, and to return them either by mail or at their next regular medical appointment.

Results and Discussion

Means and standard deviations for all measures are presented in Table 2-1. As a point of reference for interpreting these data, in the original validation paper on the MPQ (Melzack, 1975), mean scores on the sensory subscale ranged from 10.3 to 17.8, and mean scores on the affective/evaluative subscale ranged from 3.9 to 6.8. These stand in contrast to the present sample, where the mean sensory score was 18.6, and the mean affective/evaluative score was 7.12. The CES-D scores in the present sample place subjects in the moderately-depressed range (Radloff, 1977). These data suggest that the sample under consideration in the present study may have been suffering from higher levels of pain and psychological disturbance than other normative samples. As such, the results of the present study may not be representative of the general population of chronic pain.

Correlations between pain and mood measures are presented in Table 2-2. In examining the significance of correlations between these measures, a multistage Bonferroni procedure was employed (Larzelere & Mulaik, 1977) in order to correct for the spurious increase in the Type-I error rate which may occur as a result of conducting multiple significance tests on interdependent data. The multistage Bonferroni procedure was designed as an alternative to the standard Bonferroni procedure, which is excessively conservative in its alpha-level correction (Miller, 1966). In the first stage of the multistage Bonferroni procedure, the error rate per test is based on the number of

correlations in an array. In the second stage, the correction is based on the number of correlations remaining after accepting the significant correlations from the first stage. Subsequent stages proceed in the same manner until no correlations can be accepted as significant. At the stage one corrected alpha level of .005, the correlation between the CES-D and the two measures of the affective dimension of pain were significant ($r$=.46 with the MPQ affective-evaluative scale, and $r$=.45 with the VA affective scale). It was also found that the correlation between the two MPQ subscales was high and significant ($r$=.61), as was the correlation between the two VA scales ($r$=.60). The correlations between the MPQ Affective/Evaluative subscale and the VA scales were also significant ($r$s=.47 with VA sensory, and.43, with VA affective). No correlations could be accepted as significant at the second stage, where the corrected alpha level was calculated at .0125.

With the present sample of patients and pain measures, there is a clear indication that depressed mood is differentially related to the different components of chronic pain: CES-D scores were significantly correlated with both the MPQ Affective/Evaluative subscale ($r$=.46) and with the VA affective scale ($r$=.45), but were not significantly correlated with either the MPQ Sensory subscale ($r$=.19) or the VA sensory scale ($r$=.22). It was found that the correlation between the CES-D and the MPQ Affective/Evaluative subscale was significantly larger than the correlation between the CES-D and the MPQ Sensory subscale ($r$=.46 vs $r$=.19, Hotellings $t(47)$=2.38, $p$<.05). Similarly, the correlation between the CES-D and the VA Affective scale was significantly larger than the correlation between the CES-D and the VA Sensory scale ($r$=.45 vs $r$=.22, Hotellings $t(47)$=1.98, $p$<.05). This

Table 2-1:
Means and Standard Deviations for
Demographic, Mood, and Pain Variables: Pilot Study I

| Measure | Mean | (SD) |
|---|---|---|
| Age (Years) | 45.26 | (12.11) |
| Duration of Symptoms (Months) | 66.35 | (19.62) |
| MPQ Sensory Subscale | 18.60 | (6.90) |
| MPQ Affective/Evaluative Subscale | 7.12 | (2.19) |
| VA Sensory Pain (mm) | 62.50 | (14.96) |
| VA Affective Pain (mm) | 71.48 | (23.61) |
| CES-D Scores | 13.22 | (12.69) |

Notes:
All means based on a sample of n=50

Table 2-2:
Correlations Between Sensory and
Affective Pain Measures and Depression

| | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 1. CES-D | .46* | .19 | .45* | .22 |
| 2. MPQ A/E | -- | .61* | .43* | .47* |
| 3. MPQ SEN | | -- | .15 | .30 |
| 4. VA AFF | | | -- | .60* |
| 5. VA SEN | | | | -- |

* $p < .005$

Notes:

-- All correlations based on a sample of $n = 50$.
CES-D: Centre for Epidemiologic Depression Scale
MPQ A/E: McGill Pain Questionnaire Affective/Evaluative Subscale
MPQ SEN: McGill Pain Questionnaire Sensory Subscale
VA AFF: Visual Analogue Affective Scale
VA SEN: Visual Analogue Sensory Scale

pattern of correlations suggests that depressed mood is more strongly related to the affective dimension of pain than to the sensory dimension, an observation which was further supported by examining the partial correlations between pain measures after removing the influence of depressed mood. The correlation between the sensory scales was only reduced from $r$=.30 to $r$=.27 after partialling out the variance contributed by CES-D scores, thus suggesting that the relationship between these measures of sensory pain are relatively unaffected by depressed mood. In contrast, the partial correlation between the two affective scales was reduced from $r$=.43 to $r$=.25 after removing the variance contributed by CES-D, thus demonstrating that much of the variance shared by these affective measures of chronic pain is strongly related to depressed mood.

The present results have some important implications for subsequent research in cognitive processes in chronic pain. The most striking finding is that depressed mood is differentially related to the separate dimensions of chronic pain. Sensory pain measures yielded relatively low correlations with depressed mood, whereas affective pain measures yielded significant correlations with depressed mood. This finding supports previous research which has noted the prevalence of depression in chronic pain, but further suggests that depressed mood may be a particularly important source of variation in processing affective information in chronic pain. However, it must be reiterated that the results obtained in the present study may not be representative of chronic pain in general, as the descriptive statistics suggested that the present sample may have been experiencing high levels of pain.

## Pilot Study II: Research Objectives and Overview of Design

Pilot Study II is a preliminary examination of the selective effect of chronic pain and depressed mood on state-specific attentional processes, as represented by a modified Stroop task. It should be noted that Pilot Study II did not arise in sequential fashion in response to data obtained in Pilot Study I. Rather, it was designed to be a separate, independent examination of potentially relevant parameters of the Stroop task in chronic pain. Pain-relevant stimuli are assumed to activate the attentional resources of chronic pain subjects to a greater degree than stimuli which are not pain-relevant. If this assumption is correct, one would predict that on a Stroop task, chronic pain subjects will manifest increased colour-naming times for pain-relevant stimuli in comparison to other stimulus categories, as a result of differential activation of state-relevant associative pathways (MacLeod, 1991). It is expected that pain-free control subjects will not manifest such differential attentional biases. Further, it is expected that chronic pain subjects with high levels of depressed mood will manifest increased colour naming times for negative emotion stimuli in comparison with chronic pain subjects with relatively lower levels of depressed mood. This hypothesis is also based on the assumption that attentional resources will be differentially activated in the direction of state-congruent stimuli.

In Study II, pain and non pain subjects were administered a modified version of the Stroop test (Stroop, 1935). As discussed above, the Stroop test has been widely applied in the study of basic cognitive processes and abilities (Jensen & Rohwer, 1966), and has recently been utilized in the investigation of attentional biases in affective states,

including depression (Gotlib & McCann, 1984; Klieger & Cordner, 1990; Williams & Nulty, 1986), phobia (Watts, McKenna, Sharrock and Trezise, 1986), anxiety (Matthews & McLeod, 1985), examination stress (Ray, 1979), and emotional repressiveness (Dawkins & Furnham, 1989). Additionally, the Stroop has also been used in the investigation of attentional biases in chronic pain (Pearce & Morely, 1989). Although it may be viewed as a partial replication of the Stroop study conducted by Pearce and Morley (1989), the present study was designed to specifically examine the role of depression on Stroop performance among chronic pain subjects. In contrast, Pearce and Morley (1989) did not specifically assess the level of depressed mood among their subjects.

## Method

Subjects. Forty subjects took part in the present study. The chronic pain (CP) group was comprised of the first twenty consecutive consenting outpatient admissions in the Rheumatic Diseases Unit of University Hospital. This group of 17 females and 3 males suffered from a variety of chronic, benign painful conditions, including rheumatoid arthritis ($n$=3), osteoarthritis ($n$=4), fibromyalgia ($n$=9), and myofascial pain ($n$=4). For the CP group, exclusion criteria for participation in the present study were: a) first language other than English; b) pain of less than six month's duration; c) a score of less than 30 on a 100 mm visual analogue pain scale; and age > 65. The mean age of the CP group was 41.00 (SD = 14.05, range 21-59). The nonpain (NP) group was comprised of twenty hospital employees who were matched to the pain group on age ($M$ = 38.3, SD = 12.55, range 23-62) and sex. For the nonpain group, subjects were excluded whose first language was not English.

## Materials

Psychometric Measures. Psychometric measures included in the present study were the CES-D (Radloff, 1977, Appendix B), which has been described above, and three visual analogue scales. One VA scale assessed present pain level, one assessed negative mood, and one measured positive mood. Each scale was constructed of a 100 mm line anchored by verbal descriptors. For the pain VAS, the line was anchored by "no pain" and "very severe pain". For the unpleasant mood VAS, the line was anchored by "not at all unhappy" and "very unhappy". For the pleasant mood VAS, the line was anchored by "not at all happy", and "very happy". The reliability and validity of visual analogue scales for assessing pain (Chapman et al. 1986) and mood (Davies, Burrows, & Poynton, 1975) have been discussed elsewhere.

Stroop Stimuli. Twelve words were adapted from the MPQ for the purpose of the present study. It was decided to select words from the the MPQ that were most directly descriptive of pain, and to transform these words from the adjectival to the nominal form (e.g "hurting" became "hurt", "aching" became "ache"). These modifications were made in order to facilitate matching with control words on the basis of grammatical category, frequency of usage, and length.

A control list of twelve positive adjectives was generated to represent physiological sensations with a positive affective valence. This stimulus class was included to control for the possible influence of non-pain sensory input on Stroop performance. If the CP group manifested a retardation effect in response to the positive stimuli, then one could not reasonably attribute differences in Stroop performance to pain *per se*. Initial lists of appropriate words were

selected, then expanded by reference to Roget's international thesaurus (1977). Another list of twelve emotionally neutral words was generated which were matched for frequency of usage and length with the sensory descriptors, in order to control for the influence of verbal stimuli on Stroop performance. Theoretically, there should be no between-group differences on performance for neutral words, as they should bear no relationship to the emotional state of either the CP or NP group. The final stimulus list was comprised of emotionally negative words which do not describe a sensorial quality, and which have also been matched for frequency and length with the other words under consideration. The emotionally negative list was included in order to examine the influence of depression on selective attention. As discussed above, it was expected that depressed CP subjects would obtain longer colour-naming times for negative emotion words as a result of selective deployment of attention toward state-congruent stimuli. Emotional valence ratings of the neutral and negative control words have been obtained in previous research (McDonald, 1988), and the frequency rating of the words under consideration obtained from Kucera and Francis (1967). The final lists of twelve words in each of these four categories are shown in Table 2-3. In addition to the words which are unique to the present study, a simple colour-naming condition and a classical colour-word interference condition were also included in order to test for colour blindness, and to examine potential psychomotor retardation effects.

Thus the six Stroop conditions included in the present study were colour-naming (CN), colour-interference (CI), pleasant words (Pl), neutral words (Neu), pain words (Pa), and negative words (Neg). One

Table 2-3:

Painful, Pleasant, Neutral, and

Emotionally-Negative Words for Pilot Study II

| Pain Words | Pleasant Words | Neutral Words | Negative Words |
|---|---|---|---|
| Throb | Soothe | Array | Brute |
| Sore | Float | Hoof | Fail |
| Hurt | Calm | Core | Fear |
| Ache | Loose | Mule | Jail |
| Pain | Serene | Pact | Kill |
| Tender | Warmed | Ankle | Hatred |
| Suffer | Gentle | Gravity | Misery |
| Sharp | Relief | Metal | Devil |
| Sting | Sleepy | Pencil | Death |
| Agony | Cushion | Mast | Guilt |
| Cramp | Mellow | Truck | Grief |
| Tortu·e | Sedated | Abdomen | Sadness |

card was presented for each condition, with stimuli printed in letters 5cm high in brown, blue, green, or red ink. Stimuli were arranged in twelve rows of eight columns, thus providing a total of 96 stimuli per card. For each card, colour-word combinations were arranged randomly, with the following restrictions: a) for Pl, Neu, Pa, and Neg, each word appeared eight times (for CI, each word appeared 24 times); b) each colour appeared 24 times; c) no colour-word combination appeared more than twice in succession in a row.

To reiterate the hypotheses outlined above, it was expected that the CP group would show an increase in colour-naming speed for pain words relative to the other control conditions. It was also expected that affectively-distressed CP subjects would show an increase in colour-naming speed for the negative emotion words, relative to the neutral and positive words. Finally, it was expected that the NP group would show relatively little difference in colour naming latencies for the positive, neutral, pain, and negative emotion words.

Procedure

CP subjects were recruited by their attending physicians upon admission to the outpatient unit of University Hospital. NP subjects were recruited by personal contact within the hospital. Each subject was provided with a verbal and written explanation of the study prior to obtaining consent (Appendix D). Three potential CP subjects dropped out prior to participation because they felt the task might be too stressful and/or time-consuming. After obtaining consent, subjects completed the CES-D and the VA scales. Subjects were then presented with the Stroop cards in the fixed order: CN, CI, Pl, Neu, Pa, Neg. This order was chosen because previous research has shown that emotionally-charged

words may retard performance on subsequent neutral conditions (McKenna, 1986), and because the task is not subject to any appreciable fatigue effects (Pearce & Morley, 1989; Williams & Broadbent, 1986). In addition, this Stroop-card presentation order was chosen so than any practice effects would run counter to hypothesized interference effects on the Pa and Neg cards. In completing the task, subjects were asked to name the colour in which each stimulus was printed, and to ignore the meaning of the stimulus. Subjects proceeded by naming the colours from left to right across each of the 12 rows, starting at the top of the card. Each card was presented one at a time, with a brief interval between each presentation to reiterate the instructions to name colours and to ignore the semantic content of the words. Responses to the Stroop task were timed with a stopwatch, and tape-recorded for later timing by a rater blind to the subjects' pain status. After participation subjects were debriefed and provided with a letter of explanation (Appendix D).

In comparison with Pilot Study II, the Pearce and Morley (1989) used a slightly different stimulus stimulus presentation format. Subjects in the Pearce and Morley study were presented with four pairs of stimulus cards. The first pair consisted of a simple colour naming card paired with a colour contrast card. The second pair consisted of a negative emotion card paired with a neutral word card. The third pair consisted of words drawn from the sensory subscale of the MPQ and a neutral word card. The fourth pair consisted of words drawn from the affective, evaluative, and miscellaneous subscales of the MPQ and a neutral word card. Each condition in the Pearce and Morley study used ten different words. As in the present study, subjects in the Pearce

and Morley study were required to name the colour in which each stimulus was presented. Their dependent measure was the time taken to name the colours on each card.

Results and Discussion

Inter-Rater Reliability. On a random sample of eight subjects, the correlations between timing performed by the experimenter and that performed by a blind rater were very high, ranging from .95 to .99. Since the inter-rater agreement was so high, all analyses were performed on data collected by the experimenter.

Mood. As shown in Table 2.4, CP subjects expressed significantly more mood disturbance than NP subjects across all mood measures.

Stroop Performance. On the Stroop test, the CP group was consistently slower than the NP group across all six Stroop conditions, as shown in Table 2-5. A 2 (group) by 6 (test) repeated-measures ANOVA yielded significant main effects for group ($F$ (1,38)=10.23, $p$ <.01), and for test ($F$ (5,34)=61.98, $p$ <.0001). However, no significant group-by-test interaction effects were obtained ($F$ (5,34)=1.42, n.s.). Newman Keuls post-hoc analyses (Kirk, 1982, pp.123-125) revealed that all subjects were significantly slower on the colour-word interference condition than on each of the other five conditions ($p$ < .01 for all comparisons). Further, all subjects were significantly slower on the pain condition in comparison to the colour-naming condition ($p$ < .05), and on the negative condition in comparison to the colour-naming condition ($p$ < .05).

In order to examine the influence of depressed mood on Stroop performance among the CP subjects, a repeated-measures ANOVA was

Table 2-4:
Mood Ratings for CP and NP Subjects

| Mood Measure | CP Mean (SD) n=20 | NP Mean (SD) n=20 | t (38) | p |
|---|---|---|---|---|
| VA Negative Mood | 45.5 (29.3) | 6.6 (8.6) | 5.69 | .000 |
| VA Positive Mood | 44.8 (23.6) | 82.5 (15.9) | 5.92 | .000 |
| CES-D Scores | 13.9 (3.0) | 4.9 (5.5) | 6.05 | .000 |

Notes:
VA Negative Mood: Visual Analogue Negative Mood Scores
VA Positive Mood: Visual Analogue Positive Mood Scores
CES-D Scores: Scores on the Centre for Epidemiologic Studies Depression Scale

Table 2-5:
Reaction Times for CP and NP Groups
Across Six Stroop Conditions (Secs.)

| Stimulus Condition | Chronic Pain Mean (SD) n=20 | No Pain Mean (SD) n=20 |
|---|---|---|
| Colour-Naming | 64.1 (12.3) | 52.9 (7.9) |
| Colour-Interference | 97.4 (21.8) | 77.6 (17.4) |
| Pleasant | 72.0 (11.8) | 61.1 (12.0) |
| Neutral | 70.4 (12.5) | 59.9 (10.2) |
| Pain | 77.8 (12.3) | 67.5 (11.6) |
| Negative | 77.8 (12.9) | 69.7 (11.5) |

conducted across the six Stroop conditions in which the CP group was split on the basis of the median score on the CES-D. For this sample, the median score was 14.2 The mean reaction times for the depressed and nondepressed chronic pain groups are presented in Table 2-6. A 2 (group) X 6 (test) repeated-measures MANOVA yielded a significant main effect only for test ($F(5,14)=24.34$, $p<.0001$). No significant effects were obtained for either the group ($F(1,18)=2.53$) or interaction terms ($F(5,14) < 1$).

The present study did not yield the predicted results. It was expected that the CP group would show an increase in colour-naming latency for pain words relative to the other control conditions. It was also expected that affectively-distressed CP subjects would show an increase in colour-naming speed for the negative emotion words, relative to the neutral and positive words. Finally, it was expected that the NP group would show relatively little difference in colour naming latencies for the positive, neutral, pain, and negative emotion words. These results were not obtained. Instead, CP subjects were consistently slower across all six conditions than NP subjects, thus suggesting that chronic pain exerted a generalized retardation effect on attentional processing on the Stroop task. This effect could be due to the higher levels of depressed mood in CP subjects in comparison with NP subjects, or perhaps it is the case that chronic pain itself depletes cognitive resources to the point that general attentional processing is slowed. Interestingly, it was found that depressed mood had no effect, either on the overall response time among CP patients, or on the specific response time to the Neg card. This result suggests that because of the low ns (10 subjects per group), the depressed and nondepressed groups may

Table 2-6:
Reaction Times for Depressed and Nondepressed Chronic Pain Groups Across Six Stroop Conditions

| Stimulus Condition | Depressed Mean (SD) n=10 | Nondepressed Mean (SD) n=10 |
|---|---|---|
| Colour-Naming | 68.6 (13.8) | 59.6 (9.0) |
| Colour-Interference | 102.4 (19.9) | 92.5 (23.5) |
| Pleasant | 75.4 (12.0) | 68.7 (11.2) |
| Neutral | 74.7 (12.6) | 66.2 (11.4) |
| Pain | 81.4 (12.8) | 74.2 (11.1) |
| Negative | 82.5 (14.4) | 73.2 (9.9) |

not have been sufficiently distinct on the basis of mood to detect either a mood-specific attentional bias or a general retardation effect. Finally, it was found that all subjects were relatively slower on the Pain and Negative Emotion cards than on the Pleasant or Neutral cards. This result suggests that all subjects' attention was differentially activated by generally negative words, a result previously demonstrated by McKenna (1986).

These results are somewhat surprising in view of the apparently clear-cut and consistent results reported in prior pain/emotion research. For example, Pearce and Morley (1989) reported that CP subjects provided slower reaction times only on the colour interference condition and on the two pain conditions, while the CP and NP groups were equivalent on the colour-naming, negative emotion, and neutral conditions. There are several potential reasons for this discrepancy. The first concerns differences between the two studies in the criteria for the selection of verbal stimuli. In the present study the pain stimuli were not adapted directly from the MPQ, as they were in the Pearce and Morley (1989) study, but were modified slightly in order to enhance their comparability with words in the other conditions. This modification may have had the unintended effect of making the pain words more salient for both groups, thus producing relatively longer reaction times on the Pa card for both CP and NP groups. Further, the negative emotion words in the present study were selected from a list devised by McDonald (1988), in which undergraduate students rated the emotional valence of several hundred words. These words therefore, were not necessarily descriptive of a negative emotional state, as stimuli have been in previous mood research; rather, they were rated as generally

disturbing to a random selection of normal university undergraduates.

It is clear from results obtained in Pilot Study I that the inclusion of affective pain words would also be a useful condition to include in any tests of potential cognitive biases in chronic pain. Although this verbal condition was not included in Pilot Study II, the observation that affective and sensory pain were separable and differentially related to depressed mood suggests that subjects with chronic pain concomitant with depression may process affective pain stimuli differently than nondepressed chronic pain subjects.

It is difficult to explain the observation that the CP group was consistently slower than the NP group across all six Stroop conditions. It is possible that the CP group in the present study was experiencing more or less pain or affective distress than CP subjects in the Pearce and Morley (1989) study, but the two studies are not directly comparable in this regard. Pearce and Morley assessed pain with the MPQ, whereas pain was assessed by a VAS in the present study. Mood was assessed with a short form of the POMS by Pearce and Morley, whereas in the present study mood was assessed by a the CES-D and visual analogue scales. Further, it may be possible that differences in the control groups between the two studies may account for the discrepancy in results. In the present study the NP group was drawn from hospital employees, while Pearce and Morley (1989) did not specify the source of their NP controls. Finally, it may be possible that the overall retardation effect among CP subjects noted in the present study may be have been due to the effects of medication. In the present study analyses were not controlled for type and dosage of medication. However, medication usage was also not controlled for by Pearce and Morley (1989), so it is

impossible to assess whether this factor influenced the observed differences in results between the two studies.

Although the present study did not replicate results obtained by Pearce and Morley (1989), it provides useful information on potential sources of random variance which may require more stringent control. First, in order to examine the influence of mood, a group of clearly depressed CP subjects must be contrasted with a group of clearly nondepressed CP subjects. It is possible that a self-report assessment of mood does not constitute a sufficiently rigorous assessment of depression, and that a psychiatric diagnosis of major depressive episode may be necessary to show a strong selective effect of depression on information processing. Second, it may be necessary to rely on stronger validation of stimuli than the simple face validity procedures which were utilized in the present study. To ensure valid representation of pain and mood states, it may be necessary to select stimuli which have been rated by patients suffering from the disorders in question, and to equate these stimuli as closely as possible on frequency of usage within these patient populations, rather than within a general, non-pathological population. Finally, it may be necessary to assess stages of information processing other than those represented by the Stroop task. It is possible, for example, that the Stroop task is simply not sensitive to cognitive effects in chronic pain, and that such tasks as autobiographical memory test and a recognition memory test may be more sensitive to between-group differences. These concerns will be addressed in more detail in Chapter Three.

# CHAPTER THREE

## Principal Study

### General Research Objectives

The principal study to be described in the present chapter is to be conducted in three phases, and is designed to investigate the hypotheses enumerated in the introduction. Specifically, the hypotheses are:

On a modified Stroop task it is expected that: a) Depressed chronic pain subjects will show longer colour naming times for sensory pain, affective pain, and depressive stimuli in comparison with positive or neutral stimuli. b) Nondepressed chronic pain subjects will show longer colour naming times for sensory pain stimuli in comparison with affective pain, depressive, positive, or neutral stimuli. c) Depressed subjects without pain will show longer colour naming times for depressive stimuli relative to other classes of stimuli. d) Nondepressed, nonpain subjects will show relatively little variation across different classes of stimuli.

Using a reaction-time autobiographical memory paradigm, the following hypotheses are proposed: a) It is expected that depressed chronic pain subjects will take less time to retrieve memories to sensory pain, affective pain, and depressive cues relative to positive cues. b) Nondepressed chronic pain subjects will take less time to retrieve memories to sensory pain cues and positive cues relative to affective pain and depressive cues. c) Depressed nonpain subjects will take less time to retrieve memories to depressive cues relative to other

classes of cues. Nondepressed nonpain subjects will take less time to retrieve memories to positive cues relative to other classes of cues. Based on research by Williams and his colleagues (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Williams & Scott, 1988), a group by stimulus type interaction will emerge when examining the generality of autobiographical memory. Specifically, it is expected that all depressed subjects, regardless of pain status, will retrieve more general memories to positive cues than to negative cues, and that nondepressed subjects will retrieve more general memories to negative cues than to positive cues. It is also expected that a group main effect will emerge, with depressed subjects providing more general memories than nondepressed subjects across all stimulus types. Because this paradigm has not previously been used in a chronic pain sample, it is difficult to know what memory generality effects to expect. However, because chronic pain has been associated with information processing biases that are analogous to depression, it may predicted that pain status will cause analogous effects on memory generality. Specifically, pain may be related to a higher proportion of general memories to positive cues than to pain-related cues.

Because it is assumed that pain and depression exert a biasing effect on recognition memory the following hypotheses are suggested: a) It is expected that subjects experiencing pain and depression will tend to overestimate the prevalence of state-relevant stimuli on a recognition task. In other words, subjects experiencing pain and depression will provide a higher false-alarm rate for pain and depression-relevant stimuli relative to other classes of stimuli. b) Subjects experiencing pain will provide a higher false alarm rate for

pain-relevant stimuli. c) In contrast, it is expected that depressed subjects will provide a higher false-alarm rate for depressive stimuli in comparison to other stimulus classes. d) Finally, it is expected that subjects experiencing neither pain nor depression will be relatively accurate in their recognition across stimulus types. In terms of signal-detection theory, it is expected that sensitivity will be relatively unaffected by pain or emotional status. This will produce relatively invariant values of d' across groups and stimulus types. Instead, it is expected that pain and depression subjects will have a more relaxed criterion (c) for claiming recognition of state-relevant stimuli than controls, as a reflection of the predicted bias in their recognition memory. This bias should result in the absolute value of c being lower for state-relevant stimuli.

These hypotheses represent a more comprehensive exploration of questions raised in Pilot Studies I and II. As such, the principal studies were designed as theoretical extensions of the pilot studies. It will be recalled that Pilot Study I showed that depressed mood appeared to uniquely contribute to the expression of the affective component of pain. This result suggests that it would be useful for any subsequent investigation of cognitive processes in chronic pain to examine the separate contributions of pain and depression. For that reason, the present project utilized four groups of subjects: a) a depressed chronic pain group, b) a nondepressed chronic pain group, c) a depressed nonpain group, and d) a nondepressed nonpain group. In the pilot studies depressed mood was assessed psychometrically by the CES-D. Although this instrument is a valid and reliable indicator of depth of depressed mood, it was not designed to diagnose depression (Radloff,

1977). As such, it may be important to exclude from the depressed groups those subjects who do not meet the diagnostic criteria for major depressive episode, even though they may obtain high scores on the CES-D. Such stringent exclusionary criteria would ensure that analyses would clearly discriminate the effects of depression from pain on information processing.

The principal study will also employ more rigorous stimulus selection procedures than the Pilot Studies. In Pilot Study II the verbal stimuli were rated as negative or positive by a normal sample of subjects. The stimuli had also been matched on general frequency of usage in English. However, it may be important to have the emotional valence of the stimuli rated by subjects who are representative of the experimental population. This would increase the likelihood that the stimuli are valid indicators of the emotional or physical state being investigated. It may also be important to ensure that the stimuli are rated for frequency of usage within the experimental population, rather than solely within the general population, in order to ensure that the stimuli are salient to individuals experiencing pain and/or depression. These concerns will be addressed in the stimulus selection procedures in the present chapter.

To summarize, the present chapter will examine the effects of chronic pain and depression on attention, autobiographical memory, and recognition memory. In order to explore these questions, four groups of subjects completed three sets of tasks. The four groups of subjects included a depressed chronic pain group, a nondepressed chronic pain group, a depressed nonpain group, and a nondepressed nonpain group. Rather than relying solely on psychometric criteria, the depressed

groups were selected on the basis of psychiatric diagnostic criteria. The three tasks included a revised Stroop task, an autobiographical memory task, and an incidental recognition task.

## Phase I: Modified Stroop Task

### Overview of the Design

All three phases of the principal study were run consecutively on the same experimental sample. For the principal study, four subject groups were tested: chronic pain-depressed (PD), chronic pain-nondepressed (PN), depressed subjects without pain (ND), and a group of control subjects without pain or depression (NN). For the purpose of expository clarity, each phase of the principal study will be reported separately. Phase I was designed to investigate the separate effects of chronic pain and depression on selective attention, as assessed by a modified Stroop task. In order to investigate this question, the four groups of subjects were required to complete five Stroop conditions, namely positive, neutral, sensory pain, affective pain, and depressive stimuli.

### Method

Subjects. Subjects in the three pathology groups (i.e. PD, PN and ND) were recruited by referral from psychologists and physicians at three local hospitals. Nonpain/nondepressed control subjects were hospital employees recruited through personal contact. Altogether, 93 subjects were run in the present project. Of this group of 93, 60 subjects were included in the final sample. Thirty-three subjects were excluded for failure to meet diagnoistic criteria for depression. Specifically, 15 age, sex, and education-matched subjects were assigned to each of the four groups on the basis of specific inclusion and

exclusion criteria. General inclusion criteria for all subjects were: a) age less than 65, b) an education level of Grade 11 or higher, and b) English as a first language. For the chronic pain/depressed (PD) group, the inclusion criteria were: a) pain of six months duration or longer, b) a score of greater than 30 on a 100 mm visual analogue pain scale; c) a score of greater than 10 on the Centre for Epidemiological Studies Depression Scale, and d) a diagnosis of Major Depressive Episode according to DSM-IIIR criteria (American Psychiatric Association, 1987), as quantified by the SCID (Spitzer, Williams, Gibbons, & First, 1990). For the chronic pain/nondepressed (PN) group, the inclusion criteria were: a) pain of six months duration or longer, b) a score of greater than 30 on a 100 mm visual analogue pain scale; and c) a score of less than 10 on the Centre for Epidemiological Studies Depression Scale. For the nonpain/depressed (ND) group, the inclusion criteria were: a) a score of greater than 10 on the Centre for Epidemiological Studies Depression Scale, and d) a diagnosis of Major Depressive Episode according to DSM-IIIR (American Psychiatric Association, 1987) criteria, as quantified by the SCID (Spitzer et al., 1990). Exclusion criteria for the ND group were: a) a diagnosis of bipolar disorder, b) a current course of electroconvulsive therapy, c) reports of any pain-inducing physical complaints. For the nonpain/nondepressed (NN) group, exclusion criteria were: a) any current pain symptomatology, or b) any current depressive symptomatology.

Groups were matched on sex, age, and education level. Each group was comprised of 12 females and 3 males. Subjects with chronic pain were heterogeneous with respect to medical diagnosis. The entire sample of subjects comprised 23 individuals with a diagnosis of fibromyalgia

syndrome, 21 with myofascial pain syndrome, 10 with a diagnosis of low back pain, two with rheumatoid arthritis, two with undiagnosed musculoskeletal pain, one with osteoarthritis, and one with reflex sympathetic dystrophy. After assignment to experimental groups on the basis of affective criteria, the two pain groups had the following diagnostic composition: PD: five fibromyalgia, six myofascial pain, three low back pain, and one undiagnosed pain; PN: six fibromyalgia, six myofascial pain, two rheumatoid arthritis, and one osteoarthritis. Thus, although the two groups were heterogeneous with respect to medical diagnosis, no one medical diagnosis predominated in a particular group.

Materials

Demographic Data. Subjects provided information regarding age, sex, years of education, medical diagnosis (for the PD and PN groups), duration of pain (for the PD and PN groups), and current medications.

Visual Analogue Scales. Subjects in the present project completed the same three visual analogue scales which had been completed by subjects in Pilot Study II. Briefly, one VA scale assessed present pain level, one assessed negative mood, and one measured positive mood. The pain VAS was designed to assess sensory pain intensity, and was anchored by the descriptors "no pain" and "very severe pain". The negative mood VAS was anchored by the descriptors "not at all unhappy" and "very unhappy", and the positive mood VAS was anchored by the descriptors "not at all happy" and "very happy". The reliability and validity of visual analogue scales for assessing pain (Chapman et al. 1986) and mood (Davies, Burrows, & Poynton, 1975) have been discussed elsewhere.

Stroop Task. Five groups of ten words each were compiled for use in the present study. The groups were comprised of sensory pain words,

affective pain words, depressive words, positive words, and neutral words. The sensory and affective pain words were drawn from McGill Pain Questionnaire (MPQ) protocols completed by 65 chronic pain subjects in a separate research project (Boissevain, 1993). From these MPQ protocols frequency-of-usage indices were calculated for each of the 78 pain descriptors contained in the MPQ, thus enabling the matching of sensory and affective pain stimuli on the basis of their familiarity to a sample of chronic pain subjects. In addition to matching the pain descriptors on the basis of frequency of usage among a sample of chronic pain patients, the final groups of ten words each were further constrained by matching as closely as possible on the basis of length and overall frequency of usage in the English language (Kucera & Francis, 1967).

Depressive and positive stimuli were drawn from a list of words compiled by Myers (1980), who obtained self-descriptiveness ratings of 400 adjectives from depressed patients and manic-phase bipolar patients. In addition, Myers (1980) obtained pleasantness ratings for the word list from university students. For the present project, the depressive stimuli were selected from among those words which were both two standard deviations above the mean on depression ratings and two standard deviations below the mean on manic ratings. Positive stimuli were selected from among those words which were both two standard deviations above the mean on manic ratings and two standard deviations below the mean on depression ratings. From these two lists, ten depressive and ten positive descriptors were matched with the pain descriptors on the basis of length and frequency of usage (Kucera & Francis, 1967). Finally, the neutral stimuli were chosen from among those words which were within one standard deviation of the mean on

pleasantness ratings and which had not been selected for either the positive or depressive list. As with the other word categories, neutral descriptors were matched with other stimuli on the basis of length and frequency of usage. The final word lists and their respective ratings are presented in Table 3-1.

For the Stroop task, the ten words from the five categories described above were included, namely positive, neutral, sensory pain, affective pain, and depressive. In addition to these five categories, a simple colour-naming condition was included, wherein subjects were presented with a series of seven "O"s printed in one of four colours. The colour naming condition was included to allow subjects to gain familiarity and practice with the task, and to screen for colour blindness. Data from the colour naming condition were not included in subsequent analyses. Stimuli for each condition were presented on a single 21 cm by 28 cm card, with 80 stimuli arranged in 20 rows of 4 columns. Stimuli were printed 5 cm high in orange, blue, green, and red ink. For each card, colour and/or word combinations were arranged randomly, with the following restrictions: a) on all cards, each colour appeared 20 times; b) for the positive, neutral, sensory, affective, and depressive cards, each word was presented eight times; and c) no colour or colour-word combination appeared more than twice in succession in a row or column.

Semantic Processing Test. Subjects completed a semantic processing test (Appendix E) which has been shown to be sensitive to the effects of drugs (Baddeley, 1981), and which has been used in previous research on cognitive processing in emotional disorders (Williams & Broadbent, 1986a; Williams & Scott, 1988). For the present project,

this task was included so that it would be possible to detect whether drug effects would be likely to influence the results on any of the cognitive tasks under consideration. In the semantic processing task, subjects marked with either a check mark or an "X" which of 50 statements were true (e.g. "Admirals are people.") and which were false (e.g. "Tomato soup moves around looking for food."). The time taken to complete this task was recorded with a stopwatch.

Centre for Epidemiological Studies Depression Scale. Subjects in the present project completed the CES-D (Radloff, 1977), whose psychometric properties have been described previously.

Diagnostic Interview for Depression. Subjects were given a brief diagnostic interview for depression, based on the DSM-IIIR criteria for major depressive episode, and quantified in the SCID (Spitzer et al., 1990). In this interview, nine items were used to arrive at a diagnosis of depression, including depressed mood, anhedonia, weight loss, insomnia/hypersomnia, psychomotor agitation/retardation, fatigue, feelings of worthlessness, concentration difficulties, and suicidal ideation. Responses to these nine items were rated on a four-point scale where "1" indicated that a symptom is absent, "2" indicated that a symptom in present, but not in the degree necessary to confirm a diagnosis, "3" indicated that a symptom is clearly present, and "?" denoted a lack of sufficient information to determine the presence or absence of a symptom. In order to diagnose depression, at least five of the nine items must be coded "3", including either or both depressed mood and anhedonia. This interview was also structured to rule out depression due to organic factors and bereavement, and to elicit information on the lifetime history of depression (i.e. number of

Table 3-1:
Verbal Stimuli and Matching Criteria

| | Pain Ratings* | Kucera-Francis Norms | Length |
|---|---|---|---|
| **Sensory Pain** | | | |
| Throbbing | 57 | 03 | 9 |
| Aching | 62 | 06 | 6 |
| Shooting | 54 | 18 | 8 |
| Tender | 55 | 10 | 6 |
| Stabbing | 46 | 00 | 8 |
| Wrenching | 25 | 01 | 9 |
| Radiating | 17 | 01 | 9 |
| Burning | 52 | 29 | 7 |
| Pulling | 22 | 19 | 7 |
| Sore | 17 | 09 | 4 |
| Mean | 40.70 | 9.60 | 7.30 |
| (SD) | (18.18) | (9.62) | (1.64) |
| **Affective Pain** | | | |
| Exhausting | 55 | 03 | 10 |
| Nagging | 52 | 09 | 7 |
| Miserable | 45 | 11 | 9 |
| Tiring | 42 | 04 | 6 |
| Wretched | 40 | 06 | 8 |
| Sickening | 32 | 02 | 9 |
| Agonizing | 28 | 03 | 9 |
| Annoying | 25 | 06 | 8 |
| Fearful | 23 | 12 | 7 |
| Cruel | 11 | 14 | 5 |
| Mean | 35.30 | 7.00 | 7.50 |
| (SD) | (13.90) | (4.24) | (1.58) |
| **Depressive** | | | |
| Worthless | | 03 | 9 |
| Dismal | | 08 | 6 |
| Depressed | | 11 | 9 |
| Forlorn | | 03 | 7 |
| Desolate | | 06 | 7 |
| Despondent | | 02 | 10 |
| Deficient | | 03 | 9 |
| Inferior | | 07 | 8 |
| Useless | | 17 | 7 |
| Hollow | | 12 | 6 |
| Mean | | 7.00 | 7.70 |
| (SD) | | (4.99) | (1.42) |

Table 3-1 (Continued)

| | Kucera-Francis Norms | Length |
|---|---|---|
| **Positive** | | |
| Playful | 07 | 7 |
| Witty | 10 | 5 |
| Energetic | 11 | 9 |
| Hearty | 04 | 6 |
| Sparkling | 05 | 9 |
| Terrific | 05 | 8 |
| Hilarious | 02 | 9 |
| Exuberant | 07 | 9 |
| Cheerful | 10 | 8 |
| Sunny | 06 | 7 |
| Mean | 6.70 | 6.70 |
| (SD) | (2.91) | (1.49) |
| **Neutral** | | |
| Inhabited | 06 | 9 |
| Angled | 00 | 6 |
| Courteous | 06 | 9 |
| Attentive | 05 | 9 |
| Material | 02 | 8 |
| Related | 11 | 7 |
| Harmless | 05 | 8 |
| Disguised | 11 | 9 |
| Logical | 34 | 7 |
| Gradual | 16 | 7 |
| Mean | 9.60 | 7.90 |
| (SD) | (9.77) | (1.49) |

Note:
* "Pain Ratings" refers to the proportion of a chronic pain sample which selected each stimulus from the MPQ.

incidents and age of onset). A complete example of the interview and scoring protocol are shown in Appendix F. Of the 60 subjects in the present study, 20 were selected for rating by a senior graduate student in clinical psychology who had training in the administration of structured diagnostic interviews. The percentage agreement on diagnostic category was 90%, which resulted in a kappa coefficient of .80 (Cohen, 1960). Previous researchers have suggested that this represents an acceptable level of inter-observer reliability (Gelfand & Hartmann, 1975; Hartmann, 1977).

Procedure

As discussed above, subjects in the PD, PN, and ND groups were referred by psychologists and physicians at three local hospitals. Subjects in the NN group were referred by word of mouth. After the referral was made, subjects were contacted either by telephone or in person to explain the general nature of the study and to arrange a subsequent testing appointment. At the time of the experimental session, subjects were presented with a letter of explanation and informed consent was obtained (see Appendix G).

Subjects provided demographic information and completed the three VA scales and the modified Stroop task. Subjects were presented with the Stroop cards in a split-randomized order in which the order of presentation of the positive and neutral cards was randomized, as was the order of presentation of the sensory, affective, and depressive cards. However, the three negative cards were consistently presented after the two less-threatening cards. This split-randomized method of presentation was chosen because previous research has shown that presentation of emotionally-charged words may retard performance on

subsequent word presentations (McKenna, 1986). However, it was also felt that it was important to randomize the order of presentation as much as possible in order to minimize potential practice or fatigue effects. Thus the two groups of cards were randomized separately. Subjects were requested to name the colour in which the stimuli were printed by proceeding down each of the four columns, beginning at the top left-hand stimulus. Stroop cards were presented one at a time, with a brief interval between each card presentation to reiterate the instructions. Subjects' responses were timed with a stopwatch and audio-taped for later timing by a rater blind to the subjects' pain status or diagnostic category.

Following the Stroop task, subjects completed the autobiographical memory task. They then completed the semantic processing test, which was used as a distracter in the interval between the autobiographical memory task and the incidental recognition task. Following these three information-processing tasks, subjects responded to the CES-D and the depression structured interview. Subjects were then debriefed and thanked for their participation. The entire testing session required an average of 75 minutes to complete.

## Results and Discussion

Group means and standard deviations for age, education level, CES-D scores, VA mood scores, VA pain scores, and semantic processing time are presented in Table 3-2. Individual analyses of these variables are presented in the following subsections.

Demographic Information. One-way analyses of variance revealed no significant group effects for either age ($F(3,56) < 1.00$) or education

Table 3-2:
Group Means and Standard Deviations for
Demographic Variables, Mood,
Pain Levels and Semantic Processing

| Variable | Subject Group PD Mean (SD) | PN Mean (SD) | ND Mean (SD) | NN Mean (SD) |
|---|---|---|---|---|
| Age | 39.93 (11.25) | 40.80 (10.00) | 35.87 (9.37) | 42.00 (12.64) |
| Education Level | 13.27 (3.51) | 14.00 (2.73) | 14.20 (2.98) | 15.13 (2.61) |
| CES-D Scores | 18.87 (8.79) | 3.67 (11.34) | 12.00 (7.78) | 3.87 (3.81) |
| VA Negative Mood | 64.38 (22.95) | 19.07 (24.96) | 52.26 (22.13) | 5.56 (8.86) |
| VA Positive Mood | 29.13 (22.95) | 68.83 (24.96) | 38.81 (22.13) | 83.90 (23.68) |
| VA Pain | 55.93 (21.28) | 32.53 (13.92) | 0.61 (2.37) | 1.06 (3.13) |
| Semantic Processing Time | 115.47 (25.67) | 112.07 (25.22) | 126.73 (31.52) | 103.33 (24.82) |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

level ($F(3,56) < 1.00$), thus demonstrating successful matching of groups on the basis of age and education.

Mood and Pain Differences. A one-way analysis of variance on CES-D scores revealed a significant effect ($F(3,56)=35.09$, $p < .0001$). Post-hoc analyses were conducted by means of a Newman Keuls procedure (Kirk, 1982, pp. 123-125). It was found that the two depressed groups (i.e. PD and ND) did not differ from each other, and that the nondepressed groups (i.e. PN and NN) did not differ from each other. However, the two depressed groups obtained significantly higher CES-D scores than each of the nondepressed groups ($p < .01$ for all comparisons).

These results were corroborated by the VAS mood measures. A significant effect was observed for negative mood ($F(3,56)=26.55$, $p < .0001$), and for positive mood ($F(3,56)=17.85$, $p < .0001$,. Again, Newman Keuls post hoc analyses demonstrated that the two depressed groups were equivalent to each other in VAS negative mood scores, as were the nondepressed groups. The depressed groups reported significantly higher levels of negative mood than the nondepressed groups ($p < .01$ for all comparisons). The depressed groups were equivalent on VAS positive mood scores, as were the nondepressed groups. The nondepressed groups reported significantly higher levels of positive mood than depressed groups ($p < .01$ for all comparisons). These results suggest that subject assignment on the basis of mood resulted in clearly-distinguishable groups.

A one-way analysis of variance conducted on VAS pain scores also yielded a significant effect ($F(3,56)=64.78$, $p < .0001$). Newman Keuls post hoc analyses demonstrated that only the two nonpain groups did not

differ from each other on VAS pain scores. All other comparisons were significant at $p < .01$. Of particular note here is that PD group rated their pain as significantly higher than the PN group, thus suggesting negative emotion probably contributed to some of the elevation in VAS pain scores for the PD group.

These results demonstrate that in general, the four groups under consideration are clearly separable in terms of both pain and mood. On all three measures of mood the depressed groups were equivalent to each other, but significantly different from the nondepressed groups. This result provides confirmation that the diagnostic interview process was successful in discriminating subjects on the basis of mood. Although the PD group reported higher pain levels than the PN group, both of these groups are clearly distinct from the nonpain groups, who reported virtually no pain. On the basis of these analyses it can be claimed with some confidence that subsequent analyses are likely to reflect genuine pain and depression effects.

Semantic Processing Task. The results of a one-way ANOVA on semantic processing were nonsignificant ($F(3,56)=2.23$, n.s.), suggesting that in spite of medication and depressed mood, subjects did not differ in their response to this task. Thus it is possible to assume that results on the cognitive tasks to be described in subsequent sections were probably not biased by medication effects.

## Analyses of Stroop Performance

Inter-Rater Reliability. On a random sample of 12 subjects, the correlations between timing performed by the experimenter and that performed by the blind rater ranged from .94 to .99. Because of the

strength of these correlations, all analyses were performed on response times recorded by the experimenter.

Stroop Latencies. Mean latencies across the five Stroop conditions are presented in Table 3-3. To further clarify group differences, the results are presented graphically in Figure 3-1. A 4 X 5 repeated measures multivariate analysis of variance was performed on the Stroop response latency. Group was the between-subjects factor, and stimulus type was the within subjects factor. Response latency was significantly affected by group membership ($F(3,56)=11.93$, $p < .0001$). With the use of Wilk's criterion, response latency was also affected by stimulus condition ($F(4,53)=8.24$, $p < .0001$), and by the interaction term ($F(12,165)=3.93$, $p < .0001$).

In examining the group effect, Newman Keuls post hoc analyses demonstrated that across all five stimulus conditions, the two depressed groups (i.e. PD and ND) did not differ from each other on response time. Similarly, the two nondepressed groups (i.e. PN and NN) did not differ from each other on response time. However, the overall response time of each of the depressed groups differed from each of the nondepressed groups at $p < .05$. This result suggests that the presence of depression resulted in a general psychomotor retardation effect on Stroop performance.

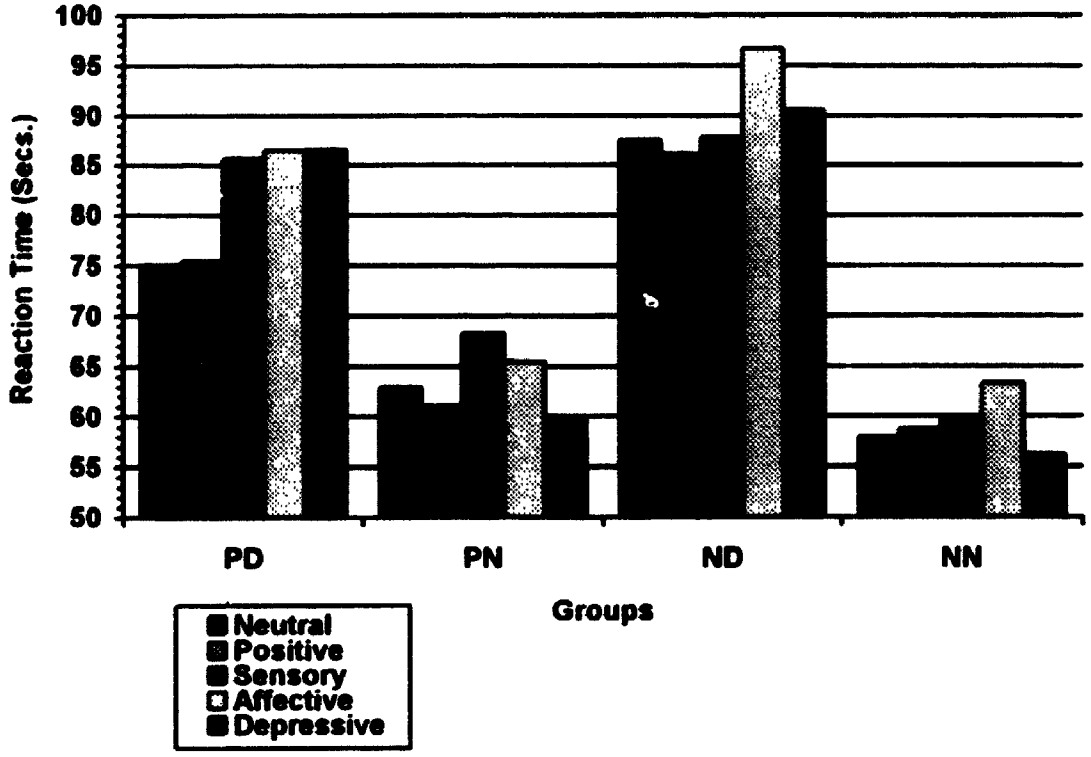
In examining the stimulus condition effect, Newman Keuls post hoc analyses demonstrated that all five stimulus conditions were statistically equivalent, except for the comparison between affective pain stimuli and neutral stimuli ($p < .05$), and the comparison between

Table 3-3:
Reaction Times Across Five Stimulus Conditions
Modified Stroop Task

| Stimulus Type | Subject Group PD (n=15) Mean (SD) | PN (n=15) Mean (SD) | ND (n=15) Mean (SD) | NN (n=15) Mean (SD) | Stimulus Type Mean (SD) |
|---|---|---|---|---|---|
| Neutral | 75 07 (14.94) | 62.90 (10.23) | 87.53 (22.57) | 57.90 (9.67) | 70.85 (18.84) |
| Positive | 75.49 (16.43) | 61.05 (9.04) | 86.13 (25.38) | 58.80 (9.25) | 70.36 (19.57) |
| Sensory | 85.68 (24.74) | 68.22 (10.54) | 87.81 (20.61) | 59.79 (8.61) | 75.37 (20.76) |
| Affective | 86.54 (25.01) | 65.41 (8.36) | 96.72 (26.51) | 63.32 (12.14) | 78.00 (23.86) |
| Depressive | 86.60 (21.76) | 60.02 (8.21) | 90.56 (23.60) | 56.28 (10.50) | 73.36 (22.93) |
| Group Means (SD) | 81.87 (19.55) | 63.51 (8.74) | 89.75 (22.89) | 59.21 (9.31) | |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

Figure 3-1:
Reaction Times Across Five Stimulus Conditions
Modified Stroop Task



affective stimuli and positive stimuli ($p < .05$). These results suggest that some attentional interference occurred for all subjects on the affective pain stimuli, perhaps because these stimuli may have had a generalized negative emotional valence which resulted in an attentional interference effect which was equivalent across all subject groups.

In order to examine the differential performance of each group across the five stimulus conditions, individual group means were further analyzed by Newman Keuls post hoc analyses (Kirk, 1982, pp. 123-125). Post-hoc analyses demonstrated that for the PD group, response times to the neutral and positive stimuli were equivalent to each other, as were the response times to the sensory, affective, and depressive stimuli. The colour-naming times for sensory pain, affective pain, and depressive stimuli were each significantly longer than the means for the neutral and positive stimuli ($p < .01$ for all comparisons). Thus the hypotheses concerning the effects of pain and depression on attention were supported: the PD group produced longer colour naming times for sensory pain, affective pain, and depressive stimuli in comparison with positive or neutral stimuli. This suggests that for this group, attention was drawn toward state-relevant stimuli, thus confirming the presence of a combined pain-specific and mood-specific attentional interference effect.

For the PN group, post-hoc analyses demonstrated that response times to the sensory stimuli were significantly slower than response times to neutral, positive, and depressive stimuli ($p < .01$ for all comparisons). Unexpectedly, however, response times to the affective pain stimuli were also slower than response times to positive and neutral stimuli ($p < .01$). Thus the hypothesis concerning the PD group

was partially supported: although the PN group showed a state-specific interference effect for sensory pain words, an unexpected interference effect also occurred for affective stimuli. Although unexpected, as noted above in discussing the main effect for stimulus condition, this result may be have been due to a generalized interference effect for affective pain stimuli due to their nonspecific negative valence.

Post-hoc analyses demonstrated that for the ND group, response times to the neutral, positive, sensory, and depressive stimuli were equivalent. For this group, only the mean for affective pain stimuli differed from the positive and sensory stimuli at $p < .01$, and from the depressive stimuli at $p < .05$. The attention-specific hypothesis was therefore not supported for the ND group: it was predicted that this group would show a specific interference effect only for the depressive stimuli. Although the colour naming time for the depressive stimuli ($M$ = 90.65) was slower than the reaction time for both the neutral ($M$ = 87.53) and positive stimuli ($M$ = 86.13), these differences were not significant. However, the ND group did show an interference effect for the affective pain stimuli, again suggesting that these stimuli produced a generalized attentional interference effect.

Finally, for the NN group colour-naming times for the response times to the neutral, positive, sensory, and depressive stimuli were equivalent. For this group, the mean for affective pain stimuli differed from the positive and depressive stimuli at $p < .01$, and from the sensory stimuli at $p < .05$. Although the overall colour-naming times were faster for the NN group than for the ND group, the two groups produced parallel profiles across the five stimulus categories, with an increased colour-naming speed only for the affective pain stimuli in

relation to the other four stimulus categories. Again, this result suggests that the affective stimuli exerted an attentional interference effect regardless of the subjects' pain or affective status.

Three observations may be made on the results obtained in Phase I of the principal study. First, it appears that depression exerted a retarding effect on the overall speed of cognitive processing on the modified Stroop task, as demonstrated by the group main effect which was obtained. Post hoc analyses demonstrated that between group differences were attributable to depression, with the two depressed groups (PD and ND) significantly slower than the nondepressed groups (PN and NN) across all five stimulus conditions. This result suggests that if cognitive processing is slowed in individuals with chronic pain, this phenomenon may be due to mood rather than to pain per se.

Second, although state-specific attentional interference effects were obtained in Phase I of the present study, they did not hold equally for all groups. As predicted, the PD group obtained slower colour naming times for sensory, affective, and depressive stimuli relative to positive and neutral stimuli. The PN group also obtained slower colour naming times for sensory pain descriptors relative to positive, neutral, and depressive stimuli. However, the PN group also manifested an interference effect for affective pain stimuli. For the ND group, the state-specific hypotheses were not supported: slower colour-naming times were obtained only on affective pain stimuli. A parallel pattern was shown by the NN group, with an interference effect on the affective pain stimuli. Thus the attentional interference hypotheses appear to hold for only the PD and PN groups in the present phase, with the ND group showing an interference effect that was not depression-specific.

The observation that all groups manifested an interference effect on the affective pain stimuli suggests that these words may be uniformly distracting to all subjects regardless of pain or affective status. However, if the affective pain stimuli and the ND group were excluded from the analyses, it appears that there would be a clear state-specific interference effect when comparing the PD, PN and NN groups. A 3 (group: PD, PN, NN) by 4 (stimulus category: positive, neutral, sensory, depressive) repeated measures MANOVA was computed to test this observation. With the use of Wilk's criterion, response latency was found to be significantly affected by the interaction term ($F(6,80)=5.27$, $p < .0001$), thus suggesting the presence of a state-specific attentional bias across these three groups, when the effect of affective pain stimuli was disregarded. However, no mood-specific effects for the pure depression group (ND) were observed, with colour-naming speed significantly different only from the affective pain stimuli. This latter finding is in agreement with some recent studies which have failed to find consistent depression-specific effects on the Stroop task. Some researchers have suggested that depression-specific Stroop effects may be found only with certain stimuli (Hill and Knowles, 1991), while others have suggested that such effects may hold only for moderately-depressed subjects (Klieger and Cordner, 1990). Such inconsistencies have led Williams and Nulty (1986) and Williams et al. (1988) to suggest that state-specific Stroop phenomena are dependent both on degree of disturbance and type of words used. They have also suggested that state-specific Stroop retardation effects are most reliably obtained with anxiety disorders, rather than with depression. Although the depressed pain subjects in the present study all had a

valid diagnosis of depression, it is possible that their cognitive processing style may share some attributes with anxiety-disordered subjects. Further research will be required to clarify this issue.

The third observation which may be made of the Phase I results concerns the attentional interference which was consistently observed on the affective pain stimuli. If all groups manifested an interference effect to the affective stimuli, it is possible that their negative valence was sufficiently intense that they drew the attention of all subjects, regardless of affect or pain status. Previous research has demonstrated that nonspecific negative verbal stimuli can exert a retarding effect on colour naming times regardless of the subjects' emotional status (Watts et al., 1986). A similar effect may have occurred in the present phase of the principal study, so that affective pain words may not be perceived as relevant only to a particular state. Rather, it may have been the case that these stimuli activated attentional resources equally for all subject groups. This result brings into question the discriminant validity of verbal affective pain stimuli when applied to subjects without pain. Indeed, it appears that none of the validity studies conducted on the MPQ addressed this issue of between-group discrimination for affective pain stimuli (e.g. Holroyd et al., 1992; Melzack 1975; Melzack & Torgerson, 1971).

In summary, it appears that pain and depression exerted a state-specific biasing effect on attention for the two pain groups, but not for the depressed group. Thus the main hypotheses concerning the effects of pain and depression on attention were supported.

## Phase II: Autobiographical Memory Task

### Overview of the Design

Phase II was run after the Stroop task described above. The autobiographical memory task to be described here employed a reaction-time paradigm, wherein subjects are cued with a word of specific emotional valence. Latency to recall a personal memory is the dependent measure in this design. Previous research with depressed subjects has generally found depression/word-type interactions (Williams et al., 1988), wherein depressed subjects are significantly slower to recall positively-cued memories, and faster to retrieve negatively-cued memories in comparison with nondepressed subjects. In addition, Williams and his group (e.g. Williams & Broadbent, 1986; Williams & Dritschel, 1988; Williams & Scott, 1988) have also found that depression is associated with the tendency to recall general, rather than time- or place-specific autobiographical memories. Phase II of the present study has adapted this methodology to the investigation of autobiographical memory in chronic pain. The same four groups of subjects described above completed Phase II, i.e. chronic pain-depressed (PD), chronic pain-nondepressed (PN), nonpain-depressed (ND), and nonpain-nondepressed (NN). All subjects were cued with four groups of words, i.e. positive, sensory pain, affective pain, and depressive.

It was predicted that: a) the PD group would take less time to retrieve memories to sensory pain, affective pain, and depressive cues relative to positive cues; b) the PN group would take less time to retrieve memories to sensory pain cues and positive cues relative to affective pain and depressive cues; c) the ND group would take less time to retrieve memories to depressive cues relative to other classes of

cues; and d) the NN group would take less time to retrieve memories to positive cues relative to other classes of cues. In terms of generality of autobiographical memory, based on research by Williams and his colleagues (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Williams & Scott, 1988), it was expected that a group main effect would emerge, with depressed subjects regardless of pain status, providing more general memories than nondepressed subjects across all stimulus types. It was also was expected that a group by stimulus type interaction would be found. Specifically, it was expected that all depressed subjects, regardless of pain status, would retrieve a higher proportion of general memories to positive cues than to negative cues, and that nondepressed subjects would retrieve a higher proportion of general memories to negative cues than to positive cues. Finally, it was expected that the presence of chronic pain, regardless of affective status, would be associated with a higher proportion of general memories to positive cues than to pain-related cues.

## Method

Subjects. Subject selection procedures were described above in the Phase I Method section.

## Materials

Autobiographical Memory Task. Five stimuli from each of four classes of words: positive, sensory pain, affective pain, and depressive were used in the present phase of the principal study. Thus each subject was cued with 20 words. The word list for the present phase was derived from the appropriate categories derived for Phase I (see Table 3-1). The pain words in each category were selected because they showed the highest likelihood of discriminant validity. For example, the word

"shooting" was omitted because, although pain subjects would be likely to apply it in a pain-relevant direction, it was expected that non-pain subjects might be likely to misapply in terms of its pain meaning. Thus words with more obvious pain connotations such as "aching", "sore", and "hurting" were selected. It was difficult to select words with face validity for the affective pain category, as all words in this category had general negative emotional connotations, as well as pain-relevant connotations. For this reason, the five affective pain words with the highest frequency of usage among patients (see Table 3-1) were selected. The positive and depressive words were selected because they matched with the pain words on the basis of length and frequency of usage. The stimuli used in the present phase are shown in Table 3-4.

Procedure

After completing the Stroop task, the autobiographical memory test was introduced to each subject by the experimenter. Subjects were given standardized instructions for responding to cue words, as follows:

> I am now going to read a list of words to you, one at a time. After I read each word, you will have 60 seconds to recall a specific personal memory which is related to the word. For instance, if I read the word "late", you might say, "I was late for dinner last Thursday." This memory is <u>specific</u> because you were able to say exactly when it happened. However, if you said, "I was always late when I was younger.", this would not be a specific memory. To repeat, I would like you to try to recall a specific personal memory to each word. Do you understand?

Subjects were given three practice cues in order to ensure that they understood the requirement for specific memories. Five series of four

Table 3-4:
Verbal Stimuli Used in
the Autobiographical Memory Task

| Positive | Sensory Pain | Affective Pain | Depressive |
|---|---|---|---|
| Playful | Aching | Nagging | Worthless |
| Witty | Sore | Miserable | Dismal |
| Energetic | Tender | Tiring | Depressed |
| Hearty | Hurting | Wretched | Forlorn |
| Cheerful | Throbbing | Exhausting | Desolate |

words were presented in the sequence: depressive, positive, sensory pain, affective pain. Subjects were given sixty seconds to retrieve a specific autobiographical memory to each cue word. If they were unable to recall a memory to a particular word, a time of sixty seconds was recorded and the experimenter read the next word on the list. If they recalled a general memory, they were prompted for a specific memory with a standard prompt, as used in Williams and Scott (1988): "Can you think of a specific time/one particular occasion?" Subjects' responses were audiotaped so that the generality of their responses could be judged by a second rater.

The second rater was instructed to use the same guidelines employed by Williams and his colleagues in coding the generality of memories (Williams & Broadbent, 1986; Williams & Dritschel, 1988; Williams & Scott, 1988). As discussed above in Chapter 1, a memory was coded as "general" if a subject was unable to give specific details of a date, day of the week, or time of day when an event occurred. Examples of specific responses would be: "last Tuesday...", or "during the summer when I was 16...". Examples of general responses would be "when I was in school...", or "I always seem to...". With the present data, on a random sample of 20 subjects, this procedure produced an interrater agreement percentage of 85%, and a kappa coefficient of .69 (Cohen, 1960), thus demonstrating an acceptable level of reliability on judgements of response generality (Gelfand & Hartmann, 1975; Hartmann, 1977).

Results and Discussion

Validity of Affective Pain Stimuli The two dependent measures of most interest in the present phase are the latency to first recall, and

the proportion of general responses. However, because of the question of discriminant validity for affective pain stimuli, responses were also rated as to whether subjects utilized a word in a valence-congruent direction or whether the word was used in an valence-incongruent fashion. An example of a sensory pain word used in a pain-congruent direction is: "My neck was tender last week.", whereas an example of the same word used in an incongruent fashion is: "The steak I ate last night was tender." This rating was performed in order to investigate the validity of the words across the four groups. The proportion of congruent responses across all stimulus types for each group is presented in Table 3-5. In order to examine the effect of group membership and stimulus type, a 4 X 4 repeated-measures multivariate analysis of variance was performed on response congruence. Group was the between-subjects factor, and stimulus type was the within-subjects factor. Response congruence was significantly affected by group membership ($F(3,56)=8.23$, $p < .0001$). With the use of Wilk's criterion, response congruence was also affected by stimulus type ($F(3,54)=111.93$, $p < .0001$), and by the interaction term ($F(9,131.57)=5.73$, $p < .0001$).

In order to investigate the discriminant validity of the affective pain stimuli, Newman Keuls post hoc analyses were used to examine the stimulus type effect. Averaged across the four groups, affective stimuli were interpreted in a state-congruent fashion significantly less often than were positive, sensory pain, or depressive stimuli ($p < .01$ for all comparisons). This result brings into question the utility of affective pain stimuli in discriminating between groups experiencing chronic pain and groups who are not experiencing chronic pain. Because, for example, only 36% of NN group's responses to affective pain cues

Table 3-5:
Group Means Across Four Stimulus Conditions:
Proportion of Congruent Responses on
Autobiographical Memory Task

| Stimulus Type | Subject Group PD (n=15) Mean (SD) | PN (n=15) Mean (SD) | ND (n=15) Mean (SD) | NN (n=15) Mean (SD) | Stimulus Type Mean (SD) |
|---|---|---|---|---|---|
| Positive | .95 (.16) | .99 (.05) | .99 (.05) | 1.00 (.00) | .98 (.08) |
| Sensory | .96 (.46) | .87 (.32) | .64 (.69) | .71 (.05) | .79 (.55) |
| Affective | .60 (.20) | .49 (.18) | .49 (.15) | .36 (.20) | .49 (.20) |
| Depressive | .96 (.08) | .80 (.24) | .88 (.15) | .76 (.20) | .85 (.20) |
| Group Means (SD) | .87 (.08) | .79 (.10) | .75 (.09) | .70 (.09) | |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

were in a pain-congruent direction, it is doubtful whether subsequent analyses on these stimuli could be said to reflect memory processes concerning pain per se. For this reason, all subsequent analyses will be limited only to responses to the positive, sensory pain, and depressive cues. In dropping the affective stimuli from analyses, the pattern of significant results was not altered. Comparison of results with four stimulus groups and three stimulus groups is presented in footnote 1.

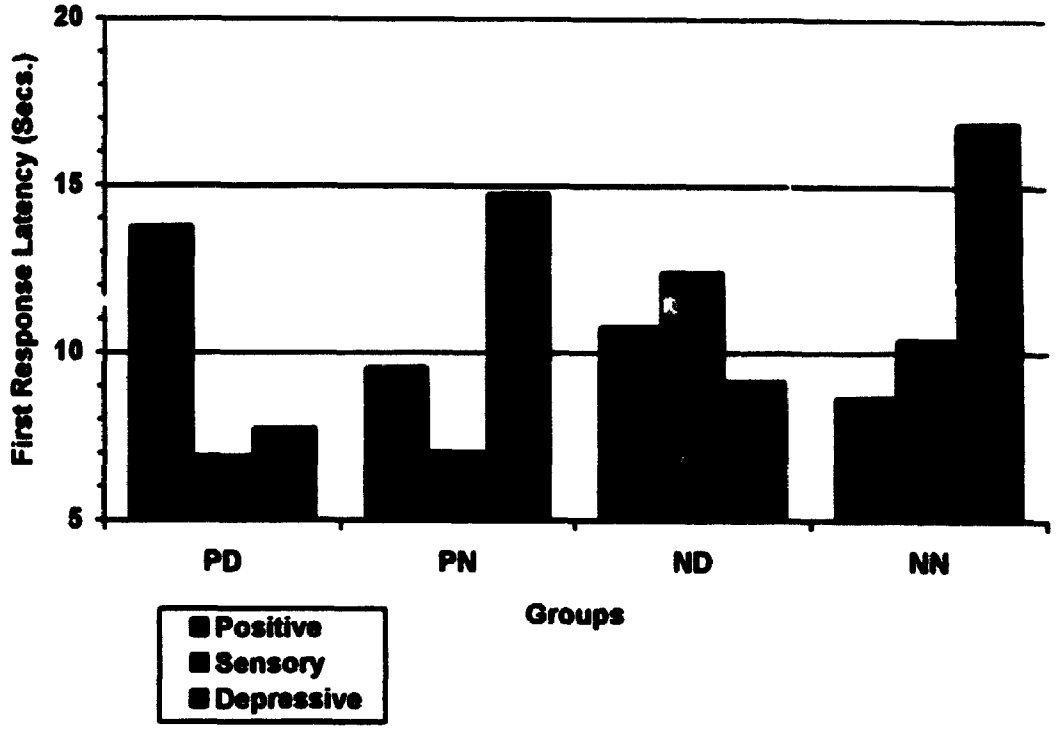
Recall Latency It was predicted above that groups would show state-dependent effects in recall latency, so that presentation of a state-relevant cue would result in faster recall times than the presentation of a cue which was less relevant. Recall latencies are presented in Table 3-6. Recall latencies are also presented graphically in Figure 3-2. It should be noted that the means presented in Table 3-6 are calculated only on those stimuli which were used in a state-congruent fashion, as discussed in the previous section. The exclusion of those stimuli which were not used in a state-congruent fashion should reduce the likelihood that recall times are contaminated by cognitive processes which do not relate to pain or mood status. In limiting the analysis to congruent stimuli, some data points were dropped from each class of stimulus. However, using a listwise deletion strategy, no individual subject had to be dropped from anlalysis due to missing data on any single class of stimulus. To examine the influence of group and stimulus type on recall latency, a 4 by 3 repeated measures multivariate analysis of variance was computed. Group was the between-subjects factor, and stimulus type was the within-subjects factor. Response latency was not significantly affected by group membership

Table 3-6:
Group Means Across Three Stimulus Conditions:
First Response Latency on
Autobiographical Memory Task

| Stimulus Type | PD (n=15) Mean (SD) | PN (n=15) Mean (SD) | ND (n=15) Mean (SD) | NN (n=15) Mean (SD) | Stimulus Type Mean (SD) |
|---|---|---|---|---|---|
| | Subject Group | | | | |
| Positive | 13.77 (9.61) | 9.56 (4.26) | 10.77 (7.11) | 8.66 (3.66) | 10.68 (6.73) |
| Sensory | 6.90 (5.46) | 7.02 (4.32) | 12.41 (7.69) | 10.39 (7.05) | 9.18 (6.55) |
| Depressive | 7.74 (6.03) | 14.78 (7.73) | 9.13 (6.01) | 16.91 (9.73) | 12.14 (8.28) |
| Group Means (SD) | 7.10 (4.35) | 7.84 (3.05) | 8.07 (4.54) | 8.99 (3.59) | |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

Figure 3-2:
Group Means Across Three Stimulus Conditions:
First Response Latency on
Autobiographical Memory Task



($F(3,56) < 1$). With the use of Wilk's criterion, response latency was significantly affected by stimulus type ($F(6,110)=6.83$, $p < .0001$), and by the interaction term ($F(2,55)=4.31$, $p < .05$).

Newman Keuls post hoc analyses demonstrated that for the PD group, retrieval times for sensory pain and depressive cues were equivalent, and were significantly shorter than retrieval times for positive cues ($p < .01$ for both comparisons). This result suggests that the PD group was biased in favour of recalling state-relevant memories, i.e. to pain and depression cues, but had more difficulty recalling memories when the cue was not state-relevant, i.e. when the cue was positive.

For the PN group a contrasting pattern was obtained: retrieval times for positive and sensory pain cues were equivalent, and were significantly shorter than retrieval times for depressive cues (Newman Keuls $p < .05$ for positive/depressive difference; $p < .01$ for the sensory/depressive difference). This result suggests that the relative absence of depressed mood in this group may have resulted in a bias in favour of recalling positive and pain-relevant memories.

For the ND group, the recall latency was significantly faster for depressed cue words than for sensory pain cue words (Newman Keuls $p < .05$). However, no difference emerged between recall times for depressed and positive cues. It appears that the absence of pain may have caused an increased recall latency to pain-relevant cues. However, for the NN group, the recall times to positive and sensory pain cues were equivalent, and both were significantly faster than the recall time to depressive cues (Newman Keuls $p < .05$). It appears that for this group, the absence of depression may have caused an increased latency for depressive words. When examining the pattern of results across the four

groups, it appears that a pattern of priority may exist in the recall of personal memories. This pattern may be summarized as follows. First, when depression and pain are present, positive memories are the least accessible. Second, irrespective of the presence of pain, the absence of depression appears to be related to relative inaccessibility of depressed memories. Third, when depression is present without pain, positive and depression-relevant memories take precedence over pain-relevant memories.

Although no difference was obtained when comparing depressive and positive recall latencies within the ND group, post hoc comparisons of recall times to depressive stimuli across the four groups revealed the presence of a state-specific memory bias. The mean recall latency to depressed cues was equivalent for the two depressed groups (PD:7.74 seconds; ND:9.13 seconds), as was the depressive latency for the two nondepressed groups (PN:14.78 seconds; NN 16.91). However, the depressed groups had significantly shorter retrieval latencies to depressive cues than the nondepressed groups (Newman Keuls $p < .05$ for all comparisons). When examined in this fashion, the results suggest that although depressed mood may not have affected the recall of positive memories, it may have facilitated the recall of depressive memories.

Newman Keuls post hoc comparisons revealed that for the NN group, retrieval times for positive and sensory pain cues were significantly shorter than retrieval times for depressive cues (Newman Keuls $p < .05$ for both comparisons). Although the response latency was faster for positive than for pain cues (8.66 seconds versus 10.39 seconds), this difference failed to reach significance.

These results provide partial support for the hypotheses outlined above. When comparing the depressed and nondepressed chronic pain groups, an indication of clear state-relevant biases emerged: the depressed pain group had faster recall times in response to pain and depressive cues than to positive cues, and the nondepressed pain group had slower response times in response to depressive cues than to pain or positive cues. With the addition of the two nonpain groups, however, the picture becomes somewhat less clear. Although the differences between stimulus types were in the predicted direction for the ND and NN groups, the contrasts within each of these groups failed to reach statistical significance. However, when recall times to depressive stimuli are compared across the four groups, it appears that depressed mood may facilitate the recall of depressive memories.

Generality of Autobiographical Memory It was predicted that depressed mood would interact with stimulus type in the generality of autobiographical memory, such that the depressed groups would produce a higher proportion of general memories in response to positive cues than to negative cues. The opposite pattern was expected for the nondepressed groups. Because chronic pain has been associated with information processing biases that are analogous to depression, it was also predicted that pain status would be related to a higher proportion of general memories to positive cues than to pain-related cues. The proportion of general responses made by each group to the three types of verbal cues is presented numerically in Table 3-7, and graphically in Figure 3-3.

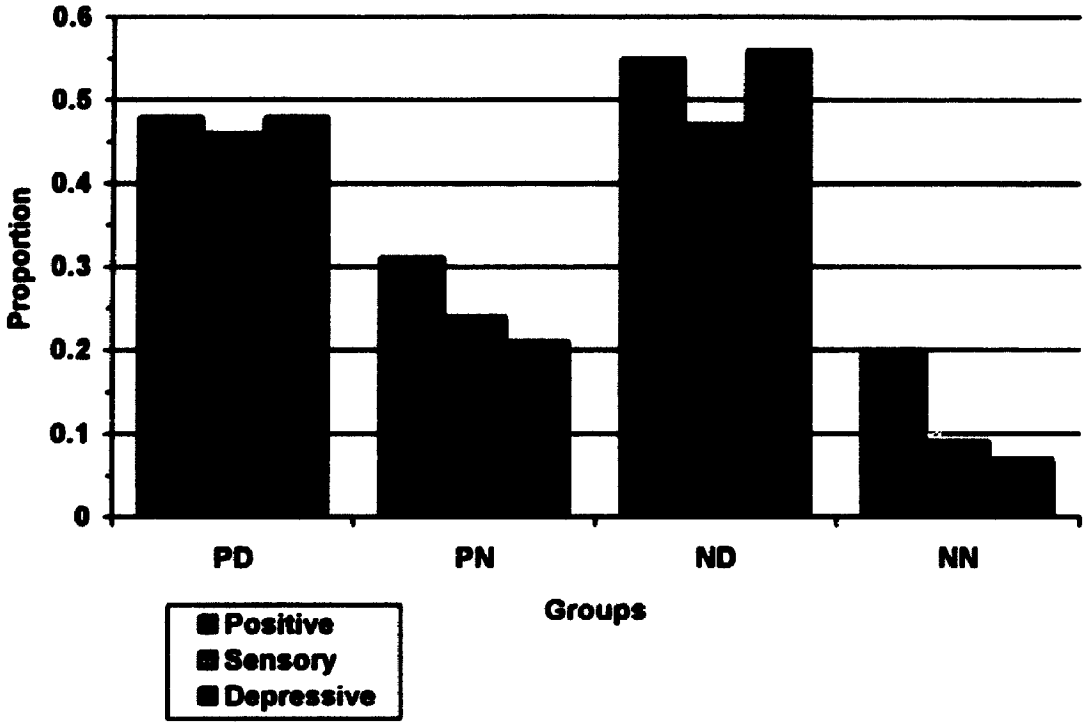
A four by three repeated-measures multivariate analysis of variance was computed to investigate these questions. Group was the

Table 3-7:
Group Means Across Three Stimulus Conditions:
Proportion of General Responses on
Autobiographical Memory Task

| | Subject Group | | | | |
|---|---|---|---|---|---|
| Stimulus Condition | PD (n=15) Mean (SD) | PN (n=15) Mean (SD) | ND (n=15) Mean (SD) | NN (n=15) Mean (SD) | Stimulus Condition Mean (SD) |
| Positive | .48 (.37) | .31 (.21) | .55 (.33) | .20 (.21) | .39 (.31) |
| Sensory | .46 (.34) | .24 (.27) | .47 (.38) | .09 (.18) | .32 (.34) |
| Depressive | .48 (.31) | .21 (.23) | .56 (.30) | .07 (.21) | .33 (.33) |
| Group Means (SD) | .48 (.27) | .26 (.18) | .52 (.28) | .12 (.18) | |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

Figure 3-3:
Group Means Across Three Stimulus Conditions:
Proportion of General Responses on
Autobiographical Memory Task



between-subjects factor, and stimulus type was the within-subjects factor. Proportion of general memories was significantly affected by group membership ($F(3,56)=10.06$, $p < .0001$). With the use of Wilk's criterion, however, neither the stimulus type nor interaction term attained significance ($F(3,55) < 1$ for stimulus type, $F(6,110) < 1$ for the interaction term). Newman Keuls post hoc analyses revealed that when averaged across all stimulus types, the two nondepressed groups (PN and NN) were equivalent to each other, and that the two depressed groups (PD and ND) were equivalent to each other. Each of the depressed groups had a higher proportion of general responses than each of the nondepressed groups ($p < .05$ for all comparisons).

Previously, Williams and his colleagues (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Williams & Scott, 1988) have consistently obtained significant group by stimulus type interaction effects when investigating the generality of autobiographical memory. In order to provide a replication of their studies, the two depressed groups were combined to form a single depressed group and the two nondepressed groups were combined to form a single nondepressed group. These two groups were then compared across only depressive and positive stimuli by means of a two by two repeated-measures analysis of variance. This analysis yielded only a significant group effect ($F(1,58)=25.24$, $p < .01$), due to the depressed providing a significantly higher proportion of general memories than the nondepressed group (Newman Keuls $p < .05$). Neither stimulus type effect nor the interaction term attained significance ($F(1,58)=2.78$, n.s. for the stimulus type effect; $F(1,58)=2.41$, n.s. for the interaction).

In order to examine the influence of pain on memory generality, the two pain groups were combined to form a single pain group, and the two depressed groups were combined to form a single nonpain group. The resultant two groups were then compared across positive and sensory pain stimuli by means of a two by two repeated-measures analysis of variance. In this analysis no significant effects were obtained ($F(1,58) < 1$ for the group effect; $F(1,58)=2.78$ n.s. for the stimulus type effect; $F(1,58) < 1$ for the interaction). Means for these analyses are presented in Table 3-8. These results stand in contrast to results reported by Williams and his colleagues in previous research. For example, Williams and Scott (1988) found that depressed subjects were more general in their positive memories, and less general in their negative memories. However, even when chronic pain subjects were excluded from the analysis in the Phase II, depressed subjects showed no variation across stimulus types (55% general responses for positive cues, 56% general responses for depressive cues). The nondepressed nonpain group showed a pattern which was opposite to that reported by Williams and his colleagues. Based on their research, it was predicted that nondepressed subjects would provide more general memories to negative cues, and fewer general memories to positive cues. The present results showed the opposite pattern: 20% of the NN group's responses to positive cues were general, while only 7% of their negative memories were general. However, this difference was not significant.

Although mood is clearly associated with a tendency to recall general autobiographical memories, It is not clear why neither pain nor depressed mood interacted with stimulus type in the Phase II of the present study. Although subject selection procedures were similar when

Table 3-8:
Means for Combined Groups:
Proportion of General Responses on
Autobiographical Memory Task

Subject Group

| Stimulus Type | Combined Depressed Group (n=30) Mean (SD) | Combined Nondepressed Group (n=30) Mean (SD) |
|---|---|---|
| Positive | .51 (.34) | .26 (.22) |
| Depressive | .52 (.30) | .14 (.23) |

| Stimulus Type | Combined Pain Group (n=30) Mean (SD) | Combined Nonpain Group (n=30) Mean (SD) |
|---|---|---|
| Positive | .40 (.31) | .37 (.32) |
| Sensory Pain | .35 (.32) | .28 (.35) |

comparing the present study with those conducted by Williams and his colleagues, stimulus selection procedures differed. Whereas the present study used stimuli which were normed on depressed subjects, Williams and his colleagues used negative words which had not been previously rated by depressed subjects. The other possible source of variation between the two studies concerns the use of state-congruent responses. It will be recalled that the present study excluded from analysis any responses where the stimuli were not used in a state-congruent fashion. Williams and his colleagues did not report any data on this variable. It is possible that the exclusion of incongruent responses may have affected the pattern of between-group responses on memory generality. However, despite the fact that the interaction term was not significant in Phase II of the present study, it is clear that the group effect remained robust, with the depressed groups providing significantly more general responses than the nondepressed groups across all stimulus types.

However, in spite of the present study's failure to replicate the memory generality interaction term observed by Williams and his colleagues in previous research, the theoretical explanation for memory generality appears to remain intact. It will be recalled that Williams and Dritschel (1988) suggested that memory generality may be due to an over-reliance on an emotional-based encoding strategy. Further, Williams and Scott (1988) speculated that memory generality may also be due to a motivational deficit at the retrieval stage which forestalls a thorough search of memory nodes. The present results do not challenge this explanation. However, the present results suggest that the encoding and retrieval deficits suggested by Williams and his colleagues may be relatively nonspecific, so that depression may be associated with

encoding and retrieval deficits regardless of the emotional tone of the material being encoded or the emotional tone of the retrieval cues.

Finally, it is also interesting to note that generality of autobiographical memory appears to be determined exclusively by affect, rather than by pain status, as the PN and NN groups were equivalent in their responses. This result suggests that pain which is unconnected with negative affect may not be associated with a pain-based encoding strategy or a motivational deficit. However, the present research was not designed to determine the specific degree to which encoding and retrieval may have been compromised by pain and/or depressed affect. Future research will be required in order to address this issue more precisely.

State-Relevant Judgement of Stimuli It was reported above that subject groups differed in the way in which they interpreted cues from the different stimulus categories. This index of response congruence was used to eliminate from subsequent analyses any responses which were not relevant to either pain or mood status. However, the data on congruence recorded in the present phase of the principal study can also permit examination of between-group differences in the way in which stimuli were interpreted, or judged.

Matthews et al. (1988) have reviewed the extant literature on depression and judgement and have concluded that among normal individuals judgement is biased in a "positive and sometimes self-serving" direction (p.132). Conversely, depression has also been found to exert a consistently negative influence on judgement. This effect has been demonstrated across a number of different outcome variables, including estimated success (e.g. DeMonbreun & Craighead, 1977; Gotlib,

1983), personal control (e.g. Alloy & Abramson, 1979), and subjective risk (e.g. Butler & Matthews, 1983). Mood-congruent judgement of ambiguous stimuli has also been demonstrated, but this effect has thus far been restricted to anxiety states. For example, Eysenk, MacLeod and Matthews (1987) found that sub-clinically anxious subjects tended to interpret homophones in a threat-related direction. This finding was subsequently replicated with clinically-diagnosed anxious subjects (Matthews, Richard & Eysenk, 1989). This latter study also found that recovered anxious subjects did not show a significant bias toward interpreting homophones in a threat-relevant direction, thus suggesting that this form of judgment bias may be state-dependent. In an unpublished study, Eysenk, Matthews & Richard (cited in Williams et al., 1988) also found that anxious subjects tended to interpret ambiguous sentences (e.g. "The men watched as the chest was opened.") in a threat-relevant direction (e.g. "The men watched as the chest was cut open.").

It is possible that the present serendipitous results represent a specific example of the general phenomenon of state-relevant bias in the interpretation of ambiguous stimuli. If this were the case, one would expect that the significant group by stimulus-type interaction term reported above ($F(9,131.57)=5.73$, $p < .0001$) would reveal state-specific differences in the proportion of congruent responses according to stimulus type. For example, it would be expected that subjects experiencing pain would be more likely than nonpain subjects to interpret pain-relevant stimuli in a pain-congruent direction, and that depressed subjects would be more likely than nondepressed subjects to interpret depressive stimuli in a mood-congruent direction. In order to

examine between-group difference for each stimulus type, a series of Newman Keuls post hoc analyses were conducted.

Although differences between groups were not significant on the positive stimuli, post hoc analyses demonstrated that the two pain groups (PD=.96, PN=.87) were equivalent in their pain-congruent use of sensory stimuli, as were the two nonpain groups (ND=.64, NN=.70). However, the pain groups were both significantly more likely than the nonpain groups to interpret sensory stimuli in a pain-congruent direction ($p < .05$ for all comparisons), thus suggesting that subjects' pain status influenced their judgement of these stimuli. In addition, post hoc analyses demonstrated that the PD group provided a significantly higher number of congruent responses to depressive cues than the two nondepressed groups ($p < .05$ for both comparisons). This result provides partial support for the expectation that mood would exert an influence on the judgement of ambiguous stimuli in the direction of that mood state. Chronic pain appeared to be related to the interpretation of pain-relevant stimuli in a way which was consonant with their pain status, and the depressed chronic pain group appeared to interpret depressive stimuli in a depression-relevant direction. Future research will be required to determine the parameters and robustness of this phenomenon.

The results of the autobiographical memory task may be summarized as follows. First, it appears that chronic pain and depression both affect the recall latency to state-relevant cues. This effect was most apparent when considering the two pain groups separate from the nonpain groups. However, the two depressed groups also had significantly shorter recall latencies to depressive cues than the nondepressed

groups. Second, it appears that depressed mood, apart from pain status, is related to generality of autobiographical memory. However, in the present study, memory generality did not differ across stimulus types. Finally, an unexpected finding was that pain and depression both appear to affect the judgement of verbal stimuli in such a way that pain or mood-relevant stimuli were more likely to be interpreted in a state-congruent fashion if the subjects were experiencing that state. Overall, the results of the Phase II of the principal study appear to confirm the general notion that pain and negative mood each exert unique state-specific effects on cognitive processing.

## Phase III: Incidental Recognition Task

### Overview of the Design

Phase III of the principal study was run after the Stroop task and autobiographical memory tasks described above. To date, relatively little research has examined the influence of pain or affect on recognition memory. Much of the research to date involving depressed subjects has produced inconsistent results. For example, some research has found that depressives produce a lower false alarm rate than nondepressed subjects (Dunbar & Lishman, 1984; Miller & Lewis, 1977), while others have found that depressives produce a higher false-alarm rate than nondepressives (Zuroff, Colussy, & Wieglus, 1983). Similarly, some research suggests that depression is associated with a lower level of hits (Dunbar & Lishman, 1984; Miller & Lewis, 1977), while other research has found that hit rate is unaffected by depression (Cole & Zarit, 1984; Davis & Unruh, 1980).

To date, it appears that only one study has been conducted which has examined the combined influence of pain and depression on recognition memory. Edwards et al. (1992) found a non-significant trend for chronic pain subjects to be more sensitive to the presence of previously-presented sensory pain stimuli. In this study, pain or depression-specific biases were not found in recognition memory.

Watts, Morris and Macleod (1987) have suggested that much of the variation in these results may be attributable to procedural variation across studies. For example, not all previous research has matched subjects on educational level, thus leaving open the question of whether verbal intelligence affected results. Previous research may also have utilized tasks which were lacking in sensitivity to between-group

differences. If the recognition task is excessively difficult, this could lead to a ceiling effect, and an attendant lack of between-group differences. Some researchers have attempted to rectify this problem by having subjects process the stimuli to a greater depth prior the recognition task, through vocalization (e.g. Watts et al., 1987), by rating the self-descriptiveness of stimuli (e.g. Zuroff et al., 1983), or through processing words in a lexical decision task prior to engaging in a recognition task (e.g. Matthews and Southall, 1991). It is notable in this regard that Edwards et al. (1992) did not require their subjects to process the stimuli. Ceiling effects in recognition tasks may also be related to the interval between processing and recognition. Although most previous research appears to have used relatively short durations of between two minutes (Matthews and Southall, 1991), and thirty minutes (Dunbar and Lishman, 1984), one study used an interval of seven days (Zuroff et al., 1983). It might be expected that a relatively long duration would increase the task difficulty, and reduce the likelihood of between-group separation on the dependent variables. In addition, there has been considerable variation across studies in the type of stimuli used. Most studies have used neutral stimuli (e.g. Cole & Zarit, 1984; Miller & Lewis, 1977; Watts et al., 1987), whereas some have used stimuli which differed in emotional valence (Dunbar & Lishman, 1984; Matthews & Southall, 1991). Even in those studies which used emotional stimuli, their criterion for se'ection and matching of stimuli has often not been made clear. In the particular case of the Edwards et al. (1992) study, subjects were presented with sensory and affective pain stimuli, and were not presented with depression-specific descriptors. The stimulus categories selected by Edwards et al. (1992)

may be particularly problematic in light of results obtained in Phase I and Phase II of the present study which have suggested that affective pain stimuli may not be valid descriptors of specific pain status. Finally, there has been considerable variation across studies in subject selection procedures, with some researchers selecting subjects on the basis of psychiatric diagnostic criteria (e.g. Matthews and Southall, 1991), and others on the basis of psychometric criteria (e.g Zuroff et al., 1983).

The present study will attempt to rectify some of the deficiencies and inconsistencies apparent in previous research by using standardized and theoretically-justifiable procedures, and to extend the research into the examination of the effect of chronic pain on recognition memory. First, subjects in Phase III have been matched on educational level (data were presented in Phase I). Second, the Phase III of the present study attempted to increase the sensitivity of the task by t .ting subjects on stimuli which had previously been processed in the Stroop task and the autobiographical memory task. Third, the present phase used a relatively short duration of five minutes between processing and recognition. Previous research has shown that short-term memory storage can be cleared in such a short interval, providing a filler task is used between processing and recognition (Matthews & Southall, 1991). However, an extremely long delay could increase task difficulty and thereby reduce the likelihood of between-group differences. Fourth, the present phase used well-standardized stimuli which were matched on the basis of length and frequency of usage. Stimulus selection procedures were presented in Phase I. Finally, subjects in the present study were selected on the basis of psychiatric

and medical criteria, thus ensuring that the groups were distinct with respect to pain and depression.

Based on previous research, the following hypotheses are suggested for Phase III. First, subjects are expected to show an increased hit (correct recognition) rate for state-relevant stimuli. This would mean, for example, that the PD group would correctly recognize sensory and depressive stimuli more readily than positive ones, that the PD group would show enhanced correct recognition for sensory stimuli, that the ND group would show ennanced correct recognition for depressive adjectives, and that the NN group would show enhanced correct recognition for positive stimuli. Second, subjects are expected to show false-alarm biases in favour of state-relevant stimuli, so that, for example, the PD group would produce a higher false alarm rate for sensory pain and depression adjectives.

Signal detection analyses were also conducted on the data from Phase III, in order to determine the source of any biases which may be evident in hit and false alarm rates. In signal detection analysis, two indices are computed. The first is $\underline{d}'$, which is a bias-free index of sensitivity, or the ability to detect a stimulus which has been previously encountered. A high hit rate and a low false alarm rate will result in a high $\underline{d}'$. With a high hit rate and a high false alarm rate, the numerical value of $\underline{d}'$ will be correspondingly decreased. The second signal-detection index, $\underline{c}$, allows evaluation of response bias, or the willingness to say "yes" to a stimulus presentation whether or not the stimulus has been previously encountered. The value of $\underline{c}$ is a monotonic function of hit and false alarm rate, so that the value of $\underline{c}$ decreases with a simultaneous increase in hits and false alarms (Macmillan and

Creelman, 1991). The effective range of c is -2.33 to +2.33, with lower values of c indicating a relatively higher rate of false alarms relative to hits. In other words, a large value for c represents a conservative criterion for making a recognition judgement, and a small value for c represents a relaxed criterion for accepting recognition of a stimulus.

As discussed earlier, previous research suggests that both hits and false alarms in the present study may be elevated in state-congruent directions. If this is the case, it would be expected that d' would be relatively invariant across word types within each group, since the low hit and false alarm rates on irrelevant stimuli should produce values for d' roughly equivalent to those produced for state-relevant stimuli, where the hit and false-alarm rates are relatively higher. However, since it is expected that pain or affective status will confer state-relevant biases in recognition memory, it is expected that groups in Phase III of the present study will have relaxed criteria for accepting the presence of state-congruent stimuli. More specifically, it is expected that groups will produce lower values for c for state-relevant stimuli, since it is predicted that both hit and false alarm rates will be elevated for state-relevant stimuli. For example, it is expected that the PD group will produce lower c values for sensory pain and depressive words relative to positive words, and the PN group will produce lower values for sensory words relative to positive or depressive words. Such a pattern of results would suggest that subjects use a more relaxed criterion for accepting recognition of state-relevant stimuli, thus confirming the general expectation that recognition memory will be biased in a state-relevant direction.

## Method

Subjects. Subject selection procedures were described above in the Phase I Method section.

## Materials

Incidental Recognition Task. Verbal stimuli were presented to subjects on a page which contained 100 words randomly arranged in four columns of 25 words each. The target stimuli were the five words from each of the word categories used in the autobiographical memory task, namely sensory pain, affective pain, depressive, and positive. The word list also contained 10 distracter words from each of the four categories, as well as 40 neutral distracters. Thus the incidental recognition form contained a total of 20 target words and 80 distracters. Stimuli were matched on length and frequency of usage.

## Procedure

Subject referral and contact procedures were described above for Phase I. After completing the Stroop task and the autobiographical memory task, subjects completed the semantic processing task described in Phase I as a filler between the autobiographical memory task and the incidental recognition task. This served to clear short-term memory storage and reduce the likelihood of recency effects. The semantic processing task was conducted in such a way as to ensure that the interval between the autobiographical memory task and the incidental recognition task was five minutes. After completing the semantic processing task, the incidental recognition task was introduced by the experimenter. Standardized instructions were used to introduce the incidental recognition task. Subjects were asked to check off those

words which they felt they recognized from the Stroop task and the autobiographical memory task.

Results and Discussion

Because it was found in Phase II that affective pain variables showed a low likelihood of being interpreted in a pain-relevant direction, this variable category was excluded from analysis in the Phase III. For the remaining three verbal categories, four dependent variables were computed. The first was the hit rate, or proportion of target stimuli which were correctly identified. The second dependent variable was the false alarm rate, or proportion of distracter variables in each verbal category which were incorrectly identified as having been previously encountered. The third dependent variable was $d'$, or the index of sensitivity to target stimuli within each verbal category. This variable is calculated by means of the formula: $d' = z(H) - z(F)$, where $z(H)$ is the standardized hit rate, and $z(F)$ is the standardized false alarm rate (MacMillan & Creelman, 1991). The effective range of $d'$ is 0 to 4.65, with higher values of $d'$ representing more sensitivity to the presence of target stimuli, and lower values of $d'$ representing decreased sensitivity to the presence of target stimuli. The fourth dependent variable was $c$, or criterion. This variable is the index of the extent to which subjects were biased towards incorrectly identifying distracter stimuli within each verbal category. This variable is calculated by means of the formula: $c = -0.5[z(H)+z(F)]$, where $z(H)$ is the standardized hit rate, and $z(F)$ is the standardized false alarm rate (MacMillan & Creelman, 1991). The effective range of $c$ is -2.33 to +2.33, with lower values of $c$ indicating a relatively higher rate of false alarms relative to hits. In other words, a low absolute value for

$c$ represents a liberal criterion for accepting or rejecting the recognition of stimuli, and a high absolute value represents a conservative criterion. Group means on the dependent variables are presented in Tables 3-9 to 3-12. For the purpose of expository clarity, the results are also presented graphically in Figures 3-4 to 3-7.

Four by three repeated measures multivariate analyses of variance were computed to examine the influence of group and stimulus type on each of the dependent variables. Group was the between subjects factor for each of the analyses, and stimulus type was the within subjects factor. Following the multivariate analyses, differences between individual means were examined by means of Newman Keuls post hoc analyses (Kirk, 1982, pp. 123-125).

Hit rate was significantly affected by group membership ($F(3,56)=3.02$, $p < .05$), due to the NN group having a significantly higher hit rate than the ND group ($p < .05$). With the use of Wilks' criterion, hit rate was not affected by stimulus type ($F(2,55) < 1$), but was affected by the interaction term ($F(6,110)=3.46$, $p < .01$). In examining the interaction effect, it was found that there were no significant differences within each group across stimulus types. Instead, between group differences within each stimulus type were found. Specifically, the NN group was significantly more accurate than the other three groups on positive stimuli, and the PN group was significantly more accurate than the ND group on sensory pain stimuli ($p < .05$) for all comparisons. These results provide modest support for the expectation that accuracy would be enhanced for state-relevant stimuli, in that the nondepressed nonpain group appeared to be more accurate in their recognition of positive stimuli compared to other

Table 3-9:
Group Means Across Three Stimulus Conditions:
Proportion of Correct Recognitions (Hits) on
Incidental Recognition Task

| | Subject Group | | | | |
|---|---|---|---|---|---|
| Stimulus Condition | PD (n=15) Mean (SD) | PN (n=15) Mean (SD) | ND (n=15) Mean (SD) | NN (n=15) Mean (SD) | Stimulus Condition Mean (SD) |
| Positive | .63 (.32) | .72 (.18) | .65 (.28) | .92 (.13) | .73 (.26) |
| Sensory | .72 (.33) | .83 (.20) | .57 (.21) | .75 (.19) | .71 (.25) |
| Depressive | .69 (.28) | .69 (.28) | .68 (.27) | .83 (.18) | .72 (.26) |
| Group Means (SD) | .68 (.25) | .75 (.15) | .64 (.21) | .83 (.12) | |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

Figure 3-4:
Group Means Across Three Stimulus Conditions:
Proportion of Correct Recognitions (Hits) on
Incidental Recognition Task

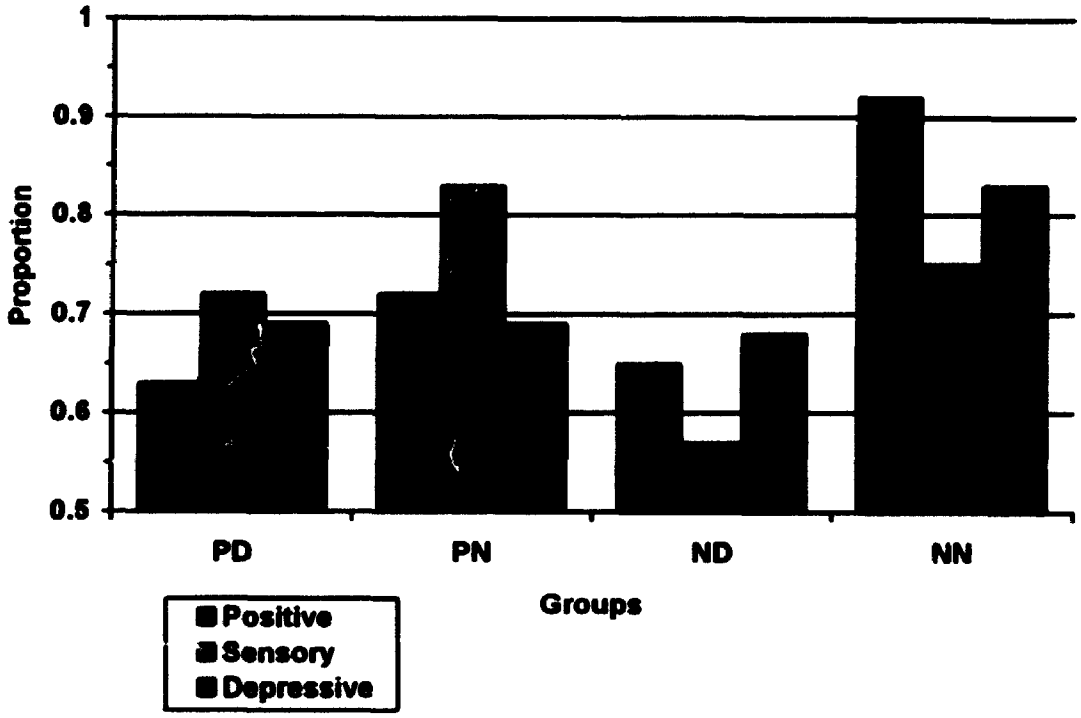


Table 3-10:
Group Means Across Three Stimulus Conditions:
Proportion of Incorrect Recognitions (False Alarms) on
Incidental Recogntion Task

| | Subject Group | | | | |
|---|---|---|---|---|---|
| Stimulus Condition | PD (n=15) Mean (SD) | PN (n=15) Mean (SD) | ND (n=15) Mean (SD) | NN (n=15) Mean (SD) | Stimulus Condition Mean (SD) |
| Positive | .09 (.15) | .08 (.14) | .03 (.10) | .02 (.05) | .06 (.12) |
| Sensory | .26 (.27) | .20 (.15) | .03 (.06) | .04 (.06) | .13 (.19) |
| Depressive | .26 (.22) | .14 (.13) | .20 (.12) | .07 (.09) | .17 (.16) |
| Group Means (SD) | .20 (.18) | .14 (.11) | .09 (.08) | .04 (.05) | |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

Figure 3-5:
Group Means Across Three Stimulus Conditions:
Proportion of Incorrect Recognitions (False Alarms) on
Incidental Recogntion Task

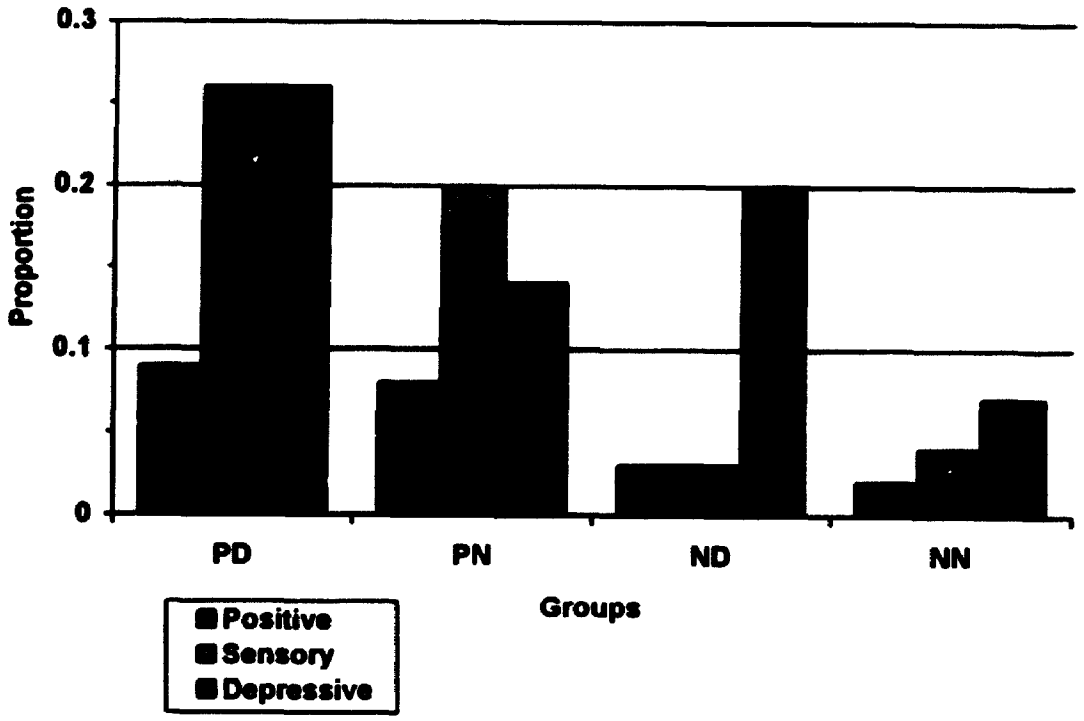


Table 3-11:
Group Means Across Three Stimulus Conditions:
D' (Sensitivity) on
Incidental Recognition Task

| Stimulus Condition | Subject Group PD (n=15) Mean (SD) | PN (n=15) Mean (SD) | ND (n=15) Mean (SD) | NN (n=15) Mean (SD) | Stimulus Condition Mean (SD) |
|---|---|---|---|---|---|
| Positive | 2.14 (1.35) | 2.49 (.74) | 2.70 (1.19) | 4.06 (.89) | 2.85 (1.27) |
| Sensory | 2.07 (1.06) | 2.43 (1.06) | 2.52 (1.21) | 2.87 (1.19) | 2.47 (1.14) |
| Depressive | 1.72 (.74) | 2.04 (1.17) | 1.83 (1.22) | 3.14 (1.34) | 2.18 (1.25) |
| Group Means (SD) | 1.98 (.78) | 2.32 (.74) | 2.34 (.93) | 3.35 (.85) | |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

Figure 3-6:
Group Means Across Three Stimulus Conditions:
D' (Sensitivity) on
Incidental Recognition Task

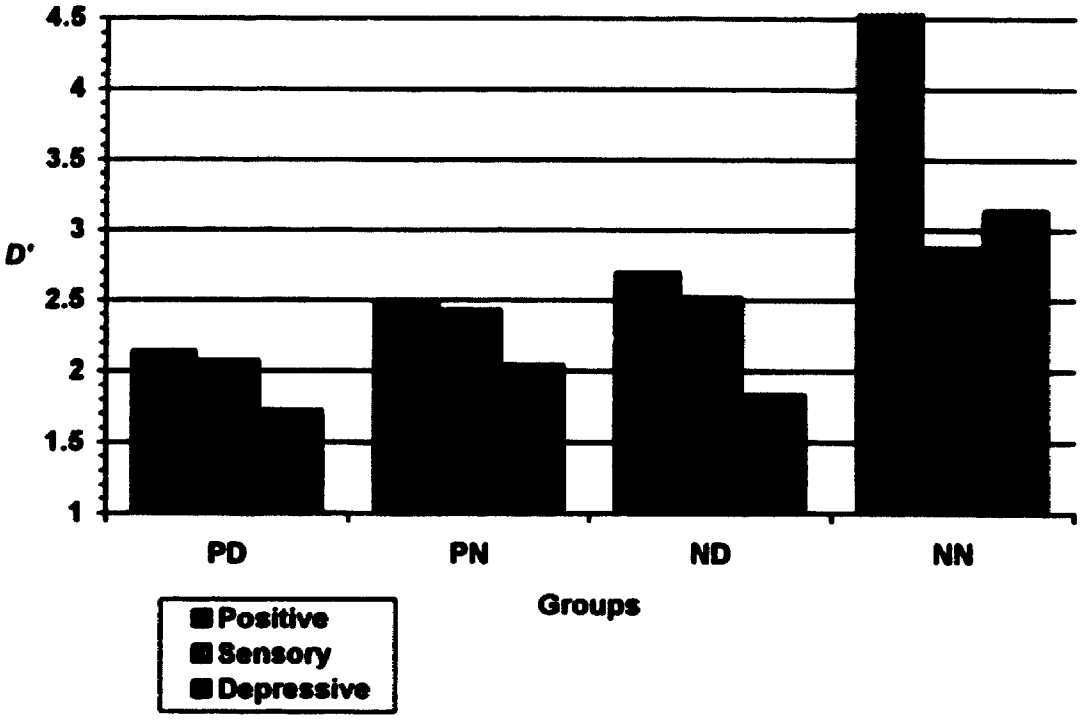
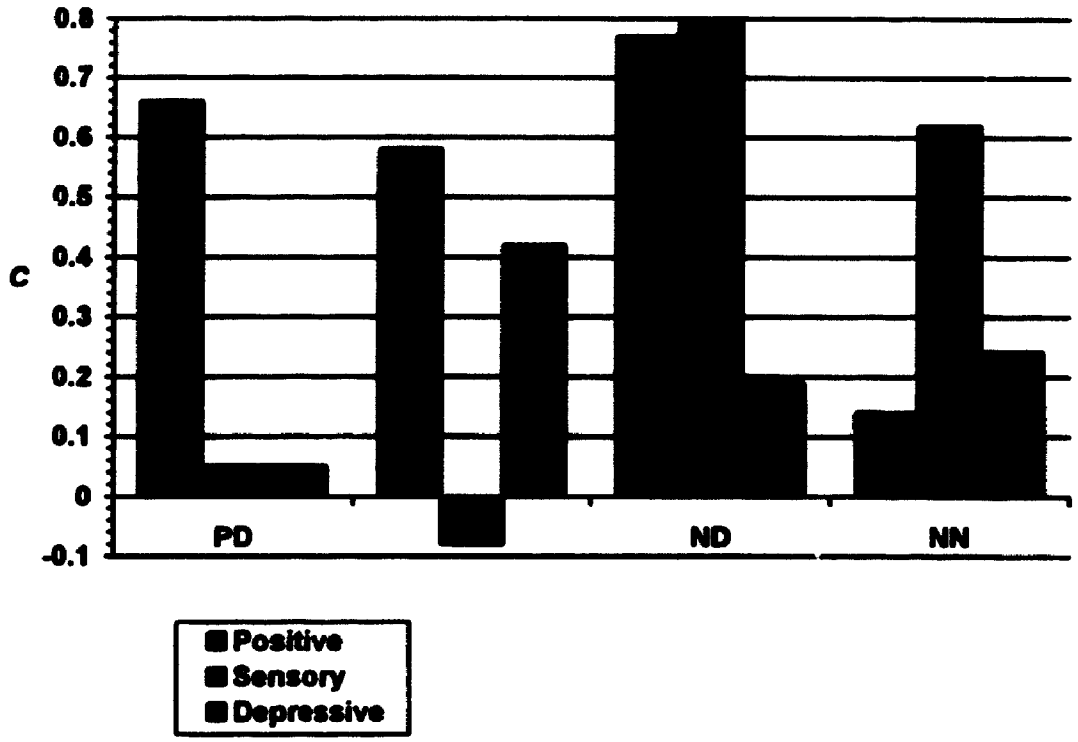


Table 3-12:
Group Means Across Three Stimulus Conditions:
C (Criterion) on
Incidental Recognition Task

| | Subject Group | | | | |
|---|---|---|---|---|---|
| Stimulus Condition | PD (n=15) Mean (SD) | PN (n=15) Mean (SD) | ND (n=15) Mean (SD) | NN (n=15) Mean (SD) | Stimulus Condition Mean (SD) |
| Positive | .66 (.90) | .58 (.70) | .77 (.61) | .14 (.43) | .53 (.70) |
| Sensory | .05 (1.20) | -.08 (.69) | .80 (.49) | .62 (.54) | .34 (.85) |
| Depressive | .05 (.99) | .42 (.82) | .19 (.62) | .24 (.50) | .23 (.75) |
| Group Means (SD) | .25 (.88) | .31 (.52) | .59 (.49) | .33 (.28) | |

Notes:
PD=Chronic pain subjects with depression
PN=Chronic pain subjects without depression
ND=Depressed subjects without pain
NN=Subjects without pain or depression

Figure 3-7:
Group Means Across Three Stimulus Conditions:
C (Criterion) on
Incidental Recognition Task



groups, and the nondepressed pain group showed enhanced recognition for sensory pain stimuli, but only when compared to the nonpain depressed group. The predicted differences within each group did not emerge.

The false alarm rate was significantly affected by group membership ($F(3,56)=5.32$, $p < .01$), owing to the PD group having a higher rate of false recognitions than both the ND and the NN group ($p < .05$). Using Wilk's criterion, the false alarm rate was affected by both stimulus type ($F(2,55)=22.82$, $p < .0001$) and by the interaction term ($F(6,110)=4.39$, $p < .0001$). The significant stimulus type effect was due to the rate of false recognitions being lower for positive stimuli than for both sensory and depressive stimuli ($p < .01$ for both comparisons). In examining the interaction effect, it was found that for the PD group, the false alarm rate was equivalent for both sensory and depressive stimuli, and both were significantly higher than the positive stimuli ($p < .05$). For the PN group, it was found that significantly more false alarms occurred for sensory stimuli than for positive stimuli ($p < .05$). For the depressed group, the false alarm rate for depressive stimuli was significantly higher than the false alarm rates for sensory and positive stimuli ($p < .05$). Finally, for the NN group, no significant differences emerged across stimulus types. These results suggest that groups generally demonstrated state-relevant recognition biases. Those groups who suffered from pain showed elevations on sensory pain stimuli, and those groups who were depressed showed elevations on depressive stimuli. Interestingly, the nondepressed nonpain group did not show differences in false alarm rates across stimulus types, thus suggesting that the tendency to overestimate

the presence of state-relevant stimuli may be limited to negative states, rather than a general function of any affective state.

The index of sensitivity, $d'$, was affected by group membership ($F(3,56)=15.99$, $p < .0001$), and by verbal condition ($F(2,55)=6.43$, $p < .005$). The interaction term was not significant ($F(6,110)=1.35$, n.s.). Averaged across stimulus types, The PD, PN, and ND groups were equivalent in $d'$, and the NN group was significantly higher than the three other groups ($p < .05$). This result suggests that the presence of pain and/or depression was associated with a reduced sensitivity to the presence of stimuli which had previously been presented, irrespective of the valence of the stimuli. Averaged across groups, $d'$ was higher for positive stimuli than for sensory pain stimuli ($p < .05$), and for depressive stimuli ($p < .01$). This result suggests that all subjects, regardless of clinical status, were more sensitive to the presence of positive targets than to sensory or depressive targets.

veraged across stimulus types, the criterion measure, $c$, was not affected by group membership ($F(3,56) < 1$). However, $c$ was affected by both stimulus type ($F(2,55)=4.58$, $p < .01$) and by the interaction term ($F(6,110)=5.47$, $p < .0001$). The stimulus type effect was due to a higher $c$ for positive stimuli than for depressive stimuli ($p <.01$), thus suggesting that all groups, regardless of pain or affective status, used a more conservative criterion for accepting the presence of positive stimuli in comparison to depressive stimuli.

In examining the interaction effect, several significant differences were found which confirmed the presence of state-congruent response biases. For the PD group, $c$ was equivalent for sensory and depressive words, and both were significantly lower than $c$ for positive

words ($p < .05$). This suggests that the presence of pain and depression was related to a tendency to be biased toward accepting pain and depression-relevant stimuli, regardless of whether they had been previously encountered. For the PN group, $c$ was significantly lower for sensory words than for positive words ($p < .05$). In addition, for the PN group, $c$ was equivalent for depressive and positive words. These results suggest that the presence of pain without depression was related to a liberal criterion for acceptance of pain words, and that a more conservative criterion was applied toward acceptance of positive and depressive stimuli. For the ND group, a bias was found only for depressive words: $c$ was significantly lower for depressive stimuli than for either positive or sensory stimuli ($p < .05$). For the ND group, $c$ was equivalent for sensory and positive words, thus suggesting that an equally conservative criterion had been applied to the acceptance of these two stimulus types. Finally, for the NN group, $c$ was significantly lower for positive stimuli than for sensory stimuli ($p < .05$). For the NN group, $c$ was statistically equivalent for positive and depressive stimuli. These results suggest that the absence of pain and depression was related to a biased acceptance of positive stimuli and depressive stimuli.

The results of Phase III of the present study provide support for the hypotheses outlined above. It was expected that pain and emotional status would each act as filters which would allow subjects to be more attuned to stimuli which represented their emotional and/or pain state. This general hypothesis led to the prediction that subjects would have higher hit rates for those stimuli which were congruent with their status. This hypothesis was only partially supported: the nonpain

nondepressed group was more accurate than the other three groups on positive stimuli, and nondepressed chronic pain subjects were more accurate than depressed nonpain subjects on sensory pain words. The clear differentiation between stimulus types which was expected within each group was not obtained. This result suggests that subjects were not generally more accurate in the recognition of state-congruent stimuli, a finding which was confirmed by examining the sensitivity index (*d'*). Although lack of depression or pain was associated with a higher level of sensitivity across all stimulus types, the interaction term was not significant, thus suggesting that mood or pain does not confer a state-congruent enhancement of recognition memory. However, the clearest effects emerged when considering biases in recognition memory. For the three chronic pain or depressed groups (i.e. PD, PN, and ND), the false alarm rates were significantly higher for those stimulus categories which were specific to pain or depression. The nonpain-nondepressed group showed no differences in false alarm rates across stimulus types. Perhaps the clearest evidence for state-congruent biases emerged in the analyses of the criteria (*c*) used for recognition of stimuli. In every group it was consistently found that a more relaxed criterion was used for acceptance of state-congruent stimuli than for incongruent stimuli. *c* is a bias index, in that it assesses the tendency to assent to a stimulus presentation regardless of its previous presentation. Because *c* was consistently lower for state-relevant stimuli, this provides clear evidence that recognition memory can be biased by emotional or pain status.

Summary

The present chapter presented three studies which were designed to examine the interactive influence of chronic pain and depression on cognitive processing. Methodologically, the present project was based on previous research which has shown that depressed mood can affect attention, autobiographical memory, and recognition memory. Theoretically, the present studies were based on research which suggests that chronic pain is more than a unidimensional, sensory, physiological experience. Instead, writers have suggested that chronic pain is a comprehensive, multidimensional experience (e.g. Fernandez & Turk, 1992). From this perspective evolved the assumption that chronic pain and depression can both exert specific effects on higher level cognitive processing.

In general, this assumption was borne out. On the Stroop test, the two pain groups demonstrated state-specific attentional interference effects, whereas the depressed nonpain group did not show the expected state-specific interference effects. On the autobiographical memory task, it was found that the presence of pain and depressed mood each specifically contributed to faster recall latency to state-relevant cues. It was also found that pain and depression individually contributed to the way in which stimuli were interpreted. In the autobiographical memory task, depression was associated with generality of autobiographical memory, whereas pain did not contribute to this phenomenon. On the incidental recognition task, it was found that pain and either positive or negative mood were related to state-specific biases. However, there was not strong support for the notion that pain

or emotional status would be associated with recognition accuracy, or sensitivity.

In general, it was found that pain exerted specific effects on attention, as assessed by the Stroop task, on long-term autobiographical memory, and on recognition memory. In some paradigms, pain appeared to affect cognitive processing in a way which was similar to the effects of depression, and in some paradigms, chronic pain appeared to exert unique effects. The following chapter will suggest ways in which these findings may be interpreted, and will discuss the theoretical and clinical implications of these results.

# CHAPTER FOUR

## General Discussion

### Introduction

The present research project was designed to investigate whether cognitive processing of state-relevant information is differentially affected by chronic pain and depression. The first pilot study was designed to delineate the relationship between depression and the sensory and affective dimensions of chronic pain. The second pilot study was designed to provide preliminary information regarding sources of variance in the modified Stroop task. The principal study was designed to generate data on the ways in which chronic pain and depression may affect different levels of cognitive processing. The cognitive processes under consideration in the principal study were selective attention, as assessed by a modified Stroop task, autobiographical memory, and incidental recognition memory. In general terms, it was expected that chronic pain would be associated with information-processing biases in a manner similar to biases which have been found in depression. However, it was expected that the content of cognitive biases in chronic pain would be specific to pain-relevant stimuli, and therefore distinguishable from the effect of depression on depression-relevant stimuli. In order to clearly separate the effects of pain and depression, four groups were studied in the principal study: chronic pain/depressed (PD), chronic pain/nondepressed (PN), nonpain/depressed (ND), and nonpain/nondepressed (NN).

It was decided to investigate depression concomitantly with chronic pain for three reasons. First, depression appears to be the

negative affective state most commonly associated with chronic pain (e.g. Dworkin & Gitlin, 1991; Magni et al., 1990), and thus has both clinical and theoretical relevance to the investigation of cognitive processing in chronic pain. Second, because depression is often experienced concomitantly with chronic pain, it was felt that depression could serve as an easily-established and ecologically valid comparison condition for chronic pain, so that the unique contributions of pain and mood to the variance in each specific cognitive process could be determined. Third, a number of well-established procedures exist which have been shown to reliably delineate the effects of depression on cognitive processing. For the purposes of comparing the effects of chronic pain and depression, it was felt that it could be helpful to compare the two states on tasks which have previously been shown be useful in investigations of cognitive processing in depression. In this way it would be possible to discover similarities and differences between pain and depressed mood across the different cognitive processes.

The general discussion will proceed by summarizing the significant results of both the pilot studies and the principal study and discussing their theoretical implications. Following this, clinical implications of the results will be discussed. Finally, limitations of the present project will be addressed and suggestions put forward regarding possibilities for future research.

## Dimensional Separation of Chronic Pain

Pilot Study I was a psychometric investigation of the relationship between depressed mood and the sensory and affective dimensions of chronic pain. Much recent theoretical literature has been devoted to

explicating the multidimensional nature of chronic pain, with sensory and affective features being the most consistently discussed features of pain (e.g. Melzack & Wall, 1988, Price, 1988; Leventhal & Everhart, 1978). However, some writers have suggested that there is considerable overlap between the sensory and affective dimensions of pain, and that they may not be empirically or clinically separable. This was proposed for example, by Merskey and Spear (1967b), who suggested that such a separation was a semantic artifact, rather than an experientially valid phenomenon. Fernandez and Turk (1992) recently reviewed the literature on this subject, and examined studies which used either multivariate statistics, signal detection analyses, or paired-scaling methodology. They noted that although there is some evidence for the separability of pain into two dimensions, the available research has also tended to demonstrate that there is a high degree of interdependence between the two aspects. Fernandez and Turk (1992) concluded that although the experience of pain may indeed contain emotional and sensory elements, it may be more useful to conceptualize pain as a gestalt which is more than the sum of its parts.

The present research supports this conceptualization and potentially sheds further light on the role of the affect in the specific case of chronic pain. In Pilot Study I it was expected that a measure of depressed mood would be more strongly correlated with the affective dimension of chronic pain than with the sensory dimension. It was suggested that such a relational pattern would demonstrate the separability of the two dimensions of chronic pain, and provide empirical justification for examining the separate contributions of the sensory and affective components of pain to cognitive processing.

As expected, it was found that depressed mood, assessed by the CES-D (Radloff, 1977), was more strongly related to the affective than to the sensory dimension of chronic pain, as measured by both the McGill Pain Questionnaire (Melzack, 1975) and a visual analogue scale. The correlation between depressed mood and MPQ affective pain was .46, while the correlation between depressed mood and VAS affective pain was .45. In contrast, the correlation between depressed mood and MPQ sensory pain was .19, and the correlation between depressed mood and VAS sensory pain was .22. This finding was taken as evidence that depressed mood is an integral component of the affective dimension of chronic pain, and that the affective and sensory dimensions of chronic pain are separable. However, because 20 percent of the variance in affective pain measures could be accounted for by depressed mood, it is also possible to infer from these results that perhaps measures of "affective" pain at least partially represent general negative emotionality, and may not be specific to the experience of pain. As will be seen in discussions of subsequent results, this suggestion has received convergent support from other research conducted in the present project. In Pilot Study I, for example, it was found that irrespective of whether pain was measured verbally (i.e. with the McGill Pain Questionnaire), or with a visual analogue scale, a high degree of variance was shared between sensory and affective dimensions of chronic pain. More specifically, the correlations between MPQ measures of sensory and affective pain were higher than MPQ-VAS sensory pain correlations, or the MPQ-VAS affective correlations. Similarly, the correlations between VAS measures of verbal and affective pain were higher than the correlations between the two types of sensory measures or the two types of affective measures.

This suggests that the degree of relationship between sensory and affective dimensions of pain may be more strongly determined by the measurement methodology than by phenomenological similarity between the "components" of pain.

Perhaps more interesting, however, is the finding that a measure of depression was more highly correlated with the affective measures of pain than with the sensory measures. In initial discussions, this result was taken as evidence of the separability of sensory and affective pain, but it is also plausible to see this result as evidence of a lack of phenomenological specificity in regard to pain-related negative affect, so that depression and "affective" pain may be aspects of general negative affect. Further corroboration of this possibility was observed in the autobiographical memory task, where it was found that about 50% of all affective pain words were likely to be used in a pain-incongruent fashion, regardless of a subject's pain status. This result suggests two possibilities regarding the affective dimension in chronic pain. The first is that the affective pain stimuli used in the present project were not specifically representative of pain. By extension, this finding also suggests that the negative affect experienced in chronic pain may not be unique to pain, but may instead also be experienced across a number of aversive states, such as hunger, thirst, or fatigue. This supposition leads to the second possibility, that verbal affective pain stimuli are poor between-group discriminators where the groups differ with respect to the presence or absence of pain, but are similar with respect to the presence or absence of negative affect. This may be so because, as noted above, affective pain stimuli may be more representative of general affective negativity. Phase I of

the principal study (the modified Stroop task) provided further support for the suggestion that verbal affective pain stimuli evoke generalized negative reactions across all subjects, rather than eliciting pain-specific biases. It will be recalled that this study found that all subjects demonstrated a slower colour-naming speed for affective pain words regardless of their pain or emotional status, thus suggesting that these words diverted the attentional resources of all subjects on the Stroop task, possibly because of the generalized negative tone of these words.

These observations suggest that it may not be profitable to consider the affective dimension of pain as distinct from other negative emotional states, especially when comparing pain groups with nonpain groups. In research which examines the role of negative affect where subjects are homogeneous with respect to pain status, this consideration is less important than in research such as the present project, which sought to illuminate differences between groups of subjects which differed with respect to the presence or absence of pain. This issue illustrates the potential greater utility, both from a theoretical and clinical perspective, in considering the role of specific affective disorders such as depression or anxiety in chronic pain, rather than attempting to disentangle the relationship between sensory and a generic "affective" component of pain. Further, this issue underscores the overarching theme of the present project, namely to delineate operational characteristics of depression as experienced in chronic pain. By thus emphasizing the specific characteristics of depression in chronic pain, it may be possible to approach a functional, rather than a semantic definition of negative affect in chronic pain.

Attentional Processes in Chronic Pain

Two modified Stroop tasks were run in the present project. The first Stroop task was an exploratory study which was designed to assess potential methodological sources of extraneous variability in the task. The second Stroop task was a more specific evaluation of the differential roles of chronic pain and attention on state-relevant stimuli. The Stroop task has been used previously in research on depression and anxiety (see Matthews et al., 1988 for a review). In general, previous research has found that selective attention on the Stroop task can be influenced by mood state, although the effect appears to be more robust for anxiety than for depression (Williams et al., 1988). In addition, one previous study has been published in which it was found that chronic pain exerted a selective influence on colour-naming speed for pain-relevant stimuli (Pearce & Morley, 1988). However, it was felt that the results of the Pearce and Morley study could be expanded by examining the role of depression in the chronic pain Stroop task, as well as by attempting to determine the relevant parameters of the verbal stimuli to be used.

In Pilot Study II subjects were not specifically diagnosed with depression. Instead, level of depressed mood was assessed psychometrically within a sample of 20 heterogeneous chronic pain subjects. Verbal stimuli were selected on the basis of their face validity in representing the domains of pleasant words, neutral words, pain words, and negative words. The group by stimulus type interaction term failed to reach statistical significance, thus suggesting that chronic pain did not exert a selective influence on attention with the stimulus sample used in Pilot Study II. When the chronic pain group was

subdivided on the basis of CES-D scores, the interaction term again failed to reach significance, suggesting that depressed mood did not differentially bias attention for different stimulus types in Pilot Study II.

In examining potential reasons for the negative results obtained in Pilot Study II, two major possibilities were discussed. The first concerned the selection of stimuli. Because the stimuli had been selected on the basis of face validity, and had not been normed on a clinical sample, it was felt that they may not have had sufficient relevance to chronic pain subjects to elicit the predicted effects. The second possibility concerned the selection of subjects. Because Pilot Study II had relied on a psychometric criteria for categorizing depression, it was felt that the depressed/nondepressed distinction may not have been sufficiently clear-cut to permit a conclusive investigation of the separate effects of pain and depression on attention.

These potential sources of variance were addressed in the principal study. The stimuli used in this study were normed on relevant clinical populations. The pain stimuli were based directly on items from the McGill Pain Questionnaire (MPQ: Melzack, 1975), and were selected on the basis of their frequency of usage among a sample of local chronic pain subjects (Boissevain, 1993). The depressive and positive stimuli had been previously rated by psychiatric patients (Meyers, 1980), and had been used in previous research in cognitive processing in depression (e.g. Gotlib & Cane, 1987). Subject selection procedures in the principal study were also more rigorous than they had been in Pilot Study II. Chronic pain subjects were separated on the

basis of a structured diagnostic interview for depression, as well as CES-D scores, so that a group of clearly depressed chronic pain subjects and a group of clearly nondepressed chronic pain subjects was formed. In addition, a group of depressed nonpain subjects and a group of nondepressed nonpain subjects were also included in the design, to further facilitate examination of the separate effects of depression and chronic pain. Selection of the two nonpain groups was also based on psychiatric diagnostic criteria and psychometric scores.

In Phase I of the principal study, it was expected that each group would experience state-relevant attentional biases which would be reflected in longer colour naming times for those stimuli which related to each group's pain or affective status. Stimuli under consideration in the Stroop task included neutral, positive, sensory pain, affective pain, and depressive words.

The first observation to be made concerning results obtained in Phase I is that all groups showed a retardation effect for affective pain words in comparison to other classes of stimuli. This result suggests that affective pain words were poor discriminators of selective attentional bias across the four groups. The theoretical implications of this observation were discussed above, where it was suggested that affective pain descriptors may be representative of nonspecific negative emotionality, rather than pain-specific affect. Earlier research on the Stroop task has shown that degree of interference on the Stroop task can be related to the familiarity of target words (Klein, 1964). Priming studies have also shown that the strength of memory association can determine degree of Stroop interference (Conrad, 1974; Merrill, Sperber & McCauley, 1981). It is possible that these mechanisms can account for

the observation that the performance of all subjects was impeded by affective pain stimuli. More specifically, it is possible that the very ambiguity and familiarity of affective pain stimuli activated relatively intense memorial associations which directed attentional resources away from the colour of the stimuli and retarded colour-naming speed.

The second important result obtained in the present study was that except for the affective pain stimuli, state-specific Stroop interference effects appeared to hold when comparing the two pain groups to the nonpain-nondepressed group. Each of the pain groups showed interference effects which were specific to their status, so that the depressed pain group was slower naming the colours of sensory pain and depressive words in comparison to neutral or positive words. The nondepressed pain group obtained a slower colour naming time only for sensory pain words, in comparison to colour naming times for other stimulus types. The nonpain-nondepressed group showed no differences across stimulus types. Interestingly, the nonpain-depressed group also showed no differences in colour-naming speed across stimulus types, although their overall Stroop performance was significantly slower than the two nondepressed groups. This latter result conforms to research which suggests that mood-specific Stroop effects are more strongly related to anxiety than to depression per se (e.g. Hill & Knowles, 1991; Williams et al., 1988). Given that in the present study the strongest effects were obtained for the pain groups rather than the depressed group, the question must be raised as to whether attentional biases in chronic pain may be mediated by anxiety, rather than depression <u>per se</u>. This question will be addressed in more detail in the theoretical discussion below.

Because the first Stroop task failed to demonstrate pain-specific biases in attention, and the second yielded the predicted results, methodological differences between the two studies can be profitably contrasted in order to draw inferences regarding some of the parameters relevant to such tasks. One of the important differences between the two studies concerns subject selection procedures. In the pilot study, chronic pain subjects were not specifically distinguished on the basis of depression, whereas in the principal study, chronic pain subjects were separated on the basis of a psychiatric diagnosis of major depressive episode. This diagnostically-based separation allowed the assessment of the separate contributions of pain and depression to Stroop performance, information which was not available in the pilot study.

Another important difference between the two studies is the issue of stimulus selection. In the pilot study, pain stimuli were based on McGill Pain Questionnaire items, but were transformed from adjectives to nouns. In addition, these stimuli were selected on the basis of face validity, rather than on the basis of empirical evidence of their relevance to chronic pain. Likewise, the positive and negative stimuli in the pilot study were selected on the basis of ratings made by a nonclinical sample of undergraduate students (McDonald, 1988), with the result that their degree of relevance to depression was unknown. In contrast, stimuli used in the principal study were selected on the basis of ratings made by chronic pain subjects and depressed subjects, so that they presumably had a sufficient degree of environmental validity to differentially activate state-relevant cognitive processes. These differences between the two Stroop tasks suggest that subsequent

research using a Stroop task on chronic pain should carefully address the issues of both subject selection and stimulus selection.

In Phase I of the principal study, pain subjects demonstrated mood and pain-specific biases in attention, which were reflected in longer colour naming times for state-relevant stimuli than for irrelevant stimuli. In formulating a theoretical explanation for these results, one must recall that according to MacLeod (1991), no one theory has emerged which can account for the classical Stroop effect. However, he suggested that the Stroop effect may not be a pure measure of attention, but that it may be the case that colour words activate associative memory pathways which compete with the associative memory pathways activated by colour. An attempt to resolve this conflict between associative pathways may lead to a greater deployment of attention toward conflicting colour-word combinations than toward either pure colour stimuli or pure word stimuli. This creates a retardation in colour naming performance in the conflicting-colour condition relative to the pure colour condition or the pure word condition.

In extending this theory to the present results, it may be suggested that for the pain groups, the personal experience of pain and/or depression themselves created associative pathways which led to the differential deployment of attention to words which reflected these states. The strength of these pain and depression memory traces can be accounted for by self-schema theory, which suggests that the self can be an effective memory encoding device (Rogers, Kuiper, & Kirker, 1977) This explanation is also supported by previous research that has shown that self-awareness is associated with attentional interference on the Stroop task (Geller & Shaver, 1975). Further, it has been shown that a

depressive self-schema is associated with enhanced recall for depressive adjectives (Derry & Kuiper, 1981), and an ability to hold depressive self-referent material in working memory (Bargh & Tota, 1988). It is likely that in the present study the strength of the associative pathways created by pain and depression thus yielded a greater deployment of attention toward pain or depression words than to positive or neutral words. These results suggest that the experience of pain may create a self-schema with semantic associations which is quite separate from that created by attendant mood states.

It is also interesting to note that this differential deployment of attention appeared to occur only in the presence of negative states, that is, in the presence of pain or depression. The nonpain-nondepressed control group showed no such differential activation for positive stimuli. The relatively invariant performance of the nonpain-nondepressed control group across different stimulus types probably reflects the presence of a "neutral" mood state, (i.e. the absence of a specifically positive or negative mood). By extension, one would only expect a retardation effect for positive words only if subjects were in a specifically positive state. This result conforms to previous research on stroop performance, which has generally shown that normals do not show an increase in colour-naming speed for positive stimuli (e.g. Gotlib & Cane, 1987; Gotlib & McCann, 1984; Hill & Knowles, 1991).

Another interesting observation regarding the Stroop results is that the depressed nonpain group showed no differences across stimulus types. Some researchers have suggested that the Stroop task may only be effective in distinguishing dysphoric subjects from normals (Kleiger & Cordner, 1990), and may not be useful in distinguishing clinically

depressed subjects from nondepressed subjects. This may be because the speed of cognitive processing is slowed in serious depression, resulting in a ceiling effect for colour-naming times, and a resultant lack of differences across stimulus types (Hill & Knowles, 1991). Indeed, Williams et al. (1988) suggested that depressives are not likely to show state-specific effects on tasks like the Stroop which require automatic processing. Instead, they proposed that such tasks are more likely to be useful in investigating cognitive processes in anxiety disorders. As Williams et al. (1988) would have predicted, the nonpain depressives in the present study showed an overall psychomotor retardation effect, but no differences in colour-naming speed across stimulus types. However, the chronic pain depressives performed as Williams et al. (1988) would have predicted for anxiety subjects, with state-specific retardation effects. This observation raises the interesting possibility that the attentional processes experienced in chronic pain may occupy a middle ground between depression and anxiety. Subsequent research will be needed to address this issue. Potential research options in this regard will be discussed below.

Autobiographical Memory in Chronic Pain

The present section will provide an overview of Phase II of the principal study. Following subsections will provide a more detailed discussion of the results concerning individual dependent variables.

Phase II was an autobiographical memory task in which subjects were requested to recall a specific autobiographical memory to positive, sensory pain, affective pain, and depressive cue words. The dependent measures on the autobiographical memory task were: latency to recall a specific personal memory, and proportion of first responses which were

general, rather than specific. On the autobiographical memory task, it was expected that subjects would show the shortest recall latencies to cues which were relevant to their pain or emotional status. It was also expected that subjects would produce the lowest proportion of general memories to state-relevant cues, and that overall, the depressed groups would provide more general personal memories than the nondepressed groups. As an incidental benefit of the study's design, the autobiographical memory task also afforded the opportunity to determine whether the cue words were interpreted in a state-congruent direction

The first observation regarding the autobiographical memory task was that a high proportion of the affective pain words were not interpreted in a pain-congruent fashion. For this reason, responses to affective stimuli were excluded from further analyses. This result is a further indication that affective stimuli may be poor between-group discriminators of pain status, and may be better understood as exemplars of general negative emotionality, rather than as a separate dimension of pain.

In terms of response latency, the clearest indications of state-relevant biases were found among the pain groups. For the depressed pain group, the fastest response times were for sensory pain and depressive cues. For the nondepressed pain group, the fastest response times were obtained for the sensory pain words. These results suggest that for the chronic pain groups, the experience of pain and/or depression increased the availability of pain- or depression-relevant personal memories, so that these memories were recalled more readily than positive memories to the appropriate cues. The nonpain depressed group produced slower response times for sensory pain cues than for the

other word types, thus suggesting that pain was a less salient domain than positive or negative mood for this group. In contrast, the nonpain nondepressed group produced the longest response times for depressive cues relative to other word types, thus suggesting that for this group, depressed mood was a less salient dimension than either positive mood or pain.

The interaction term was not significant for autobiographical memory generality, but a significant group effect was obtained. As predicted, this effect was due to the two depressed groups producing a higher proportion of general memories across all stimulus types than the nondepressed groups. This result stands in contrast to results reported in previous research which in addition to a group main effect has found that subjects generally provided a higher proportion of specific memories to state-relevant cues (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Williams & Scott, 1988). Potential explanations for this discrepancy will be discussed below.

As mentioned above, an unexpected finding was that a high proportion of affective pain words were interpreted in ways which were not applicable to pain. The design of the autobiographical memory task also permitted the assessment of the degree to which the four subject groups interpreted other stimulus classes in a state-congruent fashion. In examining this variable, it was found that subjects' pain or depression status was related to an increased probability that pain or depressive stimuli would be interpreted in a state-congruent direction.

Differences in Retrieval Latency. Previous research has demonstrated that depression is associated with the tendency to remember negative personal events more easily than positive events (Clark &

Teasdale, 1982; Lloyd & Lishman, 1975; Teasdale & Fogarty, 1979; Williams & Scott, 1988). Williams and his colleagues have also found that patients with generalized mood disturbance other than depression show enhanced recall for negative personal events (Williams & Broadbent, 1986a; Williams & Dritschel, 1988). In examining the basis for these differences, Williams & Broadbent (1986a) demonstrated that differences in recall latency among depressives was due to a delay in the recall of positive memories, rather than to an increased speed in the recall of negative memories. Richards and Whittaker (1990) have shown that differences in recall latency also emerge when comparing anxious and nonanxious subjects. However, in the case of anxiety, the differences were due to an increased speed in the recall of anxiety-relevant memories, rather than to a delay in the recall speed for positive memories.

In the present study, the responses of the chronic pain subjects shared similarities with both depressives and anxious subjects from previous research. For example, depressed pain subjects showed both a reduced speed in the recall of positive memories and an increased speed in the recall of depressive memories relative to the nonpain nondepressed control group. These results are intriguing, and suggest again that cognitive processing in chronic pain may represent an intermediate stage between depression and anxiety.

The results obtained in the present study are consistent with Bowers (1981) network theory of human memory, wherein mood is conceptualized as a node in a relational pattern of memories. In Bowers's model, any event which activates a particular node will cause semantically contiguous material to become more accessible. Given that

they are in a negative emotional state, the "mood node" is already activated, negative personal memories are more easily retrieved when negative cues are encountered because of their semantic contiguity to the emotional state. Conversely, positive memories are less accessible when a subject is in a negative mood state because of the greater semantic distance between the emotional state and the positive memories. As discussed above, previous research has suggested that depression may block access to positive memories, rather than facilitate access to negative memories, and that anxiety may facilitate access to anxiety-related memories, rather than block access to positive memories. It appears that in the present study, pain and depression both blocked access to positive memories and facilitated access to pain-relevant memories.

However, it should be noted that the depressed nonpain group in the present study did not perform as depressed subjects had in previous research, in that there was little difference in retrieval speed across stimulus types for this group. It is difficult to explain why the depressed group did not perform as expected, but perhaps this difference reflects subtle, unmeasured differences in methodology or subject selection procedures between the present study and previous research. A second possibility is that differences in group performance were due to the unmeasured influence of different levels of anxiety on cognitive processing across the four groups. Unfortunately, however, anxiety was not assessed in the present study. Future research will have to be conducted to address the question of the relative contribution of anxiety and depression to autobiographical memory processes in chronic pain.

Autobiographical Memory Generality. Previous research by Williams and his colleagues has consistently found that it is more difficult for subjects with either depression or generalized mood disturbance to retrieve specific memories across all cue types on the autobiographical memory task (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Williams & Scott, 1988). Instead, when compared to normal subjects, emotionally disturbed subjects have tended to retrieve more general memories. Further, Williams's research has consistently yielded significant group by stimulus type interaction terms, with emotionally disturbed subjects retrieving more specific memories to negative cues, and normal subjects retrieving more specific memories for positive cues. The present research partially replicated Williams's findings, in that the two depressed groups produced a higher proportion of general memories than the nondepressed groups across all stimulus types. However, the group by stimulus type interaction term was not significant. This pattern of results demonstrates that it was depression, and not pain, which influenced the generality of autobiographical memory, thus suggesting that biases in memory generality among individuals with chronic pain are likely to be wholly mood-dependent, rather than pain-dependent.

Williams and Dritschel (1988) have proposed that a group effect in generality of memory retrieval may be due to a deficit at the encoding stage, and that the interaction term may be due to mood-specific contextual difficulties at the retrieval stage. Williams and Dritschel (1988) based this supposition on previous research in cognitive psychology which has demonstrated that only a limited number of elements of an autobiographical memory are encoded (Kolodner, 1985; Norman &

Bobrow, 1979; Reiser, Black, & Abelson, 1985). The specificity of the memory is determined by the nature of these elements: those memories whose encoding is based on factual data are likely to be more specific than those memories which are based on affective data (McAdams, Lensky, Daple, & Allen 1988). Williams and Dritschel (1988) have suggested that individuals who suffer from emotional disturbance may be hypersensitive to the affective dimensions of interpersonal situations, and may therefore encode personal memories which are largely based on affect. Williams and Dritschel (1988) have suggested that because affect is a poor encoding strategy, all types of memory are encoded with few specific elements, with the result that emotionally disturbed individuals may have a preponderance of general memories in long term storage. It has been proposed that this encoding deficit may be related to the group effect which is observed in autobiographical memory generality. For depressed individuals, difficulties retrieving specific memories are compounded at the retrieval stage, because their affective status reduces the availability of positive contextual cues with which to index positive memories. Negative contextual cues are more readily available when in a depressed state, and therefore specific negative memories are more accessible than positive specific memories. It has therefore been proposed that the interaction effects observed in autobiographical memory generality may be due to mood-specific deficits at the retrieval stage.

Based on this theory, it appears that depressed mood may influence the generality of personal memory at the encoding stage, regardless of pain status. Further, although chronic pain individuals may encode information based on pain-relevant cues (as suggested by the attentional

biases evident in the Stroop task) pain may not affect the generality of encoded information in the same way that negative emotion affects memory generality. In other words, it may be the case that pain may represent a more specific encoding index for personal memories than negative affect. From a clinical perspective then, recognizing and treating depression in chronic pain patients could be regarded as primary, because such emotional disturbance could alter an individual's ability to encode specific, personally-relevant, pain-management information which may be offered as part of a treatment program.

State-Relevant Judgement of Stimuli. One of the unexpected findings in the present project was that subjects' emotional or pain status tended to influence their interpretation of stimuli used in the autobiographical memory task, so that stimuli tended to be interpreted in a state-congruent fashion. This finding conforms to some other research which has found that anxious subjects tend to interpret either homophones (Eysenk et al., 1987; Matthews et al., 1989), or ambiguous stimuli (Eysenk et al., 1988, cited in Matthews et al., 1988) in ways which conformed to the subjects' affective status. Similar findings have not been reported for depression. Matthews et al. (1988) have suggested that this phenomenon may represent a specific example of the general phenomenon of anxiety being associated with the selective deployment of attention toward threat-relevant information in the environment. In a way which is similar to an anxious subject devoting more attentional resources to a state-relevant word in a Stroop task, anxious subjects may also allocate more resources to the state-relevant option when faced with two competing interpretations. Matthews et al. (1988) have pointed out that the mechanism for this phenomenon is not

clear. It is possible that such interpretational biases represent an automatic, unconscious process, where only one interpretational option is consciously available to an individual. Conversely, it is possible that subjects are consciously aware of the interpretational options, but deliberately select only one for further processing. In any case, the present results again suggest that at a cognitive level, chronic pain subjects may process information in a way which resembles anxiety more than depression per se.

The present results also have two important methodological implications. First, as discussed above, it appears that the affective pain descriptors which are included in the McGill Pain Questionnaire (Melzack, 1975), may not specifically represent pain. One must be cautious, therefore, when making assumptions regarding their discriminant validity. Because of their potentially low discriminant validity, it may be best to avoid their use in any application where inferences are to be drawn from differences between pain and nonpain subjects on cognitive tasks. In the present autobiographical memory task, for example, only 50 percent of the affective pain words were interpreted in a pain-congruent direction across the four groups. This result demonstrates that it is not possible to meaningfully interpret between-group differences on the affective pain condition on either the Stroop task, the autobiographical memory task, or the incidental recognition task. The second methodological implication of the present study is that in any subsequent research which utilizes a similar autobiographical memory paradigm, an effort should be made to ensure that subjects are interpreting all stimuli in a similar fashion. It is obvious that when stimuli are not interpreted similarly, different

semantic networks will be activated depending on the particular meaning selected for a cue word. Such confounding differences in semantic activation processes could lead to between-group differences in recall latency which are artifacts of unmeasured interpretational processes, rather than affective status *per se*.

## Incidental Recognition Memory in Chronic Pain

Phase III of the principal study was a recognition memory task. On this task it was expected that subjects would be biased toward recognition of state relevant stimuli. Such a bias would be reflected in a higher false-positive rate for state-relevant stimuli relative to irrelevant stimuli. In terms of signal detection theory, it was expected that sensitivity (*d'*) would be unaffected by emotional or pain status, but that subjects would show a relaxed criterion (*c*) for acceptance of state-relevant stimuli.

It was found that clear indications of state-dependent memory biases emerged when examining the false alarm rates. The chronic pain-depressed group had a higher rate of false alarms for sensory pain and depressive stimuli relative to positive stimuli; the chronic pain-nondepressed group had a higher rate of false alarms for sensory pain relative to depressive and positive stimuli; and the nonpain-depressed group had a higher rate of false alarms for depressive stimuli relative to sensory pain and positive stimuli. This bias appeared to hold only for negative states, as the nonpain-nondepressed group showed no differences in false alarm rates across stimulus types. As predicted, the interaction term for the sensitivity index, *d'* was not significant, thus suggesting that groups were not differentially sensitive to state-relevant stimuli. However, each group tended to show a relaxed

criterion (c) for acceptance of stimuli which were most relevant to its particular pain or emotion state, thus confirming the presence of a state-relevant differential bias in recognition memory.

These results conform to previous research on depression and recognition memory, which has shown that depression does not affect recognition accuracy (Cole & Zarit, 1982; Davis & Unruh, 1980; Watts & Sharrock, 1987). Instead, depression has been shown to be associated with elevations in false-alarms for state-relevant stimuli (Matthews & Southall, 1991; Watts et al., 1987). Further, signal detection analyses have demonstrated that depressives recognize negative stimuli more readily than positive stimuli as a result of employing a conservative criterion for accepting stimuli which are not state-relevant (Dunbar & Lishman, 1984).

It is interesting to note that the results obtained in the present study appear much more clear-cut than those obtained by Edwards et al. (1992), who also examined the role of chronic pain and depression in recognition for state-congruent memory. It will be recalled that Edwards et al. observed a nonsignificant trend for chronic pain to be associated with increased sensitivity for state-congruent stimuli. However, they found no evidence for state-congruent bias in recognition memory. Several points of difference exist between the present study and that published by Edwards et al. (1992) which may account for the discrepancy the two results. First, Edwards et al. (1992) did not utilize depression-specific descriptors. Instead, they used affective pain stimuli, whose validity have been questioned by results obtained in the present study. Second, Edwards et al. (1992) did not require their subjects to process the stimuli in any meaningful way, whereas in the

present study subjects had processed the stimuli in a Stroop task (Phase I), and an autobiographical memory task (Phase II). This difference may have meant that the stimuli were encoded more deeply in the present study than in the Edwards et al. (1992) study. If this was the case, the deeper encoding may have activated a wider network of memory associations, thus leading to biases in recognition. There two other potentially significant differences between the two studies, although further research will be required before influence of these variables can be determined. First, the present study categorized depression based on a structured diagnostic interview, whereas Edwards et al. (1992) relied on psychometric data for the same purpose. Second, in the present study stimuli were presented visually, whereas Edwards et al. (1992) presented their stimuli auditorially.

As noted above, these results can be accounted for by Bowers's network model of human memory which suggests that mood can operate as a node in a semantic network. The experience of a particular mood will activate semantically-related concepts and make them more accessible than non-related concepts, presumably because the original memory trace was encoded in a similar mood state. However, the unique contribution of the present results is to suggest that chronic pain may have properties similar to negative mood in the activation of a memory network. This is demonstrated by the observation that the presence of pain, with or without depression, was associated with elevated false alarm rates and with reduced values of $\underline{c}$ for pain stimuli.

However, these results also suggest that at the level of retrieval, an elaborative, or constructive process takes place which results in an overinclusive acceptance of state-relevant stimuli. It is

not clear whether it is an automatic, unconscious process, or a deliberate, effortful strategy which permits more elaboration of state-relevant material. Williams et al. (1988) would suggest that any process which distinguishes between depressives and normals is likely to involve effortful, rather than automatic processing. In the case of recognition memory, then, it appears that chronic pain may operate in a fashion which is similar to depression.

Summary of Results and Theoretical Implications

In a general sense, the results of the present project can be summarized by stating that both chronic pain and depression appear to exert a biasing influence on cognitive processing. In Pilot Study I it was found that depressed mood was more strongly related to the affective than to the sensory dimension of chronic pain, as measured by both the McGill Pain Questionnaire (Melzack, 1975) and a visual analogue scale. It was also observed in Pilot Study I that irrespective of whether pain was measured verbally (i.e. with the McGill Pain Questionnaire), or with a visual analogue scale, the correlations between MPQ measures of sensory and affective pain were higher than MPQ-VAS sensory pain correlations, or the MPQ-VAS affective correlations.

In Pilot Study II (the initial Stroop task), no significant interaction term was obtained. This results stands in contrast to Phase I of the principal study (the second Stroop task), where clear indications of pain and mood-specific attentional biases were observed, as reflected in longer colour naming times for mood and pain-relevant stimuli. This effect was clearest for the two pain groups.

In Phase II of the principal study (the autobiographical memory task), three dependent variables were assessed. These included latency

to first response, proportion of first responses which were general, and proportion of responses which were interpreted in a state-congruent fashion. The clearest indications of state-relevant latency biases were observed for the chronic pain-depressed and the chronic pain-nondepressed groups. In terms of memory generality, a group effect was obtained, wherein the depressed groups produced a higher proportion of general memories than the nondepressed groups. The generality interaction term was not significant. Response congruence was a serendipitously-observed variable, but with this variable it was found that pain and depression subjects were more likely to interpret pain and depression stimuli in a state-congruent direction.

Finally, the incidental recognition task found that subjects were more likely to be biased toward erroneously recognizing state-relevant stimuli. This was confirmed in the significant interaction terms obtained in the analysis of false alarm rates, and $c$, a signal-detection index of response bias.

The present results underscore the importance of including both pain and affective variables in investigating cognitive processing in chronic pain. Previous research has demonstrated that depression is phenomenologically implicated in chronic pain (e.g. Dworkin & Gitlin, 1991; Romano & Turner, 1985). However, the present results demonstrate that pain and depression can exert an additive influence on cognitive processing, such that investigating one without accounting for or controlling for the influence of the other could produce methodological or interpretational confounds.

It must be acknowledged, however, that although the separation of subjects into depressed and nondepressed groups in the present project

is theoretically justifiable, it is to some extent phenomenologically artificial. It will be recalled that 93 subjects were tested in the present project in order to arrive at a final sample of 60. Most of the 33 subjects who were discarded were those who did not clearly fit into either the depressed or nondepressed groups by virtue of having an intermediate number of DSM-IIIR depressive criteria. It is therefore apparent that the modal affective state in chronic pain may be described as dysphoria, rather than depression per se, and that severity of emotional reaction to chronic pain probably exists on a continuum, rather than depression presenting in terms of a discrete occurrence or nonoccurrence.

It may be useful to consider the potential mechanisms underlying the severity of depressive reactions among chronic pain sufferers. Some writers have speculated that depression in chronic pain is due to passivity in the face of pain symptoms, coupled with denial of emotional and interpersonal difficulties (Blumer & Heilbronn, 1981). Others have suggested that depression results from the loss of physical and interpersonal reinforcers (Hendler, 1984; Sternbach, 1974). Some have suggested that depressive symptomatology is related to the stage of psychological adjustment to persistent pain problems, with a depressive reaction most likely to occur after the subchronic stage, at the time that the patient becomes aware that the symptomatology is unlikely to remit (Garron & Leavitt, 1983). Brown (1990) found support for this hypothesis in a prospective, cross-lagged design. He found that among a sample of 243 rheumatoid arthritis patients, pain predicted depression more strongly during the final 12 months of the 24-month study than during the initial 12 months. However, the affective characteristics of

the present sample indicate that there may be other mechanisms which underlie the severity of depressive symptomatology. Specifically, it is likely that it is the underlying cognitive characteristics of individuals which mediate the depression-pain relationship. For example, Rudy, Kerns, & Turk (1988) using a structural-modelling analysis, found that the pain-depression relationship was not significant. However, they found that measures of perceived life interference and self-control were significant intervening variables between depression and chronic pain. The present results are consistent with a cognitive-behavioural mediation model of chronic pain, in that it was clearly demonstrated that cognitive-behavioural differences emerge across depressed and nondepressed groups of pain patients. Further, it was demonstrated that these differences relate not only to processing style, but to the content of cognitions among chronic pain suffers.

Another body of literature to consider in evaluating the emotional impact of chronic pain is the research on stress, appraisal and coping. In a recent retrospective review, Lazarus (1993) argued that psychological stress can be viewed as a subset of the emotions. As such, emotional responses can be predicted by the cognitions which mediate between the person and the environment. These mediating cognitions, or appraisals, determine the emotional response, and subsequent coping efforts. In the view of this model, depression and anxiety could result from either dysfunctional appraisal of the meaning of symptoms (e.g. "This pain means that I have cancer."), or from choice of the wrong coping strategy. For example, if an individual with chronic pain chose to employ problem-focused coping strategies such as searching for a cure, or dulling symptoms with medication, then

depression could result because the appraisal of the success of the coping strategy would reveal its relative futility and cause a profound sense of discouragement. However, if an individual chose to engage in emotion-focused coping, and to modify their cognitions and reactions to the pain, then it is likely that this would result in considerably lower levels of negative emotion. (See Lazarus & Folkman, 1987 for a review of problem versus emotion focused coping.)

It should be noted that the Lazarus (1993) model has significant areas of overlap with the Rudy, Kerns, and Turk (1988) model discussed previously, but that it also opens the door to investigation of potential emotional responses other than depression. Results obtained in the present project suggest that anxiety may represent a significant component of the emotional aspects of chronic pain. However, it could also be asked whether other emotions also play a role in the expression and experience of chronic pain. Lazarus (1991a, 1991b) has proposed the existence of 15 basic emotions: nine negative, and six positive. It is possible that in the nondepressed groups in the present study, for example, that hope, relief, or happiness may have been influential in their performance on the various tasks. Similarly, it is possible that among the depressed group specific negative emotions such as anger, guilt, or envy may have also influenced task performance.

Clinical Implications of Present Research

In a general sense, the present results suggest that biased cognitive processing may be implicated in the experience of chronic pain in ways which are analogous to biases which have also been demonstrated in affective disorders. Such an observation would suggest that it may be possible to treat the cognitive aspects of the chronic pain

experience using some of the same techniques which have been developed for treatment of affective disorders

From a clinical perspective, perhaps the most interesting result to emerge from the present project is the observation that chronic pain may share cognitive similarities with both depression and anxiety. In the past, it has been assumed that depression is the most common affective disorder to be associated with chronic pain (e.g. Tworkin & Gitlin, 1991; Romano & Turner, 1985). Indeed, in the principal study reported here, it was relatively easy to form a group of chronic pain patients with a diagnosable major depressive episode, using DSM-IIIR criteria (A.P.A., 1987). In spite of the fact that this group was diagnosed with a major depressive episode, their behaviour was not identical across all tasks to the group who did not suffer from pain, but who were also diagnosed with major depressive episode. Specifically, the PD and PN groups showed state specific effects on attention on the Stroop task which were not shown by the ND group. This effect has been suggested by Williams et al. (1988) as being characteristic of anxiety rather than depression. Similarly, chronic pain subjects responded like anxious subjects on the autobiographical memory task, in that they showed an increased speed for recall of memories to pain-relevant cues relative to positive cues. However, in other ways the chronic pain patients in the present studies behaved similarly to depressed subjects. For example, chronic pain subjects showed a delay in the recall of positive memories relative to the nonpain groups. This is a similar retrieval pattern to that which has been observed previously among depressed subjects (Williams & Broadbent, 1986a). Further, pain and depressed subjects in the present research

both demonstrated a tendency to retrieve general, rather than specific personal memories, to interpret stimuli in state-relevant directions, and to be similarly biased in their recognition of stimuli.

These results suggest that it may be useful to adopt a treatment strategy for chronic pain patients which includes techniques which have been demonstrated to be effective in both anxiety and depression. For example, a standard treatment for anxiety involves exposing the patient to feared stimuli during the course of treatment, and increasing the degree of exposure to those stimuli while simultaneously teaching an incompatible response, such as relaxation (e.g. Wilson & O'Leary, 1980). A similar approach could be used in the treatment of chronic pain, where relaxation could be targeted toward a specific feared aspect of the chronic pain experience. This could be especially effective for example, where functional limitations evolve because of a phobia regarding potential muscle spasm. Similarly, specific fears sometimes develop regarding fear of reinjury during the rehabilitation process. Desensitization techniques could therefore be targeted toward these specific issues. In current treatment approaches to chronic pain, a general approach is often adopted to relaxation treatment, where the goal is to effect a reduction in muscle tension, rather than to address a specific feared aspect of the pain experience (e.g. Turk et al., 1983).

Another example of targeted treatment for chronic pain patients would be to adopt techniques to increase the amount of detail encoded regarding the particular feared object or sensation. Watts and his colleagues have found this to be an effective modality for reducing anxiety in phobic patients (Watts, 1974; Watts, Sharrock & Tresize,

1986; Watts, Tresize & Sharrock, 1986). In applying this technique, the patient is guided in the enrichment of detail regarding the feared object. It is thought that there are two mechanisms underlying the success of this technique. First, the enrichment of detail facilitates an habituation to the feared object, and a concomitant extinction of the fear response. Second, it has been found that phobics' memories are impoverished with regard to coping strategies, so that the process of embellishing the image of the feared object simultaneously serves to elaborate potential coping mechanisms. Such techniques have also been suggested for use among depressed patients as a way of overcoming memory generality (Williams & Dritschel, 1988; Williams & Scott, 1988), although they have not yet been researched. In terms of chronic pain, it possible that structured, rehearsed elaboration of feared or otherwise troublesome aspects of the chronic pain experience could likewise have the dual effect of facilitating extinction and generating potential coping responses.

Finally, another approach to consider in the treatment of chronic pain would be to investigate and modify the coping approaches used by chronic pain patients. Although there is a large body of research on coping in chronic pain, it is based largely on the use of the Coping Strategies Questionnaire (CSQ) for pain patients, developed originally by Rosenstiel and Keefe (1983), and subsequently validated in a large number of studies (e.g. Gil, Abrams, Phillips, & Keefe, 1989; Keefe & Dolan, 1986; Keefe et al., 1987; Keefe, Brown, Wallston & Caldwell, 1989; Keefe, Crisson, Urban, & Williams, 1990; Lawson, Reeser, Keefe, & Turner, 1990). The CSQ has been reliably found to yield three factors: global appraisal and beliefs about pain control, mental processes

involved in pain control, and specific mental content associated with pain coping. It is notable, however, that the extant literature on the CSQ neither addresses treatment issues nor acknowledges research the coping and stress literature amassed by researchers such as Lazarus (e.g. 1993) and his colleagues. It may be profitable to examine the degree to which chronic pain coping responses correspond to the emotion versus problem-focused distinction outlined by Folkman and Lazarus (1988), and to focus intervention on initiating effective coping strategies. As discussed previously, problem-focused coping in regard to the symptoms of chronic pain may not be effective, and may instead lead to negative emotional reactions. Instead, it may be more useful to develop emotion-focused strategies, which attempt to modify an individual's reaction to the symptoms.

Ultimately, by adopting treatment strategies which are designed to address the particular cognitive styles which the present research suggests may be unique to chronic pain, it may be possible to reduce the amount of attention deployed toward pain-relevant stimuli in the environment, as well as reduce the spread of negative semantic activation which may take place during chronic pain, and thus reducing the phenomenological negativity of chronic pain. By doing this, the therapist would be addressing the major cognitive mechanisms assumed to underlie anxiety and depression (Williams et al., 1988), and which also appear to underlie chronic pain.

However, research is needed to determine whether such treatment remediates cognitive biases in chronic pain. The assumption is made that dysfunctional information processing is a potential factor in the etiology and maintenance of chronic pain (e.g. Flor, Birbaumer & Turk,

1990). The present research provides evidence of the existence of such biases. However, these data have something of the character of a snapshot, in that they do not demonstrate whether such biases in fact do play a time-dependent causative role in chronic pain. Treatment outcome studies, or prospective research which follows the natural history of cognitive biases in chronic pain, would go some distance toward informing this very central question.

## Limitations of the Present Research and Implications for Future Research

As discussed above, several novel findings emerged from the present research. Included here are the pain and mood-specific attentional biases demonstrated on the Stroop task, the simultaneous influence of depressive and anxious cognitive styles on autobiographical memory latency, the tendency of chronic pain and depressed subjects to interpret ambiguous stimuli in state-congruent directions, and the biasing effect of both pain and depression on recognition memory. Although these findings are novel, and potentially clinically useful, their robustness has yet to be determined. It is therefore important that these studies be replicated in order to ascertain whether these results are dependent on the particular subject sample or methodology used, or whether they are general. There are two factors which argue against the likelihood that the present results are methodological or sampling artifacts. First, the studies were based on a well-developed theoretical model which has been validated in the area of affect research. Second, specific hypotheses were derived from and tested against this theoretical model. In testing these hypotheses, many of the predicted between group differences achieved statistical significance. This argues against the likelihood of these results

occurring by chance. However, it must be acknowledged that other threats to statistical conclusion validity exist, such as measurement variability, and sampling fluctuations (Cook & Campbell, 1976), which point out that replication will be necessary to determine the parameters of the phenomena detected in the present study.

One of the more interesting findings of the present research is that chronic pain appears to share cognitive similarities with depression and anxiety. However, it was not possible to determine the extent to which anxiety contributed to the present results because unfortunately anxiety was neither diagnosed nor measured. Subsequent research will be needed to address this question more explicitly. In particular, it will be important to separate depression from anxiety methodologically as well as statistically in order to determine the relative contributions of each of these affects to specific cognitive processes in chronic pain.

The results of the Stroop task as used in the present study suggest that attentional processes may be biased by chronic pain. However, a recent review has pointed out that performance on the Stroop task may be determined by semantic memory as well as attention (Macleod, 1991). In order to determine the extent to which attention is affected by pain, further research could be conducted using methodology which taps attentional processes more exclusively. An example of such a methodology would be the visual-probe experiment conducted by Macleod, Matthews and Tata (1986). In this paradigm, subjects are required visually shadow words appearing on a video display unit, and to press a button in response to the random appearance of a dot on the VDU. Macleod et al. found that anxious subjects' visual attention was drawn

away from the appearance of the dot by the simultaneous appearance of threat-relevant words. Such a methodology could be adapted for use with a chronic pain sample, and thereby provided a sensitive assessment of the degree to which encoding versus retrieval is biased by pain.

The results of the autobiographical memory task suggested that chronic pain subjects may employ retrieval strategies which resemble both depression and anxiety. This suggests that it would be profitable to explore the relative contributions of these affects to the present results. This could be accomplished in subsequent research by including a control group which had been diagnosed with anxiety as well as one which has been diagnosed with depression. However, it must be acknowledged that because the depressed subjects in the present study did not respond to the autobiographical memory task as depressed subjects had in other research, perhaps the present results may have been compromised by sampling variability. This possibility is further strengthened by the observation that depression did not interact with stimulus type in the generality of autobiographical memory, as had been reported in other research by Williams and his colleagues (Williams & Broadbent, 1986a; Williams & Dritschel, 1988; Williams & Scott, 1988). It is interesting that judgement of ambiguous stimuli was affected by both mood and pain. However, the reliability of this phenomenon may be questionable since it was serendipitous, rather than predicted. This finding does conform to some research with anxious subjects which has demonstrated that judgement of homophones is affected by the particular locus of anxiety (Eysenk et al., 1987; Matthews et al., 1989), thus suggesting that it may be replicable. However, subsequent research is required in which stimuli are selected specifically on the basis of

their ambiguity before the question of judgement and chronic pain can be answered definitively.

It was found that recognition memory was biased in a state-congruent direction by chronic pain and depression. Previous research with recognition memory and depression has produced variable results in this regard (see Matthews et al., 1988 for a review). As with the other results discussed above, it is likely that further research will have to be conducted in order to determine the reliability of this finding among chronic pain subjects. It must be acknowledged in the case of the recognition memory results that the reliability of the findings may have been affected by the size of the stimulus sample in the present research. Specifically, only 5 target stimuli in each of four stimulus categories were selected. This yielded a total of 20 targets out of a total of 100 stimuli to be judged. It would be useful for future research to include a larger sample of stimuli in order to ensure the reliability of results.

As discussed previously, emotions other than depression or anxiety may have influenced task performance in the present sample to an unknown degree. Lazarus (1991a, 1991b) has suggested that 15 different emotions are identifiable. It may be useful in subsequent research to identify, and either examine or control for the influence of emotions other than those under immediate consideration. It may be particularly useful to investigate more closely those individuals with chronic pain who do not suffer emotional distress. Such individuals may be able to provide useful information regarding coping strategies and emotion, that could add to our understanding of the psychology of chronic pain, and perhaps inform treatment.

Finally, note was made above that a large number of subjects in the present sample were discarded from analysis on the basis of insufficient criteria to arrive at a diagnosis of major depressive episode. This suggests that affective reactions to chronic pain may exist along a continuum of severity. Although there is some indication that cognitive-behavioural variables may mediate the relationship between chronic pain and depression (Rudy, Kerns & Turk, 1988), future research should be directed at more precisely specifying the mediating variables in this relationship.

Summary

The present research was designed to assess the relative contributions of pain and depression to potential biases in cognitive processing. Preliminary to examining cognitive processing directly, a psychometric study was run in order to delineate the relationship of depression to the sensory and affective dimension of chronic pain. Results of this study showed that depressed mood was more strongly related to the affective dimension than to the sensory dimension. This was initially interpreted as evidence of the separability of these dimensions. However, in light of subsequent research conducted in the present project, it was suggested that the affective dimension of chronic pain may represent generalized negative affect, rather than pain-specific affect, and was therefore less useful in distinguishing pain subjects from nonpain subjects.

In order to examine specific cognitive processes in chronic pain, a Stroop task, an autobiographical memory task, and an incidental recognition task were conducted. Results of these tasks suggested that attention, autobiographical memory, and recognition memory may be biased

by chronic pain. The effect of depression across these task was less consistent. Instead, it appeared that the way in which chronic pain subjects processed state-relevant information shared commonalities with both depression and anxiety, thus suggesting that the way that stimuli are processed in chronic pain may be unique to that state, rather than being predominantly influenced by depression. Finally, limitations of the present research were discussed, and suggestions made for future research.

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## Footnotes

[1] The deletion of affective pain stimuli from subsequent analyses did not substantively affect the pattern of significant results with either autobiographical memory latency or autobiographical memory generality. Comparison of analyses with four stimulus types and three stimulus types are presented below.

### Autobiographical Memory Latency

#### With Four Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 1.53 | .218 |
| Latency (Wilk's Criterion) | (3,54) | 4.29 | .009 |
| Interaction (Wilk's Criterion) | (9,132) | 5.33 | .000 |

#### With Three Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | .59 | .625 |
| Latency (Wilk's Criterion) | (2,55) | 4.31 | .018 |
| Interaction (Wilk's Criterion) | (6,110) | 6.83 | .000 |

### Autobiographical Memory Generality

#### With Four Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 12.15 | .000 |
| Generality (Wilk's Criterion) | (3,54) | 2.11 | .110 |
| Interaction (Wilk's Criterion) | (9,132) | .70 | .703 |

#### With Three Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 10.06 | .000 |
| Generality (Wilk's Criterion) | (2,55) | 1.90 | .159 |
| Interaction (Wilk's Criterion) | (6,110) | .65 | .692 |

## Incidental Recognition Task: Hits

### With Four Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 2.88 | .044 |
| Hit Rate (Wilk's Criterion) | (3,54) | .52 | .673 |
| Interaction (Wilk's Criterion) | (9,132) | 2.29 | .021 |

### With Three Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 3.02 | .037 |
| Hit Rate (Wilk's Criterion) | (2,55) | 0.13 | .878 |
| Interaction (Wilk's Criterion) | (6,110) | 3.46 | .004 |

## Incidental Recognition Task: Memory False Alarms

### With Four Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 6.51 | .001 |
| False Alarms (Wilk's) | (3,54) | 16.72 | .000 |
| Interaction (Wilk's Criterion) | (9,132) | 4.19 | .000 |

### With Three Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 5.32 | .003 |
| Latency (Wilk's Criterion) | (2,55) | 22.83 | .000 |
| Interaction (Wilk's Criterion) | (6,110) | 4.94 | .000 |

## Incidental Recognition Task: D'

### With Four Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 8.17 | .000 |
| D' (Wilk's Criterion) | (3,54) | 10.76 | .000 |
| Interaction (Wilk's Criterion) | (9,132) | 1.97 | .048 |

### With Three Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 7.75 | .000 |
| D'(Wilk's Criterion) | (2,55) | 6.64 | .003 |
| Interaction (Wilk's Criterion) | (6,110) | 2.23 | .046 |

## Incidental Recognition Task: Criterion

### With Four Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | 1.02 | .390 |
| Latency (Wilk's Criterion) | (3,54) | 2.99 | .038 |
| Interaction (Wilk's Criterion) | (9,132) | 3.64 | .000 |

### With Three Stimulus Groups

| Effect | df | F | Significance |
|---|---|---|---|
| Group | (3,56) | .98 | .407 |
| Latency (Wilk's Criterion) | (2,55) | 4.28 | .014 |
| Interaction (Wilk's Criterion) | (6,110) | 5.47 | .000 |

# Appendix A

## McGill Pain Questionnaire

## McGill-Melzack Pain Questionnaire

Below you will find groups of adjectives that have been used to describe the experience of pain. Within each group of adjectives, choose the one word that best describes the kind of pain you have experienced during the last week. Please indicate you choice by placing a check mark next to the appropriate word. Do not check any of the words in a group if none of them describe your pain over the past week.

---

1. Flickering ___
   Quivering ___
   Pulsing ___
   Throbbing ___
   Beating ___
   Pounding ___

2. Jumping ___
   Flashing ___
   Shooting ___

3. Pricking ___
   Boring ___
   Drilling ___
   Stabbing ___
   Lancinating ___

4. Sharp ___
   Cutting ___
   Lacerating ___

5. Pinching ___
   Pressing ___
   Gnawing ___
   Cramping ___
   Crushing ___

6. Tugging ___
   Pulling ___
   Wrenching ___

7. Hot ___
   Burning ___
   Scalding ___
   Searing ___

8. Tingling ___
   Itchy ___
   Smarting ___
   Stinging ___

9. Dull ___
   Sore ___
   Hurting ___
   Aching ___
   Heavy ___

10. Tender ___
    Taut ___
    Rasping ___
    Splitting ___

11. Tiring ___
    Exhausting ___

12. Sickening ___
    Suffocating ___

13. Fearful ___
    Frightful ___
    Terrifying ___

14. Punishing ___
    Gruelling ___
    Cruel ___
    Vicious ___
    Killing ___

15. Wretched ___
    Blinding ___

16. Annoying ___
    Troublesome ___
    Intense ___
    Unbearable ___

17. Spreading ___
    Radiating ___
    Penetrating ___
    Piercing ___

18. Tight ___
    Numb ___
    Drawing ___
    Squeezing ___
    Tearing ___

19. Cool ___
    Cold ___
    Freezing ___

20. Nagging ___
    Nauseating ___
    Agonizing ___
    Dreadful ___
    Torturing ___

# Appendix B

## Centre for Epidemiologic Studies

## Depression Scale

## CES-D Scale

INSTRUCTIONS: Below is a list of the the ways you might have felt or behaved. Use the scale below to indicate how often you have felt this way during the past week. Please indicate your response by circling the appropriate number to the right of the the statement.

1 = Rarely or none of the time (less than 1 day)
2 = Some or a little of the time (1-2 days)
3 = Occasionally or a moderate amount of time (3-4 days)
4 = Most or all of the time (5-7 days)

| | | | | | |
|---|---|---|---|---|---|
| 1. | I was bothered by things that usually don't bother me..... | 1 | 2 | 3 | 4 |
| 2. | I did not feel like eating: my appetite was poor..... ..... | 1 | 2 | 3 | 4 |
| 3. | I felt I could not shake off the blues even with the help of family & friends | 1 | 2 | 3 | 4 |
| 4. | I felt I was just as good as other people..... | 1 | 2 | 3 | 4 |
| 5. | I had trouble keeping my mind on what I was doing..... | 1 | 2 | 3 | 4 |
| 6. | I felt depressed..... | 1 | 2 | 3 | 4 |
| 7. | I felt that everything I did was an effort..... | 1 | 2 | 3 | 4 |
| 8. | I felt hopeful about the future..... | 1 | 2 | 3 | 4 |
| 9. | I thought my life had been a failure... | 1 | 2 | 3 | 4 |
| 10. | I felt fearful..... | 1 | 2 | 3 | 4 |
| 11. | My sleep was restless..... | 1 | 2 | 3 | 4 |
| 12. | I was happy..... | 1 | 2 | 3 | 4 |
| 13. | I talked less than usual..... | 1 | 2 | 3 | 4 |
| 14. | I felt lonely..... | 1 | 2 | 3 | 4 |
| 15. | People were unfriendly..... | 1 | 2 | 3 | 4 |
| 16. | I enjoyed life..... | 1 | 2 | 3 | 4 |

17. I had crying spells..... 1 2 3 4

18. I felt sad..... 1 2 3 4

19. I felt that people dislike me..... 1 2 3 4

20. I could not get "going"..... 1 2 3 4

# Appendix C

## Letter of Explanation and Consent Form: Pilot Study I

# Letter of Information
## Personal Feelings and Chronic Pain

INVESTIGATOR: Michael D. Boissevain: Graduate Student in Clinical Psychology, U.W.O.

PLACE OF RESEARCH: Rheumatic Diseases Unit, University Hospital

This research project in an investigation of whether the experience of chronic pain affects personal feelings. To help us look at this question, two groups of individuals will be asked to participate. The first group will contain individuals who have suffered from pain for at least six months. The second group will contain individuals who do not presently suffer from pain.

To participate in this study, you will be asked to complete three brief questionnaires regarding your pain and your personal feelings.

Your questionnaires will be identified by number rather than name, so that your confidentiality is further assured. Confidentiality will be further protected by carefully placing all research data in a locked file. However, the data may have to be released if required by law. If the results of this study are published, your name will not be used.

It is expected that this study will require about ten minutes of your time. There are no known risks associated with the task which was just described, but if you feel uncomfortable with the procedure, or if you have any questions regarding the task, please bring them up with the experimenter.

It is not expected that the procedure will provide you with immediate benefit. However, it is hoped that the procedure may allow us to help others suffering from chronic pain in the future.

Please understand that you are free not to take part in this study, and if you do agree to participate, you may withdraw from the study at any time without jeopardy to your future care.

If you are participating in another study at this time, it should not affect your participation in the present study.

If you have any further inquiries, please call Michael Boissevain at 434-5606, or at 679-2111, local 4726.

## Consent Form
## Personal Feelings and Chronic Pain

I have read the accompanying letter of information, have had the nature of the study explained to me, and I agree to participate. All questions have been answered to my satisfaction.

DATE

NAME

SIGNATURE

WITNESS

## Appendix D

## Letter of Explanation and Consent Form: Pilot Study II

# Letter of Information
## Investigation into Interference in Naming Colours

INVESTIGATOR: Michael D. Boissevain: Graduate Student in Clinical Psychology, U.W.O.
PLACE OF RESEARCH: Rheumatic Diseases Unit, University Hospital

This research project in an investigation of whether the experience of chronic pain interferes with the processing of certain types of verbal information. To help us look at this question, two groups of individuals will be asked to participate. The first group will contain individuals who have suffered from pain for at least six months. The second group will contain individuals who do not presently suffer from pain.

To participate in this study, you will be asked to complete one brief questionnaire regarding your personal feelings. You will then be shown six separate lists of words, where the words are printed in brown, blue, red, and green ink. Your task will simply be to name the colour of the ink in which each word is printed. You will be asked to name each colour as quickly as possible, and to not name the word itself. For instance, if you see the word "red" printed in blue ink, you will say, "red".

Your responses will be tape recorded, but your name won't be used on the tape, so that your answers will remain confidential. In addition, your questionnaires will be identified by number rather than name, so that your confidentiality is further assured.

It is expected that this study will require fifteen or twenty minutes of your time. There are no known risks associated with the task which was just described, but if you feel uncomfortable with the procedure, or if you have any questions regarding the task, please bring them up with the experimenter.

It is not expected that the procedure will provide you with immediate benefit. However, it is hoped that the procedure may allow us to help others suffering from chronic pain in the future.

Please understand that you are free not to take part in this study, and if you do agree to participate, you may withdraw from the study at any time without jeopardy to your future care.

Confidentiality will be protected by carefully placing all research data in a locked file. As noted above, your verbal and written responses will not be identified with your name. However, the data may have to be released if required by law. If the results of this study are published, your name will not be used.

If you are participating in another study at this time, it should not affect your participation in the present study. If you have any further inquiries, please call Michael Boissevain at 434-5606, or at 679-2111, local 4726.

## Consent Form
## Investigation into Interference in Naming Colours

I have read the accompanying letter of information, have had the nature of the study explained to me, and I agree to participate. All questions have been answered to my satisfaction.

DATE

NAME

SIGNATURE

WITNESS

# Appendix E

## Semantic Processing Test

## Semantic Processing Test

Many of the things we do rely on common sense, a knowledge of the world and an ability to use such knowledge. The present test looks at the speed and accuracy with which people can use such information. It consists of a series of sentences, about half of which are true and half of which are false. The true sentences are obviously all true, e.g. "dogs have four legs", or "birds have wings". The false sentences are made up by combining two true sentences, e.g. "dogs have wings", or "birds have four legs. While the true sentences may not be all quite as obvious as this, there are no trick questions. If you find a question which you really cannot answer, mark it with a ?

Work as quickly as you can without making errors. Put a check mark beside those questions which are true, and a cross in the space beside those questions which are false.

Try the following at your own speed, but do not turn over the page until you are given the signal to begin the main test.

1. ____ Rats have teeth.
2. ____ Nuns are made in factories.
3. ____ Ants are living creatures.
4. ____ Tractors grow in gardens.
5. ____ Pythons move around searching for food.
6. ____ Desks wear clothes.

1. ___ Admirals are people.
2. ___ Grapes are people.
3. ___ Beef steaks can be bought in stores.
4. ___ Dragonflies have wings.
5. ___ Footstools are small.
6. ___ Grass snakes move around searching for food.
7. ___ Prime ministers have feathers.
8. ___ Bishops wear clothes.
9. ___ Bedroom slippers are made in factories.
10. ___ Beavers have strong teeth.
11. ___ Forks are manufactured goods.
12. ___ Architects can be bought in stores.
13. ___ Prime ministers hold political office.
14. ___ Vans grow in gardens.
15. ___ Pliers are found in tool boxes.
16. ___ Tomato soup is a liquid.
17. ___ Admirals have fins.
18. ___ Wives have husbands.
19. ___ Beef steaks are footwear.
20. ___ Grapes come from plants.
21. ___ Wives are made in factories.
22. ___ Beer is sold by a butcher.
23. ___ Penguins are living creatures.
24. ___ Dragonflies are manufactured goods.
25. ___ Haddocks are fish.
26. ___ Beer is an alcoholic drink
27. ___ Haddocks have wheels.
28. ___ Architects undergo a long training.
29. ___ Tomato soup moves around searching for food.
30. ___ Vans are vehicles.
31. ___ Bishops are islands.
32. ___ Footstools wear clothes.
33. ___ Beef steaks are officers.
34. ___ Fish and chips move around searching for food.
35. ___ Climbing boots are made in factories.
36. ___ Gin is sold by butchers.
37. ___ Potatoes can be eaten.
38. ___ Can openers are said to have loud voices.
39. ___ Fish and chips are fried.
40. ___ Mothers are parents.
41. ___ Crows are in charge of ships.
42. ___ U.S. Presidents have feathers.
43. ___ Beef steak can be bought in stores.
44. ___ Corporals come from calves
45. ___ U.S. Presidents hold political office.
46. ___ Popes wear clothes.
47. ___ Drills are found in tool boxes.
48. ___ Trucks grow in gardens.
49. ___ Popes are footwear.
50. ___ Corporals are people.

# Appendix F

## Diagnostic Interview for Depression and Scoring Protocol

SCID
Major Depressive Syndrome Criteria

Items are coded:
? if inadequate information obtained,
1 if the criterion is absent or false,
2 if the criterion is present, but at a subthreshold level,
3 if the criterion is at a suprathreshold level

1. In the last month, has there been a period of time when you were feeling depressed or down most of the day, nearly every day?
IF YES: How long did it last (as long as two weeks?)

2. What about being a lot less interested in most things, or unable to enjoy the things you used to enjoy?
IF YES: Was it nearly every day? How long did it last? (As long as two weeks?

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If neither item 1 or two is coded "3", then go to item 12

---

3. During this time...did you lose or gain any weight? (How much?) (Were you trying to lose weight?)
IF NO: How was your appetite? (What about compared to your usual appetite?) (Did you have to force yourself to eat?) (Was that nearly every day?)

4. During this time...how were you sleeping? (Trouble falling asleep, waking frequently, trouble staying asleep, waking too early, OR sleeping too much? How many hours a night compared to the usual? Was that nearly every night?

5. During this time...were you so fidgety or restless that you were unable to sit still? (Was it so bad that other people noticed it? Was that nearly every day?)
IF NO: What about the opposite -- talking or moving more slowly than is normal for you? (Was it so bad that other people noticed it?)

6. During this time...what was your energy like? (Tired all the time? Nearly every day?)

7. During this time...how did you feel about yourself? (Worthless?) (Nearly every day?)
IF NO: What about feeling guilty about things that you had done or not done? (Nearly every day?)

8. During this time...did you have trouble thinking or concentrating? (Nearly every day?)
IF NO: Was it hard to make decisions about everyday things? (Nearly every day?)

9. During this time...were things so bad that you were thinking a lot about death, or that you would be better off dead? What about thinking of hurting yourself?
IF YES: Did you do anything to hurt yourself?

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ETIOLOGIC ROLE OF AN ORGANIC FACTOR IN FULL DEPRESSIVE SYNDROME

10. Just before this began, were you physically ill?
Were you taking any street drugs or medicines? (Any change in the amount you were taking?)

IF YES TO ANY OF THESE QUESTIONS, DETERMINE IF THE DEPRESSIVE EPISODE WAS INITIATED OR MAINTAINED BY AN ORGANIC FACTOR.

---

11. Did this begin soon after someone close to you died?

12. How many separate times have you been (depressed/patient's equivalent) nearly every day for at least two weeks and had several of the symptoms that you described?

How old were you when you first had a lot of these symptoms for at least two weeks?

SCID Scoring Key

| | | | | | |
|---|---|---|---|---|---|
| 1. | **Depressed Mood** | ? | 1 | 2 | 3 |
| 2. | **Anhedonia** | ? | 1 | 2 | 3 |

If neither item 1 or 2 is coded "3", then go to item 12

| | | | | | |
|---|---|---|---|---|---|
| 3. | **Weight Loss** | ? | 1 | 2 | 3 |
| 4. | **Insomnia/Hypersomnia** | ? | 1 | 2 | 3 |
| 5. | **Psychomotor Agitation/Retardation** | ? | 1 | 2 | 3 |
| 6. | **Fatigue** | ? | 1 | 2 | 3 |
| 7. | **Worthlessness** | ? | 1 | 2 | 3 |
| 8. | **Concentration** | ? | 1 | 2 | 3 |
| 9. | **Suicidal Ideation** | ? | 1 | 2 | 3 |
| 10. | **Organic Factors** | ? | 1 | | 3 |
| 11. | **Bereavement** | | 1 | | 3 |
| 12. | **History:** Number of Incidents | | | | ___ |
| | Age of Onset | | | | ___ |

**Diagnosis** 1 3

At least five of items 1 to 9 must be coded "3", including either or both of items 1 and 2

## Appendix G

## Letter of Explanation and Consent Form: Principle Studies

# Letter of Information
# Word Processing in Chronic Pain

INVESTIGATOR: Michael D. Boissevain: Graduate Student in Clinical Psychology, U.W.O

PLACE OF RESEARCH: Rheumatic Diseases Unit, University Hospital

This research project in an investigation of whether the experience of chronic pain interferes with the processing of certain types of verbal information. To help us look at this question, two groups of individuals will be asked to participate. The first group will contain individuals who have suffered from pain for at least six months. The second group will contain individuals who do not presently suffer from pain.

To participate in this study, you will be asked to complete three tasks. The first is a colour-naming task, where you will be shown lists of words printed in red, blue, green, and orange ink. Your task will simply be to name the colour of the ink in which each word is printed, and to not name the word itself. In the second task, you will be read a series of words, and asked to recall a personal memory which is brought to mind by each word. Finally, you will be asked a series of questions about your mood recently. These questions will be presented verbally, and in the form of questionnaires.

Your responses will be tape recorded, but your name won't be used on the tape, so your answers will remain confidential. In addition, your questionnaires will be identified by number rather than name, to further ensure confidentiality. All research data will be placed in a locked file. However, the data may have to be released if required by law. If the results of this study are published, your name will not be used.

It is expected that this study will require about an hour of your time, but your are encourage to take as many rest breaks as you need if you begin to feel tired. There are no known risks associated with the task which was just described, but if you feel uncomfortable with the procedure, or if you have any questions regarding the task, please bring them up with the experimenter.
It is not expected that the procedure will provide you with immediate benefit. However, it is hoped that the procedure may allow us to help others in the future.

Please understand that you are free not to take part in this study, and if you do agree to participate, you may withdraw from the study at any time without jeopardy to your future care.

If you are participating in another study at this time, it should not affect your participation in the present study.

If you have any further inquiries, please call Michael Boissevain at 434-5606.

## Consent Form
## Word Processing in Chronic Pain

I have read the accompanying letter of information, have had the nature of the study explained to me, and I agree to participate. All questions have been answered to my satisfaction.

DATE _____ _____

NAME _____

SIGNATURE _____

WITNESS _____

## Appendix H

## Incidental Recognition Form: Principle Studies

## Incidental Recognition Form

Below is a list of words, some of which you have encountered in the colour-naming task and in the personal memory task. However, some of the words in the list were <u>not</u> presented in either of these tasks. Your task is to go through the list of words, and place a check mark beside those that you recognize from the earlier tasks. Work through the list as quickly as you can. If you are not sure whether you have encountered the word before, make your best guess.

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| | | | |
|---|---|---|---|
| Torturing ___ | Playful ___ | Regretful ___ | Hurting ___ |
| Inhabited ___ | Exhausting___ | Excitable ___ | Worthless ___ |
| Throbbing ___ | Particular___ | Terrifying___ | Witty ___ |
| Unwanted ___ | Lacerating___ | Angled ___ | Nagging ___ |
| Marvellous___ | Dismal ___ | Aching ___ | Numerous ___ |
| Killing ___ | Energetic ___ | Beaten ___ | Beating ___ |
| Courteous ___ | Miserable ___ | Amusing ___ | Depressed ___ |
| Calm ___ | Trivial ___ | Dreadful ___ | Hearty ___ |
| Anguished ___ | Pounding ___ | Attentive ___ | Tiring ___ |
| Inquiring ___ | Forlorn ___ | Tender ___ | Permanent ___ |
| Engraved ___ | Humorous ___ | Ruined ___ | Rasping ___ |
| Maternal ___ | Vicious ___ | Perceptive___ | Desolate ___ |
| Several ___ | Certain ___ | Landed ___ | Adventurous__ |
| Mature ___ | Flickering___ | Socialist ___ | Suffocating__ |
| Diverse ___ | Pessimistic__ | Compliant ___ | Important ___ |
| Primitive ___ | Buoyant ___ | Posted ___ | Flashing ___ |
| Harmless ___ | Blinding ___ | Linking ___ | Lifeless ___ |
| Theoretical__ | Younger ___ | Diagonal ___ | Jubilant ___ |
| Arbitrary ___ | Sharp ___ | Disguised ___ | Industrial___ |
| Cheerful ___ | Historic ___ | Medium ___ | Plain ___ |
| Combined ___ | Outgoing ___ | Retained ___ | Splitting ___ |
| Logical ___ | Unbearable___ | Liable ___ | Incompetent__ |
| Stilted ___ | Structured___ | Cruel ___ | Hyperactive__ |
| Restrained___ | Squeezing ___ | Gradual ___ | Nauseating___ |
| Triumphant___ | Sorrowful ___ | Sore ___ | Impacted ___ |

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