Information processing biases towards pain related stimuli in pain patients

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Abstract

Chronic pain patients selective processing of pain related information was investigated in a series of experiments. No evidence was found for the existence of an attention bias towards pain stimuli on an emotional stroop task. However, pain patients exhibited a tendency to produce significantly more pain related associations to ambiguous cues, and to interpret more ambiguous homophones as pain related than control subjects. The results from a series of free recall tasks revealed that pain patients selectively recalled more pain related adjectives than controls. This last effect appears to be specific to information that was encoded in reference to themselves, and specific to information related to pain, rather than to depression, even in pain patients with elevated depression scores. Finally, pain patients did not differ from control subjects on implicit and cued memory tasks. Overall, results suggest that information processing biases towards pain stimuli are exhibited in chronic pain patients, and that these biases appear to be associated with elaboration rather than integration. The discussion focuses on the theoretical and clinical implications of these findings, and attempts to explain the results in light of schema theory.

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Section 1: Pain- a subject for psychological research

The Direct Line Transmission Model of Pain

Pain has not always been considered a subject appropriate for psychological research, or for that matter, psychological intervention. Although folklore intuitively suggests that perception of pain includes many of the aspects we are investigating today, the medical view of pain, and subsequent treatment, dealt mostly with the physiological side. Thus, against the widely found sayings concerning mind over matter, we find an opinion maintaining that pain is either 'real', meaning located in the body, or else a figment of imagination - it's all in the mind.

This perception of pain, formulated in 1664 by Descartes, is known as the Direct Transmission Model (DTM). Descartes illustrates pain using a metaphor of bell ringing; the rope pulled at the foot of the tower represents the injury, the signal travels up the rope as the signals containing the information about the injury travel through specific pathways in the body, and finally, the bell rings, and the message is registered in a specific area in the brain, a pain centre.

The DTM is based on three assumptions:
First, that there is a direct relationship between the injury and the pain resulting from it. The more damage in the original injury, the stronger the signals and the more intense the pain. Second, and related to the first, that there can be no pain without injury, and no injury without pain. Third, and most important to this research, is the

assumption that pain is purely a reaction to external stimulation, and therefore it can affect, but not be affected by other psychological processes, such as emotions. From this assumption stems the common belief that the emotions often experienced in conjunction with pain, such as fear, depression, or anger, are caused by the pain experience. This relationship flows in one direction only - pain causes emotional response, but emotions in themselves cannot cause pain. The DTM can therefore be considered also as a sequential model.

Problems for the DTM:

Context

The DTM has had a strong impact on the way in which the medical profession viewed pain. It was not until the middle of the 20th century that contradicting evidence and puzzles that could not be solved by this model became apparent. The first findings concerned the effect of **context** on pain. In 1959, Beecher, a physician working with soldiers wounded in the second world war, published his findings (Beecher, 1959). The most remarkable of these was the observation that one in three of the wounded, regardless of the severity of the injury, did not request any analgesia and reported lack of pain. Beecher attributed this response to the relief experienced by soldiers who have got out of a death trap alive and know they are on their way home. He is therefore the first to ascribe to emotion, in this case relief, the role of a pain mediator, against the assumptions of the DTM. Later research proved this assumption wrong. The reason for the lack of pain in early stages of some severe injuries remains unknown. Carlen (Carlen, Wall, Nadvorna & Steinback, 1978), working with Israeli soldiers after the Yom Kippur war, was able to replicate the finding of lack of pain report in a significant number of injured, but since those he worked with had mainly lost limbs, and showed symptoms of clinical depression, he argued that the phenomenon could not be ascribed to relief. Similarly, in a study conducted in 1982 it was found that 37% of people admitted to casualty reported no pain (Melzack & Wall, 1982). In all cases the ability to experience pain returned within hours. The above reports can be described as examples of injury without pain, where no further physiological factor has been found to account for the lack of pain. The evidence is a challenge to the second assumption of the DTM.

Disproportion between injury and pain

In conjunction with the evidence for injury without pain is the evidence for pain with no known injury. Most common of these are headaches and back ache; although there have been numerous theories regarding physiological causes for both, no conclusive evidence has been found for either. The most common explanation for headaches has blamed dilated blood vessels in the head and neck. However, Pikoff (Pikoff, 1984) demonstrated that the dilated blood vessels are equally likely to result from the pain as to be causing it. Similarly, muscle tension has been named as a common cause of back ache, but Oleson (Olesen, 1986) failed to identify muscle tension in a group of chronic lower back pain sufferers. Seventy percent of the cases of people reporting constant back ache remain undiagnosed, with modern techniques failing to find damage in any structure in the region (Melzack, et al., 1982). This does not rule out physiological causes that might come to light with further advances in medicine, but demonstrates the complexity of the problem of diagnosing the cause of pain in many cases.

The direct relationship between the degree of injury and the intensity of the pain, formulated as the first assumption of the DTM is not apparent in many complaints. These include kidney stones, which cause little injury, but produce great pain intensity, or the sharp and intense pain resulting from minor cuts and grazes. Even bearing in mind that no controlled experimentation has ever been carried out to compare the pain reported by the same person suffering both minor and major injuries, it becomes clear that the degree of injury cannot be taken as an indication of pain intensity.

The most concrete example of the complex relationship between pain and injury is the case of phantom limb pain. Melzack (Melzack, et al., 1982) describes cases in which the pain is experienced in a different area to the original damage, such as the case of the pilot who lost his leg as a result of a knee injury but experiences pain in the region of the ankle, which was involved in a minor injury some time before the event that caused him to lose the leg. Furthermore, there are examples of cases where the pain changes, both in quality and in location over time, although the healing from the amputation has long since been complete. These cases are particularly important since they serve as an example of pain becoming akin to a disease, no longer a symptom of injury, but something to be treated in its own right.

According to the DTM, the function of pain is that of a warning of injury, serving to alert a person to injury and danger, and reduce mobility to avoid further injury. This function is embedded, according to the DTM, in physiological pathways, and therefore pain can be regarded as an innate process. However, the evidence describes above shows pain to be an adaptive process, which, in certain circumstances, can become maladaptive. There is evidence to suggest that experimental conditioning, and social factors, in the form of belief and attribution patterns effect both pain processing and pain behaviour.

Culture

Research into the effect of culture on pain experience has measured thresholds of pain, pain tolerance and physiological responses to pain in various cultural groups, using both induced pain and clinical settings. Results from research on differences in threshold (defined as the moment a sensation becomes painful) have yielded controversial results: Early research that had found such differences across races (Chapman & Jones, 1944) failed to control for differences in body temperature (Meehan, Stoll & Hardy, 1954). Research into autonomic responses to pain has shown that though physiological responses might differentiate between cultural groups, the relationship between increased pain and higher rates of responses could go either way. Since genetic differences in autonomic responses may account for results, findings should be viewed with caution (Turskey & Sternbach, 1967). It is generally accepted, however, that tolerance of pain and subsequent pain behaviour does differ across cultures; many studies that have measured both threshold and tolerance to pain report differences across groups only on the tolerance condition (Sternbach & Tursky, 1965; Lambert, Libman & Poser, 1960). A recent investigation has found significant differences between cultural groups in their reports of pain intensity during ear piercing (Thomas & Rose, 1991). Separate to these are a multitude of anecdotes concerning pain in different cultural settings. One such anecdote, reported by Kosambi (Kosambi, 1967) described an Indian ritual, which involved a man swinging on a hook by the muscles of his shoulders, in a ceremony of blessing. The man, far from reporting pain, appeared to be in a state of ecstasy. Furthermore, the wounds appeared to heal much faster then expected. Although the issue of the effect of culture on pain is clouded by other factors, such as social rewards for certain pain behaviours, and the research is often methodologically flawed, it poses a problem for the DTM, which fails to account for the effects of culture on tolerance and perception of pain intensity.

Conditioning and social modelling

Research into conditioning reactions to pain has not been limited to human beings. Melzack and Scott (Melzack & Scott, 1957) reared young dogs in isolation, and observed bizarre pain behaviours. The dogs reacted to inflicted pain, but failed to show any evasive behaviour to further painful manipulation. Only with repeated exposure did they acquire the appropriate pain avoidance behaviour, which was interpreted as an indication that these behaviours are acquired by social modelling. In another setting, conditioning is claimed to have changed the subjective experience of pain itself, rather than the response to pain. Pavlov (Pavlov, 1927) combined food and shocks delivered to the right paw of dogs, and observed that the shock became a signal meaning the approach of food; not only did the dogs show no evasive response to the shock, they wagged their tails, in a gesture interpreted as an indication of pleasure. Nor had they forgotten how to respond to pain; shocking their other paw produced violent reactions.

The effect of social modelling on pain experience has been further investigated by

Craig and Neidermayer (Craig & Neidermayer, 1974), by inducing shock on 40 male students and asking them to rate pain intensity. Conditions were manipulated so that some subjects were exposed to a tolerant model, while others were exposed to an intolerant model, a non-contingent model, or no model. Pain ratings differed according to the type of model, as subjects exposed to tolerant models rated the same degree of shock as less painful. Response bias, or reluctance to report pain was ruled out as a confounding variable through autonomic response monitoring. It appears from these findings that social context affects not only pain behaviour, but subjective perception of pain intensity. This presents a difficulty for the DTM and its assumptions.

Personality, self-image, coping and mood

Other factors that have been found to affect pain experience include cognitive processing and individual differences. It has been argued that chronic pain is a result of personality traits, reflected in elevated scores on certain scales on personality tests (scales of hysteria, depression, and hypochondriasis on the Minnesota Multiphasic Personality Inventory, see Melzack & Wall 1982). It is argued that these traits lead to chronic pain after minor injuries. Taenzer et al (Taenzer, Melzack & Jeans, 1986) found that post-surgical pain is significantly influenced by personality traits such as anxiety, neuroticism, and extraversion. These personality traits effected the efficacy of coping strategies, which in turn resulted in increased levels of pain. However, significant decreases on these scales after successful treatment of the pain suggests a reverse causal path; that pain might result in elevation on these particular scales. The problem in establishing the causal path between pain and personality scores on these particular scales remains unsolved. It is probable that they operate in a cyclical fashion, influencing each other in turn, and interventions that successfully break the cycle result in reductions both in pain and the emotional states associated with it.

Similarly, self image has been suspected as a contributing factor in chronic pain since head ache, colitis and abdominal pain were found to be associated with lower levels of self-esteem. However, successful pain interventions resulted in increased levels of self-esteem, suggesting a similar pattern to the above (Elton, Stuart & Barrows, 1978).

Many chronic pain patients show increased levels of anxiety and depression, to the extent that it is hard to distinguish between restricted mobility as a result of pain, and that stemming from lack of motivation associated with depression. A recent investigation tackled the problem of identifying the causal direction between these emotional states and chronic pain. Are depressed and anxious people more susceptible to chronic pain, or are chronic pain patients more susceptible to depression? Results show that the outset of the emotional states follow that of the pain, and it appears that the idea of constant pain, with no relief offered by the medical profession, combined with loss of mobility and earning capacity lead to depression, rather than vice versa (Gamsa, 1990). Stress, and specifically anxiety, have been found to have a strong relationship with pain; the higher the levels of anxiety, the greater the pain intensity reported (Ridgeway & Mathews, 1982). Furthermore, levels of anxiety have been found to affect length of healing (Ridgeway, et al., 1982). Warning of pain, and increased anxiety resulting from it can produce higher reports of pain intensity (Hill, Kornetsky, Flanary & Wikler, 1952), and these in turn can be reduced by dispelling the anxiety through reassurance.

Coping strategies (both behavioral and cognitive) can affect perception of pain intensity, both by distracting attention from the pain, and by directing it strategically to certain aspects of it rather than others (Leventhal & Everhart, 1979). One explanation for the success of these apparently contradicting strategies is offered by Leventhal's Perceptual-motor theory of emotion, described further on. Another explanation ascribes the relief to the sense of control over pain, regardless of the strategy used. Feelings of control over the pain affect the level of pain people are prepared to tolerate. Bowers (Bowers, 1968) found that the subjects who were in control of electric shocks administered to themselves reported the shock to be less painful than subjects who had no control over the procedure. Patients recovering from surgery report less pain when they are taught relaxation and distraction strategies to cope with the pain (Mathews & Bradley, 1983; Glyn, 1971). Although it has been argued that this could be an effect of increased information about the situation, it has been shown that this alone, without the sense of control through different strategies result in magnified, rather than reduced, levels of pain (Langer, Janis & Wolfer, 1975).

Attention

Although distraction has been considered a powerful strategy to reduce awareness of pain (Glyn, 1971;Melzack, Weisz & Sprague, 1963), recent research suggests a revolutionary approach. Hypotheses stemming from a new model of pain maintain that paying attention to the sensory information content of any pain experience from the earliest stages will result in reduced pain distress (Leventhal, et al., 1979;Leventhal, 1984). This involves careful monitoring of sensory experiences, while attempting to ignore the emotional and threat aspects. Leventhal (Leventhal, et al., 1979) experimented with induced pain, and found that a group of subjects following instructions in line with this hypothesis reported lower levels of pain intensity and extended the duration of exposure to a painful stimulus. He eliminated the possibility of the effect being due to increased information about the pain experience by providing the same information to another group of subjects, this time without the explicit instructions, and a simple pain warning to a third group. He found the pain warning acted to decrease tolerance, thus concluding that subjects receiving the warning increased their processing of the distress aspects of the pain experience. He also demonstrated that the early stages of processing are the most important for these manipulations, as instructions for sensory processing provided half way through the pain induction failed to bring about the increased tolerance demonstrated by the same instructions given right from the start. In comparison with distraction strategies such as listening to music, or using imagery, he found that the direction of attention to sensory processing was more effective, though the other strategies showed some effect in increasing tolerance to pain. Johnson et al (Johnson, 1973) produced similar findings in a group of women in labour. Instructions to concentrate on the sensory aspects of the pain, combined with a thorough preparation consisting of accurate information about these sensation resulted in decreased pain intensity.

The multidimensional model of pain

Perhaps the most important physiological departure from the DTM was the Gate Control theory of pain, suggested by Melzack and Wall in 1965 (Melzack & Wall, 1965). The model was an attempt to account for non-physiological factors influencing pain by ascribing a role for messages DESCENDING from the brain, which can alter the sensitivity and transmission threshold of nerve centres along the pain pathways. Thus stress in the form of anxiety, for example, might reduce the threshold needed for a cell to fire a message of pain, reducing the individuals tolerance and increasing the intensity and duration of the pain experience. Although it has been modified over the years, in direct response to criticism (Dyck, Lambert & O'Brien, 1976), the Gate Control model remains the only physiological model of pain which attempts to account for psychological influences. All other models of pain processing, including that of Leventhal (1979,1984) must be viewed within the context of the above theory. Discussion of pain processing from here on will attempt to investigate which factors operate to mediate pain processing, and at what stage of processing, without further discussion of the physiological framework within which the processing takes place.

The multidimensional model of pain is an abstract representation of pain processing as it is thought to take place within the gate-controlled system. For the sake of coherence, the factors thought to affect pain have been divided into three categories; sensory, social and psychological factors. However, it must be stressed that these factors interact in parallel during processing of pain.

The sensory factors include the intensity, the location of injury, the duration of exposure to pain and to the injury before healing can take place, and the motor implications. These include the degree of disability rendered both by the original injury, and by the subsequent pain during the healing period. These are the main factors included in the DTM. To these are added, in the social category, factors such as the context in which both the original injury and the subsequent period of healing takes place. Other social factors include past experiences, pain behaviours and reactions learnt from social models, and reinforcement both during the injury and subsequently. It is possible, therefore, for social rewards to increase or decrease both pain behaviours, and through interaction with psychological factors, pain experience. The psychological factors known to affect pain include emotions (such as anxiety, depression and surprise), motivation, self image and health beliefs (which include both conceptual, reason-like beliefs, readily available to conscious awareness, and 'schemata', rule like structures which affect processing. These are associated with processing biases such as selective memory and attention, which can preferentially filter information associated with pain, thereby affecting **all** of the above categories.

The model contains three assumptions: First, that all processing is carried out simultaneously, with factors interacting in parallel to produce a final outcome. Second, that these factors affect both conscious and preconscious processing, so individuals are often unaware of the factors that mediate the pain experience. Finally, that interventions aiming at pain relief must take place on as many levels as possible, for a durable effect.

Conclusion

It is these findings that form the rationale for the current investigation; if information processing can affect the subjective experience of pain, it needs to be studied not only to explore how patients are processing pain, or even who is more vulnerable to pain because of their processing biases, but because it might offer a new direction in intervention.

This section has described the Direct Line Transmission Model of pain, and explained how accumulated evidence challenged each of its basic assumptions. However, perhaps the most important factor contributing to the demise of the DTM is the constant, if not growing, population of chronic pain patients. These people, suffering constant pain for over 6 months, often for periods exceeding 3 years, are a cause of frustration for the medical profession. It is often the case that even the most sophisticated interventions, including successful surgical interventions at virtually all levels of the nervous system, fail to guarantee reduction in chronic pain (Beard, Reginald & Pearce, 1986). It is now generally agreed that chronic pain in particular must be viewed as an experience stemming from multidimensional factors; tackling only the injury will not produce relief. Intervention must take account of all the other factors operating to produce or maintain the pain.

The approach adopted in this thesis to investigate pain processing is based on information processing theories. This approach covers behaviour and perception, conscious and preconscious effects, physiological, social and psychological phenomena. Section 2 describes interventions that are currently employed in the management of chronic pain, while section 3 describes information processing theory in general and in relation to pain in particular. Section 4 outlines the evidence that has been produced in related fields, and explains the relevance of the paradigms and methodologies to the investigation of pain.

Psychological interventions with chronic pain patients:

Cognitive research in clinical groups should always be seen as a tool to guide and assist interventions. Thus, this section will describe the clinical intervention currently available for pain patients. A goal of the thesis is to attempt to tie in the findings from the present experiments to psychological interventions currently employed with chronic pain patients, and explain how interventions might be expanded to tackle issues that have emerged from the research. Theory of pain, as described above, culminated in a multi-dimensional model of pain, which includes psychological, social, behavioral and physiological components interacting in parallel to produce a pain experience. Despite the fact that many physicians accept the multi-dimensional model, and in spite of evidence suggesting that psycho-social factors have primary effects on the pain experience, many pain patients receive only physiological treatment. However, psychological interventions for pain management have been developed and introduced in clinical population in recent years, and preliminary assessment of outcome seems favourable (Skinner, et al., 1990). These interventions are generally divided into those based on a behavioural framework and those based on a more cognitive approach.

Operant conditioning

Operant conditioning, or contingency management, is an intervention based on the work of Fordyce (Fordyce, 1976). The interventions are aimed at tackling the behavioural aspects of pain, and specifically aim at reducing pain behaviours such as complaining and taking medication, and increasing well behaviours, such as increased activity. Taking into account the evidence for social factors affecting pain, Fordyce conceptualized chronic pain, regardless of the initial underlying cause, as an operant problem, or a behaviour that has emerged through re-enforcement. The interventions focus on changing these behaviours through new patterns of re-enforcement. This is done as part of an in-patient course, in which the medical staff give no attention to pain behaviours but provide praise and re-enforcement for well behaviours. The interventions include a physical exercise programme aimed at increasing activity, and medication is provided on a time contingent basis, rather than as a response to levels of pain intensity. The latter is an attempt to sever the associative link between pain and medication. Operant conditioning has been demonstrated to change pain behaviour, but results seem less reliable in terms of reduction of pain intensity (Pearce & Richardson, 1987). The behavioural approach can also be criticized for its failure to provide patients with skills to control their own pain, both in terms of external behaviour (such as activity levels) and internal behaviour (such as distress, or ruminating).

The cognitive approach

The cognitive approach has been divided into two broad categories (Pearce & , 1983); Those that attempt to directly modify the pain experience, and those that attempt to mediate other factors, such as stress, that are known to affect pain. Of the latter category, relaxation and stress reduction are the main strategies employed. This work will not discuss these in more detail, but rather focus on the psychological interventions that attempt to modify pain directly. The cognitive interventions aimed at directly modifying pain have been classified by Turk et al (Turk, Meichenbaum & Genest, 1983) into the following:

Imaginative inattention describes the task of imagining a context which is incompatible with the pain experience, such as sunbathing on a beach. Theoretically the success of this strategy would be explained in terms of activation of a 'rival' schema, and as resources are switched from pain related schemata to those absent of pain references, awareness of pain is reduced.

Transformation of context involves imagining the pain taking place in a different context, such a heroic setting. This strategy is based on the attempt to create new associations between the physiological components of pain and a more positive aspect of affect, such as courage. Although there may be little change in the pain intensity experienced by the patient, pain-distress could be reduced.

Imaginative transformation describes the task of re-labelling the pain sensations as tightness or numbness. **Somatization** refers to the task of distancing one self from the pain, so that the description of the pain reads like a biology report. Both strategies can be conceived of as an attempt to focus attention on the sensory, rather than the distress channel of processing (see Leventhal's model of pain processing, described in detail in chapter 1).

Finally, **attention diversion** describes both external diversions, such as music, and internal diversions, such as mental arithmetic, which attempt to reduce awareness of pain. This strategy can be described as an attempt to re-allocate resources, resulting reduced processing of pain.

In recent years psychological interventions that have adopted the multi-dimensional model of pain have attempted to tackle pain on as many levels as possible. Multi-disciplinary teams have been formed, so that the physiological aspects of pain could be monitored by physicians and physiotherapists while the psycho-social aspects are tackled by psychologists and other therapists. The behavioural aspects have also been considered, and work has been extended to educate both patients and their families. For example, this approach is currently employed by the multi-disciplinary team of COPE, a pain management programme located at UCH-Middlesex Hospital. It is, however, too early to assess outcome.

In summary, interventions with chronic pain patients have evolved to include psychological input, both in terms of behaviour modification and in teaching a host of coping strategies aimed at directly altering the pain experience. The importance of affect as an influential factor is acknowledged and stress reduction and relaxation are included in many programmes. In some cases, depressed pain patients are prescribed anti-depressants; other interventions rely on support groups to assist with coping with the emotional problems faced by the patients and their families. The main problem with psychological interventions is, in fact, their diversity. Since it is unknown which of all the possible strategies will assist patients most, and since the most effective interventions appear to be those that employ the most strategies (Pearce, et al., 1987), psychologists dealing with pain have ended up with 'a bag of tricks'. Better individual diagnosis, resulting in concentrated input into the areas most in need of mediation is the next step in developing effective ways of treating pain patients. It is hoped that the results from this research will indicate possible guide-lines in the development of these interventions. Specifically, it is hoped that information processing tasks will reveal salient concerns in pain patients, which will be later adapted and addressed through interventions. The findings may also form the first step in developing a diagnostic tool that will indicate what strategies would be best employed with each individual patient.

Section 3: Information processing theories and pain

This section deals with the theories that describe processing, both of emotional material in general, and of pain associated information in particular. It has been argued in the above sections that emotional states can influence processing. The following section will demonstrate that emotions can also drive mechanisms that will regulate the flow of information through selective attention, selective elaboration during encoding and selective recall. This section will begin by describing theories of emotions and cognition. It will then outline several attempts to describe the structure of the storage, and activation of information with emotional content, including information about pain. Finally, the concept of schema, and particularly self-schema, as a structure that could account for information processing biases will be discussed, and hypotheses specific to the following chapters will be outlined.

Cognitive theories of emotions

Early attempts to describe emotions in cognitive terms explained the phenomenon as a conjunction of peripheral physiological arousal patterns with the label these patterns are given (Schachter, 1964). The arousal is nonspecific, but appraisal, mainly through attribution patterns, which take into account context and past experience, produce the label. Experiments to find support for the theory (Schachter & Singer, 1962) found ambiguous patterns of results: By manipulating the physiological arousal levels in subjects they succeeded in producing emotions of happiness, but failed to produce anger. Further investigations resulted in mixed reports , but there is no evidence that the experience of emotions is reduced when arousal is restricted, as in the case of spinal cord injury or use of blocking agents (Reisenzeim, 1983).

A more complex theory of emotional processing is offered by Lazarus (Lazarus, Averill & Opton, 1979). Lazarus regards emotions a result of a series of appraisals which he divides into primary and secondary appraisal. **Primary appraisal** evaluates material in regard to its relevance to the well-being of the individual, thus dividing it into benign-positive and stressful components. Stressful material is in turn split into three categories: That related to harm-loss, based on past injuries, that related to threat, based on anticipated injury, and that related to challenge, and possibility of positive gain. Although Lazarus does not specify the relation between these categories and emotional disorders, it is plain to see that depression would fit in with the first while anxiety would be more closely associated with the second. Pain, and pain-distress belong to some extent to both stressful categories, but as the experience of pain continues over time, it is assumed that appraisal of pain related material would be more closely associated with harm-loss than with threat. **Secondary appraisal** evaluates the resources needed to deal with the situation, both in terms of personal resources available to the individual, and environmental resources she can manipulate to her advantage. A constant reappraisal updates the emotional response through the success of coping efforts and the impact of the event on the individual. This accounts for the accumulating effect of exposure to certain stimuli, which only produce an emotional response over a period of time.

Lazarus regards emotions to be associated with a pattern of somatic reactions, a physiological response profile. (Such a response could account for pain associated emotions maintaining and exacerbating the experience of pain.) Experimental evidence supporting the dependence of emotions on cognitive appraisal emerges from a series of experiments (Lazarus, et al., 1979), involving stressful films, where different sound tracks manipulating appraisal were found to increase or decrease anxiety.

Zajonc (Zajonc, 1980) challenged Lazarus's theory, and argued that emotions are not necessarily post-cognitive, i.e. occur only after cognitive appraisal, but rather inescapable and holistic, quite independent of cognition. By providing subjects with material for a period too brief for recognition, and showing that nonetheless subjects expressed a preference for the familiar material over new material, he concluded that affect could be independent of cognitive processing. Zajonc suggested parallel, independent systems for processing cognition and affect, so that affective responses accompany all cognitions, but not vice versa; the adaptation of positive or negative attitude towards stimuli occurs before, or separate to the cognitive operation of recognition and classification.

Some support for the idea of two separate systems was suggested by Rachman (Rachman, 1981), who demonstrated that phobic reactions, namely the experience of fear, take place even when the cognitive appraisal of the situation suggests that the information is harmless. It has been suggested, however, that Zajonc's description of cognitive processing is too narrow; it relates only to conscious recognition and affect, but does not rule out the possibility that prior to an emotional response some degree of preconscious processing takes place (Isen, 1984; Lazarus, 1982). Lazarus further argues that emotions can occur almost immediately to very incomplete information, which will later be modified, as further information is processed. The current investigation regards emotion and cognition to be interlinked parallel systems, described in detail further in this section. Some credence for this notion is derived from the evidence, presented above, showing that though affective processing must originate from some cognitive processing, it can also influence and modify cognitive processing in turn.

Network theory

Probably the best known theory incorporating emotions into a cognitive framework is that suggested by Bower (Bower, 1981), based on the general associative network theory of long term memory (Anderson & Bower, 1974). The network theory postulates concepts, represented as nodes, to be connected by links in varying strength, depending on closeness of association. The relationships between nodes are based on past experience, and new associations can be created at any time. Activation of any node spreads through the stronger links, and when this exceeds a threshold level in any node, the concept, in the form of thought or image enters consciousness.

Bower suggested that emotions are represented by a set of 'emotion nodes', linked to automatic reactions, facial expression, verbal labels for the emotion, typical associated situations, and memories of past experience. Activation of any of these serves to activate the emotion node, which in turn operates to make associated thoughts and beliefs more accessible to consciousness. This theoretical structure yields both the hypothesis about state dependent recall, and that concerning mood congruent recall biases. Evidence for these hypotheses, presented above has been ambiguous; although overall the evidence supporting mood congruent recall bias has been accepted as robust (Brewin, 1988;Blaney, 1986), the effects are not always directly in line with the hypothesis. Recall biases have been shown to be of an inhibitory nature against material inconsistent with mood, rather than then a preference for recall of material congruent with mood (Williams & Nulty, 1986), and evidence for state dependent recall has been hard to replicate (Bower & Mayer, 1985). Network theory has difficulty in explaining the asymmetry between the biases; although positive mood has been shown to facilitate positive recall, the opposite is not always true (Isen, Shalker, Clark & Karp, 1978; Isen, 1984).

However, a more serious criticism has been that the concept of the emotional node does not allow for activation of the concept of affect without the experience of the affect itself. To accommodate this criticism, Bower & Cohen (Bower & Cohen, 1982) postulated a set of governing interpretation rules, that allows recognition of context and meaning of activation, and adjusts the level of activation accordingly. Another criticism has been the failure to find evidence for priming by mood in lexical decision tasks (Martin & Clark, 1985; Macleod, Tata & Matthews, 1987). These tasks involve subjects distinguishing between words and non-words, and the network theory would predict that current mood, by activation of affect nodes, would result in faster reaction time to mood congruent material. However, depressed patients have shown no such bias towards recognising negative words, when compared with positive and neutral words (Macleod, et al., 1987). This might be due to a different type of search to that used in free recall; described as the difference between a search through an 'index' and a search through an 'encyclopedia' (Simon, 1982).

Finally, network theory does not distinguish between the effects that different mood states have; according to the theory, associated information should result in a processing bias both in encoding and retrieval. However, mood congruent recall is difficult to demonstrate in anxious groups (MacLeod, Mathews & Tata, 1986; Mogg, Mathews & Weinman, 1987; Watts, McKenna, Sharrock & Trezise, 1986b), while attention biases are more difficult to produce in depressed groups (Williams, Watts, Macleod & Mathews, 1988). Indeed, in an investigation of spider phobics, Watts (Watts, et al., 1986b) found a recall bias against mood congruent words, suggesting that other mechanisms, such as perceptual defence (Dixon, 1981) or repression, could affect processing. Network theory has difficulty in explaining these findings.

A more complex model of emotional processing, with special relevance to pain processing is suggested by Leventhal (Leventhal, et al., 1979;Leventhal, 1984;Leventhal & Scherer, 1987). The model describes an interactive parallel processing system, including physiological and psychological components.

The expressive-motor processing model

Leventhal assumes that pain evokes powerful emotions that sustain emotional involvement in health. The effect of these emotions on the subjective pain experience forms the basis for the expressive-motor theory. The theory challenges the assumption that emotions are a sequential addition to sensory information. Evidence suggests that psychological factors influence change both in tolerance levels and pain detection thresholds (Clark & Mehl, 1973; Clark & Goodman, 1974). Leventhal postulates a parallel processing model divided into distress-emotional and informational components. The latter processes information about location and sensory properties while the former processes feelings of suffering and distress. Most of this processing is carried out preconsciously and different filters bring material into focal awareness. These filters, also described as channels, are the influencing factors in processing biases, and a detailed description follows. The final experience is described by Leventhal as 'pain distress', the end product of the integration of information about noxious stimuli and emotional reactions.

Evidence for preconscious processing of pain arises from the work of Hilgard (Hilgard, 1973), who demonstrated a division between verbal reports of pain under hypnosis, and preconscious processing of pain as registered by automatic conditioned hand signals. Evidence for the disassociation between information about sensory components and the emotional components of pain emerges from the work of Johnson (Johnson, 1973), who demonstrated that a group of subjects who received sensory information reported less distress than those who did not receive this information when pain was induced to both groups. The rated intensity of the pain showed no difference between the groups. The possibility that these results could be attributed to accuracy of the information rather then a division between sensory and emotional processing was ruled out by the finding that accurate pain warnings produce higher distress rates (Epstein, 1973). Indeed, Brown et al (Brown, Engquist & Leventhal, 1977) tested four groups involving all possible combinations of pain warning and giving sensory information (each in turn, both and neither) found significant reduction of distress in the group receiving sensory information only in comparison with other groups.

Leventhal maintains that elaboration of the information, both sensory and emotional, is generated by a hierarchical set of interactive processing mechanisms. These take place from the gate (see gate control theory) onwards. These interactive paths include: perceptual-motor processing, an automatic and largely innate level of processing resulting in a perceptual signal recognised as an emotional response; schematic processing, which acts to integrate the perceptual-motor signals with schema based on past experience; and conceptual processing based on beliefs, concrete memories and reasoning.

Perceptual-motor processing

The perceptual-motor system generates output that makes up the perception of the fundamental sensory attributes or properties of the noxious stimulus. These include generation of the experience of touch, coldness, location and duration, as well as intensity of each of these, i.e., sensation information. It is not clear from Leventhal's description why these properties belong in the perceptual-motor, rather than the informational pathway. Indeed, in his description of experiments, sensation information is labelled separately from the distress-pathway. However, Leventhal also postulates that perceptual-motor processing includes a component of general arousal and a specific emotional response. This state of arousal can alter a variety of autonomic functions and these, accompanied by motor reactions, become associated with the specific emotional state. The description is somewhat obscure and seems of little help to the investigation of pain, as it is virtually impossible to test. Leventhal himself sums up:

"The neurological evidence suggests that three types of pathway generate the perceptual experience of pain. The first appears to be purely information, dealing with features such as location sensory attributes and so on. The second and third appear to create pain distress; the second generates somewhat information like bright, pricking pain and the third most clearly emotional-motivated path seems to generate a generalized arousal state and a specific emotional response, such as distress."

(In Emotions in personality and psychopathology,

Edited by Izzard, Plenum Press, 1977, page 279).

The conceptual level of processing

The conceptual level includes causal attribution and beliefs about consequences of pain-distress experiences. These will lead to pain behaviours, including external reactions such movement or taking pain killers, and internal reactions such as coping strategies. The activation of these propositions, or any changes in beliefs and expectations will infiltrate and affect the schematic level of processing described below. Leventhal maintains that information is stored in two distinct cognitive memory systems; the first in the form of analogue records of the eliciting conditions, the expressing-motor and autonomic response accompanying them, and the subjective emotion itself. Another makes an abstract reasoned self-record of the situation, response and consequences. The former is stored in the schematic processing level, while the latter describes the storage in the conceptual level of processing. One can verbalise rules and propositions from the conceptual level, but schematic processing is largely preconscious automatic conditioned processing.

Schematic Processing

Built on earlier experience, schema act to integrate incoming information with the existing structure. Schemata can be viewed as blue prints of stereotypical actions, attributes and relationships associated with a given concept. This blueprint imposes structure on incoming information, resolves ambiguity and provides supplementary information. The final representation will include elements of the schema as well as the original data (Graesser & Nakamura, 1982; Hamilton, 1983;Mandler, 1984). Thus mild physical sensations might be interpreted as pain experience by chronic pain patients, after schematic processing, assuming well-developed pain schema due to past experience. The function of schemata is therefore to control and structure the incoming information according to past experience, beliefs and expectations. Although there are contradictions in the various schema theories, resulting in conflicting predictions (see Graesser and Nakamure 1982) it is a useful way of accounting for selective processing. Leventhal argues that phantom limb pain is an example of schematic processing of pain. Since phantom limb pain cannot be readily explained by hypotheses based on continuing stimulation of remaining peripheral nerve roots (Morgenstern, 1970), and surgery often fails to bring relief (Leventhal, et al., 1979), Leventhal argues that memory structures are the cause. Activation of some features in these schema result in reactivation of the entire pain schema.

In pain, schemata can bind different emotional reactions to the information component of pain; distress and fear are the two most common accompanying emotions. The relationship between pain-distress emotion schema and information-sensory processing operates both ways; different characteristics of the noxious stimulation will provoke different emotional responses and interact with different schema. Tomkins (Tomkins, 1962) hypothesised that constant high levels of stimulation will provoke distress, while very high levels will provoke anger. Intense stimulation that increases rapidly over-time will result in startle-fear. Chronic Pain patients are therefore characterised by high levels of distress, while acute pain patients may be characterised by fear. Leventhal makes use of the concept of scripts (Gagnon & Simon, 1973) to describe the expansion of schemata over time and interpersonal context. Disconfirmation of the expectation arising from these scripts leads to heightened awareness and arousal and results in new emotional responses. Thus interventions geared at pain behaviour can affect emotional pain associated schema, and cognitive intervention can successfully challenge internal assumptions and expectations (Beard, et al., 1986).

Schema and self-schema

Most investigations into the effects of schema on processing have been carried out in groups suffering from emotional disorders. The schema concept was originally used to describe processing in pathological groups by Beck (Beck, 1976;Beck, Rush, Shaw & Emery, 1979;Beck & Emery, 1985). Beck suggested that emotional disorders are characterised by constellations of schema with content concerned with interpreting emotional information. Depression is associated with schema relating to loss, negative self image and pessimistic world view, while anxiety involves schema concerning personal vulnerability and danger. Beck regarded a schema as a stored body of knowledge which interacts with encoding, comprehension and retrieval of information.

The key to emotional disorders might be a distortion in a particular schema specific to the individual's concept of the self, or self-schema.

Some evidence for the existence of concepts such as self-schema is the superior recall for self-referential material (Rogers, Kuiper & Kirker, 1977;Bower, Monteiro & Gilligan, 1978;Lord, 1980;Klein & Kihlstrom, 1986). However, this could also result from a better search strategy rather than a better organised and complex body of knowledge about the self. Direct evidence for Beck's theory concerning depression emerged from a series of investigations into self-referential recall in depressed patients. Derry and Kuiper (Derry & Kuiper, 1981) demonstrated that depressed patients show a self-referenial bias towards negative mood congruent words, while non-depressed show the reverse, a bias against such information in relation to themselves. Furthermore, the bias towards negative word recall in depressed patients disappears when the words are encoded in reference to others, i.e., the bias towards negative recall is specific to the self referential condition (Mathews, et al., 1983). However, it remains to be seen whether these findings are due to self-schema, or are a result of search strategies.

Williams et al (Williams, et al., 1988) describe possible organisations of self knowledge:

1. Self schema could be a particular case in a general 'person' schema. The 'person' schema includes knowledge about peoples common attributes, and about the attributes that vary between people. Self schema could be a set of tags by which the individual differs from most people (Graesser, et al., 1982).

2. Another possibility is a separate structure containing all the information about ourselves. This structure might store the knowledge differently to that of knowledge about others; for example, evidence suggests that although **words** about the self are better recalled, it appears that **images** about others are better recalled (Lord, 1980). This is possibly a result of visually observing others continuously, while seldom seeing ourselves.

3. Williams et al prefer, however, to regard self schema as a 'frame' which operates to extract information from the general data base. According to this view, different aspects of self knowledge are available in different context, largely dependent on current mood and circumstances. Although emotional disorders are characterised by a rigid self-schematic frame, interventions aimed at creating a more flexible self-referenial frame could result in a decrease in processing biases (Williams, et al., 1988).

Although the concept of self-schema is a useful explanation for processing biases, it fails to explain why the nature of information processing biases vary across different disorders. It appears, for example, that attention bias is less associated with depression (Gerrig & Bower, 1982; Mathews & Macleod, 1985) than with anxiety. Memory bias has not been readily found in anxious groups (Mogg, et al., 1987), and lexical decision tasks have shown no mood congruent effects (Clark, Teasdale, Broadbent & Martin, 1983).

The integrative model: elaboration and integration

An integrative model, attempting to account for these discrepancies is offered by

Williams et al (Williams, et al., 1988): They maintain that both encoding and retrieval involve a passive, automatic aspect and an active, strategic aspect, and while a bias may be found in one there need be no bias in the other. The difference between the two processes has been described above; automatic processing operates without awareness, in parallel and is unconstrained by capacity, while strategic processing is capacity limited, relatively slow, and usually serial (Schneider & Shiffrin, 1977). In Leventhal's model, described above, the first would be associated with the automatic processing at the sensory motor level, while the latter takes place in the conceptual level. It is less clear what happens in the schematic level.

The radical departure in the Williams et al model is the assumption that automatic processing takes place in the recall stage as well as in the attention or encoding stage. Evidence for this claim is offered from the experiments on perceptual memory, also named implicit memory. Graf and Mandler (Graf & Mandler, 1984) demonstrated that learning followed by completion of word stems showed that subjects responses had been biased by exposure to the material at the encoding stage, even when they were not attempting to recall previous material. Jacoby and Witherspoon (Jacoby & Witherspoon, 1982) demonstrated that amnesics, though unable to recall the words learnt previously show a memory bias in stem completion, without any awareness of the study phase.

An explanation for this is offered by Graf and Mandler (1984). They distinguish between two processes which operate on mental representations: integration and elaboration. The first is rapid and automatic, and acts to make stimuli more accessible. It is driven by simultaneous activation of different components in **a single schema** (defined as "a cluster of perceptual and semantic variables which represent a word or concept in the cognitive system", Williams et al 1989). Integration (or priming) results in a strengthening of the internal organisation of the presentation of that particular information. The word becomes more accessible through raising the activity towards the threshold needed for it to fire. Thus it comes to mind more readily when only some features are present.

Elaboration depends on interaction between **several schema**, it takes place later on in the processing, and acts to effect recall of material mediated by the activation of relationships between schema. Elaboration is more strategic, and involves activation in relation to other representations, forming new links and strengthening old ones. This results in the word being more retrievable, as the search travels through more associative links and reinstated old paths.

Williams et al (1988) hypothesise a decision mechanism capable of judging the affective salience of each item, which operates both at the pre-attentive and elaboration stages of processing. At the pre-attentive stage the decision mechanism determines the priorities for subsequent processing. This process (Neisser, 1976) involves passive intake of partial information, mapping onto existing schemata which act to direct resources during the next intake towards certain aspects of the information. The allocation of resources will depend on the decision mechanism. The increased allocation of resources is equivalent to multiple exposure to the information and acts to prime the item. As a result the item is more likely to be produced (or heard or seen) even when only some of its features are present.

As elaboration processes start, another decision mechanism assesses the emotive salience of the information. The more salient, the more resources are allocated to elaboration, resulting in increased mnemonic cues. Different mood states may differentially affect the degree to which mood congruent associations are encoded with an item. It seems that anxiety makes certain items more accessible while depression makes other items more retrievable. This investigation aims to discover where pain patients fit in to these patterns.

Conclusion

It appears that emotional processing is an important part of pain processing, which may hold the key for reduction in levels of distress, if not in pain intensity. Similarly, it appears that emotional processing is typified by processing biases, both in attention and recall. An attempt to discover whether pain patients demonstrate any of these biases towards pain-distress stimuli will use paradigms that have been proved useful in research in related fields. The third section in the introduction outlines research employing these methodologies.

Section 4: methodology and findings in related fields

Attention and emotional disorders

The cognitive approach to emotional disorders characterises them by excessive dwelling and preoccupation with experiences and events associated with certain emotions (Williams et al 1989). Information processing theory maintains that three explanations can be offered for this behaviour, which are exclusive or combined: the evidence to date suggests that patients either notice more of these experiences, or they are more affected by them, or they have a recall bias, so they remember selectively more events associated with their emotional disorder. The first possibility describes selective attention, which occurs early on in processing. It is generally regarded as an automatic rapid shifting of resources towards information associated with a specific emotion, and has been demonstrated in anxious groups (Williams, et al., 1988; Eysenck, MacLeod & Mathews, 1987; Mathews, et al., 1985; MacLeod, et al., 1986; Eysenck, 1992).

Selective attention is an area rich in theory and investigation, starting in the 50s with the notion of some sort of filtering process of information, and culminating in specific research in the area of emotional disorders. Generally speaking the phenomenon deals with constraints, i.e., the allocation of limited perceptual resources to the flow of information from the environment. There are many pools of resources and different tasks compete for them. Each task involves one or many mechanisms, each with a limited capacity, so that two tasks that are processed by the same mechanism interfere with each other. Selective processing depends on many aspects of the information, some as simple as its physical properties, such as brightness and loudness, others to do with its context, which can make it easier or harder to spot (figure ground effect). It is agreed that this allocation can be directed at will towards certain aspects of the environment (as in the cocktail party syndrome described by Cherry in 1953), but it is assumed by most researchers of attention biases in anxious groups that the bias is a result of automatic, uncontrolled processing (Williams, et al., 1988; Eysenck, 1992). Further distinction between these two types of processing follows further on.

The easiest analogy for selective attention is that of a beam of light, which can be swept around the environment, lighting up different areas while leaving others in the dark. The areas lighted up will yield a lot of information, while the dark areas will yield very little. Although we might see the entire room, we will probably remember only the properties of the areas lit up. Also, like a beam of light, the wider the area we light the less powerful the light ray becomes, while concentrating it on one small spot results in a very bright beam. Since the brighter the beam the more information is revealed, the more focused the perceptual array, the more elaborated the information perceived.

It is generally agreed that selective attention is pervasive throughout processing (Erdelyi, 1974), in contrast to earlier theories that maintained either that selective attention occurred early on in processing and was based in physiological differences between relevant and irrelevant inputs (Broadbent, 1958), or that it occurred later and depended on some semantic processing (Treisman, 1960; Deutsch & Deutsch, 1963;

Broadbent, 1971).

Selective attention can be divided into two distinct processes:
Automatic processing, which is incapable of flexibility, needs no conscious effort to direct it, and is driven by certain features in the data, both physical and semantic. It can be a result of innate or learnt sets of schema, and since it occupies no conscious attentional resources, several automatic procedures can be carried out simultaneously.

Strategic processing, on the other hand, is modifiable, demands conscious effort, since it is driven by wilful attention, and is highly constrained by capacity limitations. Although strategic processing can be generally carried out at will, there are times when uncontrolled automatic processing overrides our voluntary allocation of resources. For example, no matter how hard one might concentrate on a task, the sound of our name interferes and we involuntary switch our attention towards the source of the interruption. This appears harmless enough, but what if an individual suffering from a specific phobia would involuntarily keep switching attention towards anything associated with their phobia? This would not only interfere with the completion of other necessary tasks, but could serve to maintain and even exacerbate the phobia. By distortion, reality would appear to be a much more dangerous place than it is, since the proportion of threat associated information would be exaggerated. This is a possible explanation for preoccupation with experiences associated with emotional disorders, as described above. Schneider et al (Schneider, Dumais & Shiffrin, 1984) argue that controlled processing is essential for dealing with novel tasks, and is instrumental in the development of new automatic processing. However, once automatic, individuals will have difficulty in preventing responses to certain sets of data. Controlled processing cannot easily modify automatic processing, although the opposite can occur. Automatic processing of the type described in anxious groups could present a problem for interventions. However, in the case of the reverse causal path, where anxiety affects attention, the automatic bias might be reduced after successful treatment of the anxious disorder. In a comparison between anxious patients, recovered anxious patients and controls, attention biases were found only for the currently anxious group (Mathews, May, Mogg & Eysenck, 1990).

Selective attention to emotional features in incoming information is generally regarded as a consequence of differential processing, i.e., a result of internal structures associated with certain emotions (Neisser, 1976; Hochberg, 1978; Johnston & Dark, 1986). However the opposite has also been argued, namely that selective attention can be thought of as the cause of differential processing, i.e., processing that gives preference to certain types of information (Shiffrin, 1985; Kahneman, Treisman & Burkell, 1983; Marcel, 1983). The main argument against the latter is that it ascribes to the attentional system the ability to select information on a semantic basis. The alternative view regards priming, through past experience, i.e., the degree of activation in certain schemata, and their complexity, as the driving force behind selective attention, which is in itself passive (Williams, et al., 1988). These questions related to pain processing ask whether being a chronic pain patient should lead to an attention bias towards pain stimuli, or whether an attention filtering mechanism acts to maintain pain in certain individuals by selecting pain information from the environment. Although it is assumed that these processes operate in a cyclical fashion, the first is an example of a cognitive mechanism altered by emotional-physiological experience, while the latter could be an indication of vulnerability.

Evidence for selective attention in emotional disorders

A simple methodology to test whether words associated with emotional disorders will interfere with a task is the stroop paradigm. Originating from research carried out by Stroop in 1935, the task consists of colour naming of words. Subjects are asked to ignore what the words say and respond simply to the colour of the ink in which they appear, but when the words consist of conflicting colour names, subjects experience difficulties, resulting in slower reaction time and more errors. This effect has been shown to occur in anxious groups with words consisting of threat content and anxiety related material, where reaction time was significantly slower than a control group, and significantly slower than the same subjects reaction time to neutral words (Mathews, et al., 1985; Watts, et al., 1986b). A review of the stroop effect in anxious groups and in pain patients in offered in chapter 2, which describes a stroop experiment with chronic pain patients.

The stroop effect has been criticised, however, for the confounding effect of a response bias. This would mean that subjects slow down not because of an attention interference, where resources are pulled away from the task and directed automatically towards certain stimuli, but rather, they slow down as a result of anxiety in response to the stimuli, which acts to disrupt performance. To overcome this possible confounding effect, Macleod, Mathews and Tata (MacLeod, et al., 1986) devised the visual probe paradigm. This paradigm displays pairs of words towards the top or bottom of a VDU screen, combining threat and neutral words on each trial. Randomly, a small dot appears where a word has been, and subjects are asked to press a button in response to the dot. Since subjects take longer to respond to the probe if their attention has been drawn elsewhere, the interaction between the type of word and the position of the dot tests attention bias towards threat stimuli. Testing 16 anxious patients revealed significantly slower reaction times to dots appearing in a different location from the location of threat stimuli, in reverse to the pattern found with a control group. In other words, anxious groups retain attention in an area where they locate threatening stimuli, while controls orient away from this material. Macleod et al concluded that anxious patients have difficulty switching off their 'danger mode', and repeatedly scan their environment for danger. Since the dot is a neutral probe, which cannot cause anxiety by its salience, the results indicate a mechanism that is independent of response bias. The application of this paradigm to the investigation of a bias towards pain stimuli in pain patients is discussed in chapter 2.

Mathews and Macleod (Mathews, et al., 1985), and Mathews and Eysenck (1987) suggest that attention bias towards stimuli perceived as personal threat is closely linked with anxiety. This bias will act so that more reassuring information might be ignored, while highly elaborated schemata are created concerning threat and danger. Judgement about ambiguous situations will then be affected by these elaborate and easily activated schemata. A similar effect might occur in chronic pain patients, where ambiguous physical sensations could be mislabelled as painful. This notion is further supported by the finding that these types of judgements rely heavily on most readily accessible information, a processing mechanism known as the availability heuristic (Tversky & Kahneman, 1974). This means that the more elaborate schema are more likely to be active in the interpretation of ambiguous material, so elaborate pain schema would result in the distortion described above.

However, as noted above, not all groups with emotional disorders exhibit an attention bias towards material associated with their pathology. Although there are some conflicting accounts, most investigations with depressed groups have failed to show attention biases (Mogg, et al., 1987). The hypothesis of an attention bias to pain stimuli in pain patients is investigated in chapter 2 through an emotional stroop task.

Recall bias in emotional disorders

Experiments investigating the relationship between emotion and recall are based on the associative network theory (Anderson, Bower & , 1973; Bower, 1981) described above. Generally speaking the theory postulates two effects:

State dependent learning is the tendency for material to be recalled best when conditions at recall match those of the encoding of the data. Experimental evidence supporting this hypothesis has been gathered from several investigations (see review by Blaney 1986), but contradicting results have also been demonstrated. Although Bower himself reported successful results in 1978, when a group of subjects encoded data under induced mood, and recalled better after induction of matching mood, he failed to replicate these findings in 1985 (Bower, et al., 1985; Bower, et al., 1978). Nonetheless, other experiments have shown some support for the notion of state dependent recall, using different types of mood induction (Schare, Lisman & Spear, 1984).

Mood congruity effects depend on similarity between the subjects mood and the material to be recalled, with the hypothesis that negative mood will result in better recall for negative information and vice versa. Blaney (1986) reviewed over 30 studies and concluded that indeed there appears to be superior recall for mood congruent material. For example, Teasdale (Teasdale, Taylor & Fogarty, 1980) demonstrated that induced negative mood resulted in bias towards mood congruent autobiographical memories. However, there is evidence to suggest that another factor might be operating to mediate the effect; evidence shows that people have a recall bias towards material which is closely associated with their self-concept (Clark & Teasdale, 1985; Isen, et al., 1978; Teasdale & Russel, 1983b), and the congruity effect might be strengthened through such an association. This would mean that the more negative the self-concept the more the tendency to recall negative material associated with the self, but not necessarily accompanied by a tendency to recall more negative material associated with others.

Recall bias for negative material in depressed groups has been demonstrated by several experiments. Blaney (1986) found both mildly depressed students and clinically depressed groups to be more likely to recall negative material than positive or neutral material, as opposed to control groups that show an opposite trend, towards positive material. This effect is most pronounced when subjects are asked to focus on the applicability of the material to themselves, at the encoding stage, by, say, estimating past failures. The idea of self-schema, discussed above and in chapter 4, led Mathews and Bradley (Mathews, et al., 1983) to manipulate the encoding stage further, so that subject learnt the stimuli in two conditions, once in relation to themselves and once in relation to others. The results show a bias for negative material only in the self-reference condition, giving some credence to the idea of a self-schema operating to mediate recall. Lloyd and Lishman (Lloyd & Lishman, 1975) found depressed patients faster to recall unpleasant memories, and the bias appeared in direct relationship with the severity of their pathology. The results of other experiments involving memory of past experiences in depressed groups (Teasdale & Fogarty, 1979; Teasdale, et al., 1980; Clark & Teasdale, 1982) show a robust effect both when recall is spontaneous and when directed. However, the bias for learning certain words better than others appearing in a list shows more ambiguous results; Breslow et al., (Breslow, Kocsis & Belkin, 1981) demonstrated that depressed groups learnt less positive words, but showed no preference for learning negative ones. McDowell (McDowell, 1984) replicated these finding using mixed lists, and separate ones for positive and negative words, and found the effect only in the mixed list condition. This could be explained possibly as a result of competition for resources.

Although it is not inconceivable that depressed subjects show a recall bias towards negative memories simply because they have been exposed to more of these than the average person, this argument is challenged by the evidence arising from experiments using induced moods, and from evidence for the bias being specific to self referential encoding.

Investigations concerning recall biases towards threat stimuli in anxious groups have generally failed to show this bias (Mathews, et al., 1985), but conflicting evidence exists to suggest that the effect might take place in certain circumstances; Nunn, Stevenson and Whalan (Nunn, Stevenson & Whalan, 1984) demonstrated that agoraphobic patients recalled more passages with agoraphobia related words (e.s., 'Street') than controls, and Martin et al (Clark, et al., 1983) showed high trait anxiety subjects to be associated with better recall of negative self-referential words. Chronic pain patients have been shown to recall more pain related words than neutral ones (Pearce, et al., 1990; Edwards & Pearce, 1992). Chapter 4 attempts to establish whether this recall bias is specific to self-reference or a general bias, and to eliminate the possibility of a frequency effect confounding the results. The latter would mean that results are due to exposure to pain words, resulting in a decreased threshold needed for activation during search procedures. Chapter 5 investigates implicit and explicit recall in pain patients, in an attempt to demonstrate independence between integration and elaboration in pain patients. Chapter 6 investigates the specificity of the recall bias; could it be attributed to high depression levels in pain patients, and if so, do these patients demonstrate a recall bias towards depression related stimuli?

Interpretation of ambiguous information:

Apart from filtering information both in encoding, through attention biases, and retrieval, through recall biases, information processing theory hypothesises that ambiguous information will be perceived in line with activated schema. This means that schemata will act to impose their content on ambiguous stimuli. Although it is not clear whether this processing bias is regarded as part of integration or elaboration, there is a wide range of evidence to suggest that the effect takes place.

The most common paradigm involves subjects writing down words that are read to them. The stimuli include target homophones with two possible spellings, one describing threat related words, the other a neutral one. Eysenck (Eysenck, et al., 1987) found that anxious groups were more likely to produce threat related words than controls. These findings have been replicated with students and clinical groups (MacLeod, 1990; Mathews, Richards & Eysenck, 1989). Chapter 3 addresses the problems inherent in this paradigm in an investigation of interpretation bias towards pain related words in pain patients.

Section 5: Summary and predictions

The literature so far suggests that anxious and depressed groups differ in their responses to different paradigms. Table 1 indicates the split between the two groups, where tasks associated with integration appear to be associated with biases only in the anxious group, and tasks associated with elaboration show evidence for a bias in the depressed group. A goal of the thesis is to compare pain patients responses on each of the same tasks, to enable the table to be extended to include chronic pain.

Table 1: Information processing biases in depressed and anxious groups

	Depressed subjects	Anxious subjects
Dot-Probe	No	Yes
Emotional stroop	Probably Not	Yes
Interpretation of ambiguous homophones	No	Yes
Recall bias	Yes	No
Implicit memory bias	No	Yes

The following specific questions will be addressed:

1. Do chronic pain patients have an attention bias towards pain stimuli, (which might operate to increase anxiety and maintain pain)?

2. Do chronic pain patients exhibit a tendency to interpret ambiguous information as pain related?

3. Do chronic pain patients have a self- referential memory bias for pain related information (that could act to induce depression and a sense of hopelessness)?

4. How do chronic pain patients fit into the integration/elaboration divide in terms of their processing bias?

5. Are recall biases in chronic pain patients specific to pain stimuli, or are they in fact an artefact of mood, and therefore include depression related material?

The following chapters attempt to answer these questions through the application of the methodological paradigms described above.

Chapter 2: Do pain patients show interference when colour naming pain words?

Abstract

Chronic pain patients and control subjects were tested on two colour naming stroop tasks. In the first experiment they were presented with eight types of stimuli: sensory words, affective words, positive words, physical threat words, social threat words, neutral words, and congruent and incongruent colour names. The words (in blocks of wordtype) were presented on a VDU screen one at a time in a fixed order. Both groups showed marked interference to incongruent colour names, but there was no difference between the groups in their response times across the experimental conditions. In the second experiment, Stimuli in blocks of 50 trials were presented on cards, comprising of eight categories: sensory, affective, positive, three neutral lists matched with each of the above, simple colour naming and incongruent colour naming. Results in both experiments failed to replicate past findings; no support was found for the hypothesis of a bias towards pain stimuli in pain patients' response time. However, a free recall task revealed a bias towards the recall of sensory words in pain patients. Results are discussed with reference to information processing theories, including the hypothesis of elaboration and integration of information during processing.

Introduction

Information processing theories concern the continuum of processing through attention and encoding to retrieval. This chapter concentrates on the earlier stages of encoding, namely, attention and interference in the allocation of attention. Both attention bias and interference are part of the processing category described as 'integration' (described below), which is defined as automatic, fast processing and is also known as priming (Williams, et al., 1988). The tasks which have been used to test priming have included the dot-probe paradigm (MacLeod, et al., 1986), and the emotional stroop task (Watts, et al., 1986b). The current investigation employs the emotional stroop task to test the hypothesis that neutral tasks of information processing in chronic pain patients will show interference when pain stimuli are present. Such interference may result in the strengthening of pain schemata and the maintenance of the pain experience.

The theoretical basis for this investigation, as outlined in Chapter 1, incorporates the idea of schemata (knowledge structures stored in long term memory), which interact with incoming information (Williams, et al., 1988). These schemata, constructed through past experience and influenced through conceptual processing, select from incoming information the features which are congruent with the schematic content, and impose interpretation on ambiguous or missing data. Thus, a highly elaborated schema with content associated with depression might act to bias processing towards negative information. The consequences of such processing have implications for the maintenance and exacerbation of emotional distress (Beck, et al., 1979). Schema should act to guide attention towards congruent material, resulting in preferential selection of such information for further processing. This in turn will strengthen activation of the schema, producing stronger memory traces, and faster search paths to such information. Schema theory therefore predicts biases for schema congruent information in both attention and retrieval stages of processing. However, evidence suggests that different emotional disorders are characterised by selective processing at different stages; anxiety has been found to be highly associated with an *attentional* bias towards threat stimuli, while depression has been associated with a *memory* bias towards negative information (see williams et al, 1988 for review).

Although there has been some evidence to suggest that depressed subjects are slower than control subjects on a colour naming task when reading negative depression associated material (Gotlib & McCann, 1984), measures of anxiety were not taken and the effect may be due to anxiety, rather than depression. Indeed, Mathews and Macleod (Mathews, et al., 1985) found an attentional bias to threat stimuli in anxious subjects who were also more depressed than controls, but partial correlation analysis indicated that anxiety, rather than depression, was significantly associated with latency to colour name threat words. Further investigations using both anxious and depressed groups in the same paradigm found an attention bias to threat stimuli in anxious patients, but not in depressed subjects (MacLeod, et al., 1986). It appears that different emotions may have specific effects on cognitive processing.

A theoretical basis for the differentiation between memory and attention biases was originally suggested by Schneider (Schneider, et al., 1977), who distinguishes between automatic and strategic processing. The former operates without awareness, is rapid and unconstrained by capacity. The latter is relatively slow and capacity limited. Williams et al., (1988) argue that both encoding and retrieval involve a passive, automatic aspect and an active, strategic aspect. Therefore, different emotions may affect different aspects of processing, and a bias in one need not entail a bias in the other. Graf and Mandler (Graf, et al., 1984) propose a model that distinguishes between two types of processing; integration (priming), and elaboration. Priming involves automatic activation of the components that make up the internal representation of a word, thus strengthening the internal organization and making the word more accessible. This means the word will be activated more readily and with less information present. Priming can be assessed by tasks involving the measurement of perceptual thresholds. Williams et al. (1988) suggest that the dot-probe task (described below) may reflect automatic priming. Elaboration concerns the activation of a representation in relation to other associated representations. By forming new relationships and activating old associative pathways between representations, the word becomes more retrievable. Elaboration can be assessed through certain memory tasks, described in later chapters.

The study of information processing biases in pain processing must therefore acknowledge that a recall bias towards pain stimuli does not necessarily indicate an attentional bias towards pain stimuli. This investigation aims to discover the role that attention might play in the processing of pain related stimuli in chronic pain patients.

Chronic pain patients have been shown to selectively recall more sensory words than neutral words when these have been presented to them in a mixed list (Pearce, et al., 1990; Edwards, et al., 1992). This suggests that over time an elaborate pain related schema has developed in chronic pain patients. It is yet to be established whether this bias is due to selective encoding, elaboration, or retrieval of pain material. However, the bias demonstrated is consistent with the type of processing defined by Graf and Mandler (1984) as elaboration. Evidence for the selective priming of pain stimuli in pain patients (the more automatic process associated with attention biases), is less consistent: There is some evidence to suggest that pain patients are slower than control subjects on colour naming of pain related words (Pearce & Morley, 1989), but two separate investigations employing the dot-probe paradigm (Pincus, unpublished MSc, Moses, unpublished MSc) have failed to find evidence for an attention bias in pain patients towards pain stimuli.

The dot-probe technique measures subjects reaction time to a dot-probe that appears directly after a pair of words. The word pairs comprise one emotionally salient word and one neutral word, and by manipulating the positioning of these on the screen in relation to the position of the probe, it is possible to detect the tendency to direct attention towards emotionally salient stimuli. Moses (unpublished MSc 1989) used a list of physically threatening words as the target stimuli. Pincus (unpublished MSc, 1990) used words extracted from the McGill pain questionnaire, which include both sensory descriptions of pain, and affective-evaluative descriptions of pain. Furthermore, the latter list was identical to the stimuli that has been used in the investigation of memory biases in pain patients. Neither experiment showed a difference in the reaction times of pain patients and those of control subjects towards these stimuli, thus indicating that pain patients do not appear to have an attention bias towards pain stimuli.

The emotional stroop task is a refinement of the classical stroop task (Stroop, 1935), originally used to explore attentional processes and interference. Subjects were asked to name the colour of the ink in which an item was printed, while ignoring the semantic meaning of the item. Stroop (1935) found that subjects were slower to name the ink colour when the item was an incongruent colour name. More recently the stroop task has been used to measure latency to name colours of negative affective words in different groups, including normal populations, clinically depressed groups, and anxious groups (Gotlib, et al., 1984; Mathews, et al., 1985; Williams, et al., 1986; Watts, et al., 1986b). Studies have used neutral or positive words as controls for emotional words which are specific to the psychopathology of different groups, and compared performance between these groups and healthy controls.

Mathews and Macleod (Mathews, et al., 1985) compared the latency to name the colour of threat related words in anxious subjects and controls. They divided their experimental group of anxious patients into those who were predominantly concerned with social threat and those who primarily concerned with physical threat. Using 4 cards (containing physical threat words, social threat words and two conditions of positive words matched for frequency and word length), they found a different response pattern between controls and anxious subjects. Controls showed no difference in reaction time to the four cards, while anxious subjects showed not only longer reaction times in naming colours of threat words, but exhibited a relationship between their reaction time and their specific subject of anxiety. Thus, anxious patients who primarily worried about social issues exhibited interference effects only on social threat words, but not when colour naming physical threat words, while anxious patients concerned with physical threat revealed interference effects in colour naming all threat stimuli. This was interpreted as evidence for an attention bias towards stimuli that is specifically salient to the subjects, rather than to emotional stimuli in general or negative threatening stimuli in general.

To investigate further the specificity of this effect, Watts et al. (Watts, et al., 1986b) added a general emotional category to a set containing stimuli specific to the disorder of their experimental group - spider phobics. The experimental group did not differ from the control group in their response to this general emotional category, but showed large disruption in colour naming of spider words. The possibility of this effect being a result of frequency differences between the groups (i.e., that spider phobics were more familiar with spider associated words through prior exposure, and this familiarity is the cause of the disruption) appears unlikely, since the disruption diminished after an intervention programme, although the frequency of spider associated words would be higher after constant exposure during intervention.

Colour naming of pain related material in chronic pain patients has been investigated by Pearce and Morley (1989). Pain related stimuli were constructed from the sensory and affective-evaluative scales of the McGill Pain Questionnaire, and to these was added a general negative-emotion category (failure, depressed, grief). Each of these three categories was presented on a separate card, with matching control cards for each category. Finally, the classical stroop task and a control condition of a series of XXXX in different colours were presented on separate cards. By subtracting reaction time to the control conditions from the reaction time to the target cards' interference to each word category was calculated. The interference was highest for the classical stroop task, but with no difference between the groups. However, a planned contrast analysis revealed that pain patients were slower to colour name the sensory and affective-evaluative word category than the control group. Since there was no difference between the groups in colour naming of the general emotional category, Pearce and Morley argued that the effect cannot be due to differences in the groups in general emotional disturbance. Furthermore, scores on the short Profile of Mood States (POMS) showed few correlations with the interference scores. Pearce and Morley concluded that the stroop task reveals attention biases towards pain stimuli in pain patients, through reallocation of cognitive resources which leads to an increase in interference in the colour naming task.

The differences in the results of the studies investigating attention bias to pain stimuli in pain patients may be due to the paradigms used targeting different stages of processing; the dot-probe task involves very early stages of processing and it is argued that the task reveals automatic biases in attention (MacLeod, et al., 1986). The stroop task, on the other hand investigates interference and might involve later processing stages, and may include elaboration. Certainly the latter paradigm is more susceptible to a response bias (Williams, et al., 1988). It is also possible that the results obtained in the stroop experiment could be partly due to differences in levels of anxiety and depression between the groups. Although a general emotional category was included in the design, there is evidence to suggest that colour naming latencies are specific to the subject of fear (McKenna, personal correspondence), and therefore pain related words should evoke this response in anxious chronic pain patients. The current investigation was designed to control for the possibility that latency to colour name pain words in pain patients could be a directly related to anxious and depressed emotional states rather than pain per se.

Two experiments were planned; in the first, the stimuli presentation was computer controlled. On each trial a single word appeared on the screen and the latency to press the appropriate colour button was recorded. This methodology has the advantage of precise timing, and is relatively free of experimenter bias. However, to replicate Pearce and Morley's experiment, the second experiment was conducted using the more traditional cards and stop watch. The latter included a free recall task, both in an attempt to replicate the past finding (Edwards, et al., 1992) of a recall bias for pain stimuli in pain patients, and to investigate the relationship between attention and recall bias in this group.

In the first experiment, the two pain related categories were comprised of sensory and affective words from the MPQ (Pearce, et al., 1989). To these were added two anxiety based categories; physical threat words, and social threat words (MacLeod, et al., 1986). A bias due to anxiety, rather than pain, would be revealed by a longer latency to colour name the stimuli in either of the threat categories. Anxiety focused on health issues should result in a longer latency to colour name the physical threat category only. To account for the possibility of an emotional stroop effect on any type of emotionally salient material, a positive word category was included. The neutral control condition for these five target categories was a list of household objects (to control for the effects of categorisation, (Broadbent & Broadbent, 1988). Finally, the classical stroop condition, with conflicting colour names, and the facilitating condition of congruent colour naming were included. Measures of pain were taken on the MPQ (Melzack, 1975), measures of state and trait anxiety were taken on the Spielberger State and Trait Anxiety (Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983), and measures of depression were taken on the Beck Depression Inventory (Beck, Ward, Mendelson, Mock & Erbaugh, 1961).

The problem of differentiating between selective processing effects due to anxiety or depression and those due to pain in chronic pain patients is thus tackled in two ways; firstly by including stimuli that should evoke selective processing in anxious subjects, and secondly by directly measuring anxiety and depression and correlating the scores with colour naming latencies to each category. An interaction between group and word category, in which pain patients are significantly slower to name the colour of pain related words, but show no difference in latency to colour name other word categories, could therefore be interpreted as evidence for selective processing of pain stimuli in pain groups. Analysis of anxiety and depression scores and their relation to colour naming latencies would reveal the part these emotional states play in processing.

Experiment 1: Method

Subjects

Seventeen chronic pain patients, (12 females, 5 males) were invited through "Self Help In Pain", a support organisation for pain sufferers. All of them had had pain for more than six months, from various causes. The group mean for the usual pain intensity on a scale from 1 to 5 was 3.35. As a reward for participating in the study, pain patients were offered a workshop on pain management. Seventeen control subjects, (11 females, 6 males) were recruited through local advertisements, and were paid £3 for their participation. They had no history of chronic or current pain, but 4 of them had spouses who suffered from chronic pain. A comparison between the groups mean age and questionnaire results is presented in Table 2. (The BDI scores for items N,O,Q, and T are deducted from the total score, as they confound the effects of mood and pain. This scoring hold for the entire thesis). Neither group were aware of the hypothesis under examination.

Design and Procedure

A 2 x 7 factorial design was employed with one between subjects factor (group), and one within subjects factor (word category). The eight different categories of words were presented in a fixed order to all subjects. The first category included neutral adjectives and was used as a practise session to achieve a steady baseline in performance. The experimental categories were presented in the following order: sensory words (from the McGill Pain Questionnaire), colour naming (colour of ink and name of colour congruent), affective words (from the affective scale on the McGill Pain Questionnaire), positive words (Mathews, et al., 1985), physical threat words (Mathews, et al., 1985), household objects (Mathews, 1988), classical Stroop (ink and name of colour incongruent), social threat words (Mathews, et al., 1985). The physical threat, social threat, positive words, and household objects were matched for frequency. Subjects completed the task in two sessions with a break between positive words and physical threat words. Each category consisted of 10 words, repeated randomly five times, to create 50 trials. In addition, 25 neutral fillers were interspersed between each category to avoid spill-over (Watts, et al., 1986b). Stimuli were presented one at a time, by a BBC computer using three colours (pink, yellow and blue). As each word appeared on the screen, subjects were asked to identify the colour of each word by pressing the appropriate colour-marked key. Reaction times to each word were measured in milliseconds, and errors were recorded by the computer. There was a gap of 500 milliseconds between subject's response and the appearance of the next target word. Between trials subjects rested their finger on a finger rest located at an equal distance from all three colour buttons. On completion of the experiment, subjects were asked to fill in the McGill Pain Questionnaire, the Beck Depression Inventory, and the Spielberger State and Trait Anxiety Inventory.

Apparatus

A BBC computer was used to present the data, linked to a three-button response handset, which recorded subjects responses.

Table 2: Stroop, experiment 1: mean age and questionnaire scores

	pain group	controls	t(df=32)	p
age	56.76 (13.20)	61.47 (8.15)	-1.25	NS
MPQ sensory	15.64 (6.45)			
MPQ affect	9.94 (9.94)			
MPQ PPI	3.35 (1.45)			
STAI state	35.71 (10.93)	35.47 (7.40)	0.07	NS
STAI trait	49.71 (16.83)	37.47 (9.24)	2.54	<0.05
BDI	11.76 (6.15)	6.82 (3.98)	2.77	<0.05

MPQ = McGill Pain Questionnaire

STAI = State-Trait Anxiety Inventory

BDI = Beck Depression Inventory

Results

Table 2 represents the means and standard deviations of the ages, the scores on the Beck inventory and the Spielberger inventory for each group, and the MPQ scores for the pain group alone. As can be seen there were significant differences between the groups in the levels of depression and trait anxiety.

The category of colour-naming was incorporated in the design to achieve a reaction time baseline for the classical stroop condition, so that interference could be compared between the classical stroop effect and emotional stroop effects. An interference score is calculated by subtracting the mean for the congruent colour condition from the mean for each of the other word categories for each subject; thus individual differences are reduced. After the colour naming deduction from each score and a constant addition of 500 (to avoid negative scores), an analysis of variance revealed no group effect ($F<1$) or interaction ($F<1$), But a highly significant word type effect ($F(6,192)=21.9, p<0.0001$). The lack of homogeneity between categories and the large standard deviation in the interference scores could be responsible for obscuring any effects present: The facilitating colour category was therefore excluded from the analysis, which was repeated on mean reaction time for each category, rather than using the interference scores. Seven word categories were analyzed; sensory words, affective words, positive words, physical threat words, household objects, classical stroop (incongruent ink/colour name), and social threat words.

The mean reaction time (correct response only) for each word category for each subject was computed with the exclusion of any trials with a reaction time outside two standard deviations from the mean of each category (within each subject). Two subjects, one from each group were excluded from the analysis as outliers, since their scores were consistently more than two standard deviations from the group mean. A mixed 2x7 factorial analysis of variance was carried out on the remaining 32 subject means, with group as the between subjects variable, and word category as the within subjects variable. No overall difference in reaction times appeared between the two groups ($F<1$). However, a significant difference in the reaction times across groups to the different word categories was observed ($F(6,180)=20.57$, $p<0.0001$). The interaction between group and word condition was not significant ($F<1$). All subjects show a marked increase in reaction time to the classical Stroop condition (see Figure 1).

A priori contrasts adapted from the hypotheses of Pearce and Morley (Pearce, et al., 1989) were conducted to further investigate the differences in reaction time to the different categories (table 3). The first contrast compared all the conditions with the classical stroop (Pearce, et al., 1989). Both groups show a significant increase in reaction time to the classical stroop ($F(1,180)=118.63$, $p<0.0001$), but no group differences emerged.

Contrasting the two pain categories (sensory and affective words) with the anxiety based categories (physical and social threat) revealed no overall difference between the pain and threat stimuli ($F<1$). This contrast was not significant for either of the groups (Pain group $F(1,180)=1.08$, $p<0.299$, Control group $F<1$).

Comparing the sensory category with the neutral (household objects) category revealed no difference between the two ($F<1$). This held for comparisons within the groups as well ($F<1$ for both groups).

Comparison between the affective category and the neutral category approached significance ($F(1,180)=3.33$, $p<0.069$). In the pain group this effect was maintained at a level approaching significance ($F(1,180)=2.94$, $p<0.088$), but the control group did not show a similar trend ($F<1$). These results are might be viewed as a weak support for the finding of Pearce and Morley (1989), at least in regard to affective words, as they show interference (approaching significance) in the pain group but not in the control group.

To investigate the possibility that any apparent differences between the groups are an artifact of differences in emotional states, reflected in the significant difference in levels of anxiety and depression, the scores on the Beck Depression Inventory were incorporated as covariates and the analysis of variance repeated. (the scores on the BDI and the Spielberger trait were significantly correlated ($r(16)=0.57, p<0.05$), so only one of these was selected to be entered as a covariate). The BDI was selected because the scores in the pain group correlated significantly with response time to the affective category ($r(16)=0.48$, $p<0.05$). A comparison between the original means plotted and the adjusted means plotted for each word category is presented in Figure 2. The apparent difference between the pain group and the control group disappears once depression is incorporated as a covariate.

The relationship between depression and anxiety scores and reaction time to pain stimuli in the pain group was further investigated using partial correlations (Pearce, et al., 1989). Holding Pain scores constant (from the Overall pain category of the McGill Pain Questionnaire, which gives a 0-5 rating of pain), the partial correlation between trait anxiety and colour naming times in the sensory category was 0.633 ($df=16$, $p<0.014$). Partial correlation between the Beck scores and the affective category (holding pain scores) revealed a significance relationship between the two ($r(13)=0.605$, $p<0.016$). However, pain scores showed little correlation with colour naming times in the sensory category when anxiety was held constant($r(13)= -.192$, $p<0.492$). This suggests that reaction time to the pain associated word categories is related to anxiety and depression rather than pain intensity.

The overall correlation table reveals that depression scores are highly associated with reaction time to affective words ($r(16)=0.48$ in pain group, not significant in control group, $r(16)= -0.12$) and social threat ($r(16)=0.31$ in pain group, not significant in control group, $r(16)= -0.11$) categories. State anxiety is a significant predictor of both physical threat ($r(16)=0.41$) and social threat ($r(16)=0.51$ in pain group, not significant in control group (physical threat, $r(16)=0.22$, social threat, $r(16)= -0.11$). On the other hand, pain scores do not correlate with any of the word categories. Scores on the sensory scale of the McGill Pain Questionnaire did not correlate with reaction times to the sensory category ($r=-0.036$) and nor did scores on the affective scale correlate with reaction time to the affective category ($r=0.089$).

Table 3: Stroop, experiment 1: response time to word categories

	Pain patients	Control Subjects
Sensory	754 (124)	714 (156)
Colour naming	727 (99)	699 (131)
Affective	805 (117)	767 (150)
Positive	773 (127)	741 (158)
Physical threat	747 (101)	732 (156)
Household Objects	727 (102)	721 (150)
Classical Stroop	1049 (480)	999 (241)
Social threat	760 (165)	772 (124)

* Response time in m/secs.
* Sd in brackets

Discussion

The results fail to replicate Pearce and Morley's (1989) findings. Chronic pain patients showed no marked interference in the colour naming of pain associated words, in comparison to a control group. The discussion will attempt to explain these findings in relation to current and previous paradigm differences, and from a theoretical point of view.

If chronic pain patients are more susceptible than controls to interference from pain associated stimuli, it is possible that the methodology employed in this first investigation was not sensitive enough to reveal these differences. This could be either because of the single presentation, the use of only three colours, or the button pressing as opposed to the verbal response. This is felt to be unlikely since all of these have been used in the past both in investigation of the classical stroop (Macleod, 1991) and specifically with emotional stroop tasks in anxious groups (Mckenna, personal correspondence). Golden, (1974) has shown that there is no difference in the stroop effect between the use of three to five colours. The evidence on the use of manual versus verbal response is more controversial; Roe (1980) found no difference between the two responses (Roe, Wilsoncroft & Griffiths, 1980), but Macleod (1991) concluded that the effect is diminished.

Nonetheless, the results of the first experiment show both a marked increased latency in the classical stroop category, and a small rise in latency to name the affective category. This particular category is supposed to consist of words associated with the affective experience of pain. However, it could be equally described as a general negative affective category, which could be related to depression rather than pain. One would predict that performance on this category would be related to scores on the depression inventory. Although, the overall contrast between this category and the neutral control category approaches significance, indicating that BOTH groups show some interference, the contrast within the groups shows this trend to hold only for the pain group. This could be taken as some evidence for interference with pain associated stimuli, or as a result of pain patients being significantly more depressed than control subjects. The partial correlation shows the significant relationship between the mean time to name this category and the depression scores in the pain group. The analysis of covariance reveals that any apparent difference between the groups on their latencies to name the affective category disappear once depression scores are incorporated as a covariate. This can be interpreted as evidence that the difference in depression levels between the two groups are responsible for the difference in response time to affective words.

Pearce and Morley (1989) used the shortened form of the Profile of Mood States (POMS) to assess the possible confounding effects of mood. They argue that this is a measure of general mood, and that since it showed little correlation with the interference scores, the possibility of the latency times being affected by mood was ruled out. It appears from the present results that anxiety and depression are both significantly correlated with latency times to pain stimuli, and it seems plausible that these factors affected results in the precedent. Indeed, Williams and Broadbent (Williams, et al., 1986) investigating emotional stroop in suicide attempters, found the despondency/depression score on the POMS to produce consistent correlations with response times. Pearce and Morley (1989) failed to replicate this finding, but the present results suggest that depression might play an important role in colour naming of pain words in pain patients, and specifically with negative-affective stimuli.

The pain patients participating in the first investigation were (i) recruited through a self-help association and (ii) tested in a university environment. The first of these factors is probably the more important; it is possible that this group does not represent pain patients as a whole, since their levels of self motivation was higher than pain patients in general, resulting in a more positive outlook and self-image. This explanation seems rather implausible considering the high scores on anxiety and depression observed.

Finally, it is possible that verbal and manual responses operate at different processing levels. The stroop task involves deeper levels of processing than the dot-probe paradigm, which concentrates on direct automatic response to external stimuli. The stroop paradigm by comparison is not free from response bias, and this could be heightened by the use of speech instead of button pressing response. It is currently known that pain patients have a marked recall bias for pain associated stimuli (Pearce, et al., 1990; Edwards, et al., 1992) and that they do not have an attention bias towards similar stimuli (Pincus, unpublished MSc, Moses, unpublished MSc). If the stroop paradigm taps processing somewhere between these two, and assuming a processing continuum, it is likely that the effect will be weak and difficult to replicate. It is also plausible that a change from verbal to manual response will eliminate the effect all together. It is possible that stroop tasks involve both automatic and elaborative aspects of processing, as discussed in the introduction. The elaboration of pain stimuli might be employed to a greater extent in the verbal response task than the manual response.

It must be noted that this investigation did not compare interference on the classical stroop with interference on the emotional stroop, as did the preceding studies (Pearce and Morley 1989, Watts., 1986). Probably because of the single presentation, subjects did not respond consistently faster to the colour congruent words. They commented that they anticipated a 'trick' trial to come up next, i.e., an incongruent colour word, which resulted in high standard deviations of raw latencies on the colour naming category. It appears clear though, that at least in terms of response to the classical stroop, these results replicate the findings of earlier studies.

In summary, this investigation failed to provide evidence for the hypothesis of an emotional stroop effect to pain stimuli in pain patients. However, a close relationship was observed between levels of emotional distress (anxiety and depression) and latencies to name associated categories. These emotional states were not measured in the earlier studies and could account for the contradictory findings. However, since the methodologies employed in the previous study and the present one differed significantly between the two studies, a further investigation, utilizing Pearce and Morley's design was carried out. A further measure of recall was incorporated in the design in an attempt to replicate the finding of a recall bias for pain stimuli in pain patients. If pain patients are shown to selectively recall more pain related words, but no differences are found on the stroop task between the groups, there would be little reason to believe that pain patients exhibit biases in the early stages of processing.

Experiment 2: Method

Design and procedure

A 2x8 factorial design was employed, with one between subjects factor (pain patients versus control subjects) and one within subjects factor (wordtype categories including sensory, affective, and positive words, three neutral word lists, the classical stroop and an xxxx colour naming condition). Each condition consisted of 10 words repeated 5 times to create 50 trials for each card. The dependent variable was the latency to name the colours on each card. Subjects were asked to read out loud the names of the colours in which the lists were presented as quickly and accurately as possible. Timing commenced from the reading of the first words on the card. The cards were presented in a fixed order for both groups. On completion of the stroop task, subjects were asked to complete an intervention task by counting backwards from 300 for two minutes. They were then tested on a free recall task, and were asked to fill in the Hospital Anxiety and Depression Scale (HADS) questionnaire. Pain intensity ratings were then taken from the pain patients. These included stating the diagnosis, location and intensity of pain at the time, and at its worst on a scale of 1-100 (Jensen, Karoly & Braver, 1986). Damage ratings on a scale of 1 to 10 were obtained from the anaesthetist for each pain patient.

Subjects

Twelve females and 8 males attending St. Mary's pain clinic were asked to participate. They had all had pain for more than 6 months, and all were native English speakers. The control subjects comprised 20 volunteers (12 females) who had no history of chronic pain. All subjects were unaware of the hypothesis and were unfamiliar with the stroop task. The groups were matched for age, with the pain group having a mean of 49.5 years (sd=10.19) and the control subjects a mean of 48.85 years (sd=9.56).

Materials

Nine 50-word lists were constructed (one practice, the classical stroop, the colour naming list and six experimental lists). The six experimental lists are presented in table 4. The experimental lists were used to form four pairs of Stroop tasks, each including a target list and a control condition. The order of presentation of stimuli was as follows: the colour naming list; classical stroop; neutral list 1; positive words; neutral list 2; sensory words; neutral list 3; affective words. The neutral lists were individually matched to each emotional target list for word length,number of syllables and frequency. All target words were identical to those used in experiment one apart from the affective list, which was constructed from words generated by the pain unit at University College London. Stronger evidence for a bias in endorsement and recall in pain patients has been obtained using these negative pain words than more general negative words, and were therefore considered better targets than the affective words on the McGill (see chapter 7). The practice list comprised ten alternating blocks of five 0's and five neutral words.

Each list contained 10 words repeated five times (Pearce, et al., 1989). Each item was printed in one of five colours in the following fixed order: Red,brown,blue,orange and green. The letters were 5mm in height. The items were presented in a pre-determined randomized order with the constraint that no successive items were of the same category or colour. The nine word lists were presented on A4 card in a ring binder, and a stop watch was used to record response latencies.

Table 4: Stimuli for stroop experiment 2

Sensory	Control neutral
Throbbing	Footnotes
Pounding	Coasted
Sharp	Upper
Aching	Sleeve
Burning	Descend
Dull	Hail
Tender	Rendered
Sore	Flew
Gnawing	Mention
Hurting	Flowed

Affective	Control neutral
Vulnerable	Generation
Suffering	Receiving
Dependent	Interval
Tortured	Filtered
Disabled	Presided
Mutilated	Variously
Miserable	Societies
Agonized	Refunded
Weak	Crew
Ill	Ore

Positive	Control neutral
Beautiful	Curly
Joyful	Suggested
Lucky	Classify
Caring	Owner
Wonderful	Utter
Warm	Beginning
Jolly	Structural
Generous	Says
Prosperous	Used
Good	Assure

Results

Stroop task

The mean response times for each group were calculated for each word category and are presented in table 5. Interference was calculated by subtracting the latency to name colours from the latency to name incorgruous words/colours (the classical stroop), and by subtracting the matching neutral lists from the positive, sensory and affective lists for each subject. The four interference means were analyzed in a 2x4 (group by wordtype) analysis of variance. The main effect for word type was significant ($F(3,114)=211.02, p<0.0001$), and that for group approached significance ($F(1,38)=3.14$, $p=0.08$). The interaction between group and word category, however, was not significant ($F(3,114)=1.74$). When the analysis was repeated without the classical stroop interference condition, (were latencies were much higher than the emotional word categories), the significance of both main effects vanished (group $F(1,38)=1.42$, word category $F(2,76)=2.25$). The method of calculating interference by subtracting neutral lists resulted in large standard deviations. To reduce the variability in the data, the simple colour naming mean was used as a base-line for each subject and analysis was repeated with four categories; sensory, affective, positive and neutral (The list matching the sensory words was selected). The colour naming mean was deducted from the mean of each of the four categories and a 2x4 (group by word category) analysis was carried out. There was no significant main group effect ($F(1,38)=2.92$), or interaction between group and word category ($F<1$). However, a significant word category main effect was found ($F(3,114)=5.66, p<0.001$).

Measures of depression and anxiety were higher for the pain group (depression $F(1,38)=13.51, p<0.001$, anxiety $F(1,38)=8.63, p<0.01$). The correlation matrix revealed that scores on anxiety were significantly correlated with response time to sensory words ($r(39)=0.349, p<0.05$). To avoid the possibility of anxiety ratings confounding the results, an analysis of covariance was carried out. The pattern of results remained unchanged, with no group effect or interaction, but a significant word category effect. In summary, results did not provide evidence that pain patients and controls differ in their processing of sensory and affective words on the stroop task.

Recall

The number of words recalled in each category (sensory, affective,positive and neutral) was calculated for each subject, and a transformation (sqrt x+0.5) carried out on the data to achieve homogeneity of variance (Howell, 1987). Means and standard deviations are presented in table 6. A mixed 2x4 (group by word category) factorial analysis of variance was conducted revealing no group effect ($F<1$), a significant word category main effect ($F(3,114)=9.97, p<0.001$) and a significant interaction ($F(3,114)=2.77, p<0.05$).

Simple effects analysis compared each word category between the two groups; the groups differed only in their recall of sensory words ($F(1,114)=4.97, p<0.05$). Pain patients tend to recall more sensory words than controls, but on other word categories there is no difference in recall between the two groups.

However, there was no evidence to suggest that this bias was related to pain (including pain intensity at the time, at its worst that week, length and damage) or to mood scores (including depression and anxiety). The correlation matrix for the pain group alone revealed NO significant relationship between the recall scores and any of these measures. Overall, there is evidence to suggest the presence of a recall bias towards sensory words in the pain group, but this bias appears to be unrelated to subjective ratings of pain intensity.

Table 5: Stroop, experiment 2: depression, anxiety and mean response times

	Pain group	Control subjects
Depression	9 (4.33)	6.93 (2.6)
Anxiety	10.7 (4.19)	7.15 (3.41)
RT Sensory	44.45 (8.64)	41.73 (6.44)
RT Affective	43.8 (8.51)	42.67 (6.78)
RT Positive	42.62 (9.17)	40.76 (6.87)
RT Control Sens.	40.96 (7.03)	40.32 (6.69)
Rt Control Affect.	43.22 (7.77)	40.56 (6.99)
RT Control Pos.	40.61 (6.8)	40.93 (6.5)
Stroop	65.66 (13.19)	61.92 (11.54)
Colour naming	31.52 (4.01)	32.9 (6.13)

*RT= Mean response time to read each card in seconds.

*Sd in brackets

Table 6: Stroop, experiment 2: mean recall of word categories

	Pain patients	Control subjects
Sensory	0.96 (0.24)	0.75 (0.27)
Affective	1.00 (0.39)	1.19 (0.37)
Positive	0.8 (0.24)	0.85 (0.27)
Neutral	0.78 (0.22)	0.76 (0.16)

* After transformation

*Sd in brackets

Discussion

The results of the second experiment fail to replicate the finding of an emotional stroop effect in pain patients with pain related stimuli. The methodology was the same as that used by Pearce and Morley (Pearce, et al., 1989) who obtained an effect, and therefore is unlikely to be responsible for the contradicting results. Whereas the experiment described previously compared means for each category, this study compared interference scores, and is therefore more comparable to Pearce and Morley's experiment. The fact that a recall bias towards sensory stimuli was observed in the pain group in the second experiment, replicating past findings (Edwards, et al., 1992; Pearce, et al., 1990) presents strong evidence against the results being a type II error. It appears from both experiments that early processing in pain groups is not marked by biases towards pain related material; these biases seem to develop in later stages of processing, and are evident in processes involving elaboration. It also appears that mood states, and in particular anxiety and depression, might account for past findings concerning a stroop effect in pain patients. Results from both experiments suggest that this may be the case; in the first, a possible difference in response time to affective words between the groups was no longer evident when depression was incorporated as a covariate, while in the second a significant relationship was observed between anxiety measures and response times to sensory words. It appears from these results that affective states in chronic pain patients affect processing of affective pain stimuli, at least in the early stages. The importance of targeting intervention to deal with these emotional states as well as the physiological aspects of the pain experience is emphasised by theories of information processing (see Williams et al., 1988, or Dalgleish and Watts 1990, for a review). The matter of interference caused by pain associated stimuli in pain patients remains unresolved, and replications are needed for both the verbal and manual response paradigms. However, the findings from these experiments suggest that pain patients do not consistently exhibit biases associated with integration, as measured on tasks such as the dot-probe and the emotional stroop, but that they do exhibit biases associated with elaboration as measured on a free recall task.

Chapter 3: Do pain patients selectively interpret ambiguous information as pain related?

Abstract

Three experiments were carried out to investigate the hypothesis of an interpretation bias for ambiguous stimuli in pain patients. Pain patients and non-pain control subjects (who were exposed to pain without personal pain experience) responses to ambiguous cues were compared in two experiments. In the first, pain patients, control subjects and physiotherapists were asked to produce a list of spontaneous associations to ambiguous cues (such as 'terminal' and 'growth'). The experiment was repeated measuring anxiety and depression in three groups: Pain patients, osteopaths and a non-pain control group. Results indicate that pain patients systematically produce more pain related associations than the other groups, and that this effect is independent of anxiety and depression levels. In the third experiment the interpretation of ambiguous homophones, with both a pain related and neutral interpretation, was compared between pain patients and controls. The pain group portrayed a significant bias towards pain interpretation. Anxiety and depression measures were incorporated as covariates, but the effect appeared to be independent of these. Both groups reported awareness of the ambiguity of some words, and their recall of these words was incorporated in the analysis as an indirect measure of response bias. The results were not altered. A free recall task also replicated past findings concerning a memory bias for pain stimuli in pain groups. The results are interpreted as evidence for a bias towards pain interpretation of ambiguous stimuli in pain patients, as predicted by schema theory.

Introduction

Theories of information processing in emotional disorders predict that these may lead to a bias for the processing of salient stimuli. This may be expressed as an attentional bias (in which the environment is scanned for salient stimuli), a distraction bias (in which tasks are interrupted by the presentation of such stimuli, or a bias (in which salient stimuli are preferentially processed in situations where it is presented concurrently with neutral stimuli. Chapter 2 concentrated on the hypothesis of an attention bias towards pain related stimuli in pain patients and concluded that if such a bias exists it is not a robust effect.

The current chapter explores the possibility of selective interpretation of ambiguous stimuli in pain patients, a hypothesis extracted from theories of schematic processing (Leventhal, 1984; Beck & Emery, 1985; Williams, Watts, Macleod & Mathews, 1988) or semantic networks (Bower, 1981; Bower, 1987). Both theories predict that individuals will selectively attend, encode and retrieve stimuli that are congruent with their current emotional state and long-term emotional tendencies. Pain patients can be viewed as individuals who have, through a prolonged exposure to pain suffering, constructed extensive pain related schemata. These would act to selectively process pain related stimuli from more general information. Another approach, with a stronger emphasis on the physiological component of pain processing describes processing of ambiguous stimuli, and in particular ambiguous sensations as a key factor in the maintenance of pain in the absence of further injury (Pennebaker, 1982).

Theories of information processing predict a bias in the interpretation of ambiguous stimuli, which results in the interpretation congruent with emotional concerns and distress being preferred to other interpretations in groups suffering from mental disorders (Beck, et al., 1985; Bower, 1981; Williams, et al., 1988). Most of the evidence to support this prediction has been gathered from anxious subjects. Several studies have been carried out on students divided into low and high trait anxiety groups (Eysenck, et al., 1987; MacLeod, 1990; Eysenck, Mogg, May, Richards & Mathews, 1991). Subjects were asked to perform a simple task of writing down words presented auditorily. The words included homophones with two possible interpretations, distinguished by their spelling; one neutral, the other threatening (Die/Dye, Pane/Pain). A positive correlation of 0.6 was observed between trait anxiety and the tendency to interpret the words as threatening (Eysenck, et al., 1987). Macleod (1990) extended these findings by including arousal as a factor and incorporating ambiguous sentences in the stimuli. Mathews et al (Mathews, et al., 1989) found a similar pattern of results in a group of clinically anxious patients.

The current investigation employs ambiguous cues to evoke association. To tackle the problem of frequency as a confounding variable a third group was included in the design. This group included people who are exposed to pain stimuli during most days, and yet do not suffer from pain themselves. Physiotherapists and osteopaths appeared the best choice for this group, as their work often involves pain assessment and they are extremely familiar with pain related descriptions.

In the first stage of the current investigation the associations to ambiguous cues produced by large groups of chronic pain patients, controls, and physiotherapists were compared. If pain patients have come to acquire pain related schemata, these should act to produce biases to pain stimuli. Pain patients should come up with more pain associations to the ambiguous cues than the controls or the physiotherapists, and the amount of pain associations should be predicted by the degree of pain intensity and distress experienced regularly by the subjects.

The second stage of the experiment repeated a trimmed version of the questionnaire on smaller samples, with measures of anxiety and depression included, to investigate the possibility of results depending on mood differences between the groups rather than being an effect of pain. Schema theory has recently emphasised the relationship between disorders and processing biases towards congruent content (Greenberg & Beck, 1989). Based on these theories, we predict a bias towards pain associations in our pain groups, but not in our control groups, and we anticipate that this bias will be related to pain ratings, but not to anxiety and depression scores in the pain group.

The third experiment employed the spelling paradigm used by Eysenck et al (1987). It was predicted that pain patients would interpret ambiguous homophones as negative-health related, in comparison with controls. We attempted to control for differences in awareness of ambiguity between the groups by asking subjects to recall as many ambiguous words as they could. A test of free recall was incorporated to replicate past findings concerning a bias towards health related words in pain patients, and to investigate the relationship between the number of negative-health related interpretations and recall of such material.

Experiment 1: Method

Design and procedure

In an independent group design, 3 groups were presented with a questionnaire; chronic pain patients, non-pain controls, and physiotherapists. The questionnaire consisted of 14 ambiguous cues, which were generated by the pain research team at University College London. (see table 7). These were presented interspersed with neutral cues, to form 28 cues. Subjects were asked to write down the first word that came to their mind when they read the cue word. Two examples were presented: "people usually respond to the word 'table' with the word 'chair', and to the word 'mother' with the words 'father' or 'baby'". Subjects were informed that they should respond with the first word that came to their mind, even if it was unusual. They were told that if they 'blank out' and cannot respond to a cue they should continue to the next, and return to the cue at the end of the list. On the following page pain patients were asked to rate their pain on a scale of 1-100 (Jensen, Karoly & Braver, 1986), at the time of completion and at worst that week.

Subjects

The chronic pain patients were recruited through a self-help pain organization. They were contacted by mail with a covering letter explaining that they were being asked to participate in an experiment concerning health and langauge. 134 out of 200 responded by completing the questionnaire, of which 27 had suffered pain for less than 6 months and were excluded. The remaining 107 subjects consisted of 81 females and 26 males. Information concerning their age and pain history is presented in table 8. 119 control subjects were recruited from evening classes, but 25 of these had a history of pain and were excluded. The remaining 94 subjects consisted of 50 females and 44 males.

The physiotherapists were recruited through Bloomsbury and Islington health authority (see table 8). 13 of the 80 that completed the questionnaires had a history of pain and were excluded. 52 of the remaining 67 physiotherapists were females. All subjects were unaware of the hypothesis under investigation.

Table 7: Interpretation of ambiguous stimuli, experiments 1 & 2: stimuli

Ambiguous cues:	**pain** responses**	**neutral response**
Terminal	Illness, growth	bus, train, airport
Needle	Injection,shot	cotton
Wheel	Chair	car
Plaster	of paris, fracture	walls
Growth	cancer, tumour	children,economy
Wrenching	pain	spanner
Block	nerve	flats,tackle
Back	pain, ache	front
Relief	pain	laugh
Nerve	pain	guts,courage,endings
Bed	ridden	spread
Pound*	pain	coin
Shot*	injection	gun
Attack*	heart	rape,etc.

*Experiment 1 only.
** for scoring purposes

Results and discussion

Each response to the target cues was scored for it's direct relevance to pain and suffering. A conservative scoring was adapted to avoid a possible type II error. Thus the responses 'pain' or 'block' to the cue 'nerve' were accepted, but 'ending' rejected. Similarly 'illness' and 'cancer' were accepted for the cue 'terminal', but 'end' was rejected.

A one way analysis of variance was computed on the proportion of pain related associations from the possible 14 in each group. This revealed significant differences between the groups ($F(2,243)=13.94$, $p<0.001$). Contrast analysis showed no difference between the physiotherapists' response and the control group ($F<1$), but pain patients scored significantly higher than either of the other groups ($F(1,295)=27.88$, $p<0.0001$) (for means and sd see Table 8). Since age differed significantly between the groups ($F(2,261)=69.4$, $p<0.001$), the analysis was repeated with age incorporated as a covariate. Results remain significant ($F(2,260)=10.86$, $p<0.001$). Pain intensity ratings accounted for 11% of the variance in the scores of the pain patients ($F(5,86)=2.22$, $p<0.05$).

The results indicate that pain patients are more likely to respond with pain associations to ambiguous cues than either non-pain controls or physiotherapists. Means and standard deviations were almost identical for the two control groups (table 8), which suggests that the results are not influenced by a frequency effect; if this was the case we would expect a linear relationship between the scores of the three groups, with a larger proportion of pain associations in the physiotherapist group than in the non-pain controls, and a larger proportion still in the chronic pain group.

However, a possible confounding variable, mood, may account for the results. Pain patients consistently score higher on measures of depression and anxiety than non-pain controls. There is some evidence to suggest that pain patients anxiety and depression is specific to their pain disorder, and differs from general anxiety and depression concerns (see chapter 6). However, since there is a large body of evidence suggesting that anxious groups selectively process ambiguous stimuli as threatening (Eysenck, et al., 1987; Eysenck, et al., 1991; MacLeod, 1990), it is possible that pain patients who also suffer from high levels of anxiety are responding to the ambiguous cues as threat related; i.e., that the results are an indication of an anxiety processing bias, and are independent of pain. The experiment was therefore repeated with smaller samples, and measures of anxiety and depression were taken. Three cues, which appeared related more to anxiety than to pain were removed from the study; 'Shot', 'Attack', and 'Pound'.

Table 8: Interpretation, experiment 1; means of scores, age and pain ratings across groups

	Pain group	Physio-therapists	Control group
PPA	20.3% (10.2)	14.1% (9.5)	14.1% (8.4)
Age	53.2 (14.9)	30 (9.3)	38.4 (12.9)
Pain at time	44.7 (30.5)		
Worst Pain that week	68.3 (29.9)		
Pain duration In years	10 (9.9)		

* sd in brackets
**proportion of pain associations

Experiment 2: Method

Design and procedure

In a between groups design, three groups were compared for the amount of pain related associations they produced to ambiguous cues. There were 11 ambiguous cues, presented alternatively with neutral cues, to form 22 trials. These were presented as before in the form of a questionnaire. The Hospital Anxiety and Depression Scale was administered to each subject after their completion of the question, and pain intensity scores were taken for the amount of pain they were in at the time, and at maximum that week.

Subjects

The subjects consisted of three groups:

Group 1: Pain patients: N=47, of which 36 were female. These were patients attending private sessions with osteopaths. They all had pain for more than 6 months, and were all english speakers. The mean rating of pain at the time of completion on a scale of 1-100 was 26 (sd=20), and the mean rating for the worst pain they had experienced all week was 43 (sd=23). The mean length of pain history for the group was 11 years (sd=12).

Group 2: 43 Osteopaths, (29 female) both students and staff at the British School of Osteopathy.

Group 3: 25 Undergraduate students at University College London attending a first year laboratory class (16 female). None had suffered regular pain.

All subjects were told the questionnaire concerned the use of langauge, and were not aware of the hypothesis under investigation.

Results and discussion:

One way analysis of variance was carried on the number of pain related associations produced by each subject in each group. The results revealed a significant difference between the groups ($F(2,118)=10.8$, $p<0.0001$). However, since there was a significant difference between the mean age across the groups ($F(2,112=23.08$, $p<0.0001$), and their scores on depression ($F(2,112)=3.64$, $p<0.05$), these were incorporated as covariates, and the analysis of variance repeated. Results show the pattern of results unchanged ($F(2,110)=7.43$, $p<0.001$). The original mean scores, adjusted mean scores, and means of age, anxiety and depression are presented in table 9.

A-priori contrast analysis, weighted for unequal group size, further revealed that the pain patients produced significantly more pain associations than the osteopaths ($F(1,118)=8.02$, $p<0.01$) and the control group ($F(1,118)=20.35$, $p<0.0001$). The Osteopaths in turn produced significantly more pain associations that the non-pain control group ($F(1,118)=4.49$, $p<0.05$).

In the Osteopaths group, 17 reported that they suffered from regular pain, but sought no medical help for their pain. A further 26 Osteopaths reported no experience of regular pain. Since almost half the osteopaths reported suffering from regular pain, the osteopaths group was further split in half: the mean pain association scores of those who reported pain were 1.33 (after the appropriate transformation), with a standard deviation of 0.43, while the mean for those who did not experience regular pain was 1.296, with a standard deviation of 0.36. The two groups did not differ significantly from each other ($F<1$). Linear contrast analysis was carried out on the four groups,(pain patients, osteopaths with pain, osteopaths without pain, and controls). This revealed a significant trend ($F(1,117)=18.36, p<0.001$). Quadratic and cubic contrasts analysis were not significant ($F<1$).

Results indicate that pain patients interpret ambiguous cues as pain related, and subsequently respond with more pain associations than non-pain patients. There appears to be a frequency effect, in that the two osteopathy groups differed from the non-pain control group. Although half the osteopaths suffered regular pain, they still differed from the pain patients; it is possible that the effect is primarily due to pain intensity, which would suggest that the pain suffering osteopaths suffered less pain than their patients, and therefore produced significantly fewer pain associations from them. However, another explanation derived from schema theory (Beck, Rush, Shaw & Emery, 1979) is that pain patients differ qualitatively from other groups in their self-definition. It is not simply suffering from regular pain that accounts for processing biases, but rather the incorporation of pain related information into one's self-schema. This experiment failed to take measures of pain intensity from the osteopaths, and the comparison between these two explanations cannot be carried out.

Anxiety and depression did not account for the results; it appears clear that the interpretation bias is related to pain, rather than mood disorder. However, there remains the problem of a response bias: pain patients might have guessed the hypothesis under investigation and attempted to respond accordingly. This seems unlikely, both because of the low scores in proportion of pain association in all groups, and because the analysis of fillers (the neutral alternating cues between the ambiguous cues) showed no pain association in any of the groups.

Table 9: Interpretation, experiment 2; mean scores of pain associations, age, anxiety and depression across groups

	pain patients	osteopaths	controls
age	41 (14)	30 (8)	23 (8)
depression	4.82 (3.2)	3.16 (2.8)	3.4 (3.3)
anxiety	8.61 (3.8)	7.32 (3.38)	8.36 (3.36)
PPA**	1.5 (0.42) ***1.55	1.31 (0.38) ***1.29	1.10 (0.35) ***1.09

* sd in brackets

**proportion of pain associations

***adjusted scores with age, anxiety and depression as covariate.

Experiment 3: Method

Subjects

Two groups of 20 subjects participated in the study. The pain group consisted of patients attending the pain clinic at St. Charles hospital, London (55%) female. Inclusion criteria were a history of over 6 months of pain prior to the visit, English as a first language and no history of mental disorder. 60% of these patients had been diagnosed; the most frequent diagnosis was nerve damage as a result of injury or surgery. Other diagnoses included compression of cervical discs, trigeminal neuralgia and frozen shoulder. All pain patients reported pain during participation in the study. Measures of pain at the time and at worst that week on a scale of 1-100 (Jensen, et al., 1986) are presented in table 10.

The control group were volunteers from the community, who had no experience of chronic pain. They were matched as closely as possible with the pain group on measures of age, sex-ratio and verbal intelligence (measured by the Mill-Hill Vocabulary Scale synonym selection test, (Raven, Court & Raven, 1979), as presented in table 10. Analysis of variance applied to this data revealed that the groups did not differ significantly on these measures.

Materials

A list of 9 homophones (see table 11) was assembled, each homophone having both a neutral and a negative health related meaning distinguished by their spelling; these were adapted from previous studies with anxious groups (Mathews, et al., 1989). Each of the interpretations was matched with an unambiguous word for frequency and length. 16 unambiguous fillers were added to this list; 3 of these were placed at the top of the list and three at the end to avoid recency and primacy effects in the recall task. This resulted in a list of 43 words.

Design and procedure

The experiment was carried out in laboratory conditions for both groups. Subjects received the following instructions:

"In this experiment you are going to hear a list of ordinary english words. Each word will be followed by a five second interval for you to write down the word that you have just heard. Please listen carefully and write clearly."

The words were presented auditorily, in 3 different orders, matched across the groups. The orders were randomised by a computer with the restriction that no two ambiguous words will be presented sequentially. On completion of this task subjects were asked to perform a 2 minute distraction task (counting backwards in threes from 600). They were then asked to recall as many words as possible from the lists they heard earlier. Subjects were then asked if they were aware that some words had more then one spelling and meaning, and were asked to recall as many of these as they could. Finally, subjects completed the Hospital Anxiety and Depression Scale, the synonym section of the Mill-Hill vocabulary test and pain rating were given by pain patients.

Table 11: Interpretation of ambiguous homophones: stimuli

Ambiguous homophones:
die/dye
slay/sleigh
moan/mown
groan/grown
pain/pane
weak/week
bury/berry
flu/flew
heal/heel

Neutral controls to pain interpretation:
card
bike
mop
quiz
odd
clock
apple
mint
grind

Neutral controls to non-pain interpretation:
glide
fry
chant
thank
balloon
girl
willow
tube
plot

Fillers:
airport
vase
picture
kettle
party
cloud
play
garden
shop
piano
Primacy and recency controls: fruit door park table pen skirt

Results and discussion

The means of the proportion of pain interpretations of the homophones for each group are presented in table 12. A one way analysis of variance revealed that the pain group interpreted significantly more homophones as pain related ($F(1,38)=24.69$, $p<0.0001$). Since the groups differed significantly in their measures of anxiety and depression (see table 10), these measures were incorporated as covariates and the analysis repeated. The results confirm that the effect is independent of these mood differences ($F(1,36)=9.94$, $p<0.001$). The adjusted means are included in table 12.

Most subjects in both groups reported that they were aware of the ambiguity of some of the words (90% of the pain patients, and 70% of the controls). However, recall of ambiguous words, as an indirect measure of the degree awareness of ambiguity did not differ between the groups ($F<1$), and when incorporated as a covariate in the analysis of variance, the pattern remained significant ($F(1,38)=23.01$, $p<0.0001$). To attempt to control for possible response bias the analysis of variance was repeated on the proportion of pain related interpretations made by each subject minus those recalled as ambiguous (having two meanings). The results remain significant at the $p<0.0001$ level ($F(1,37)=25.93$). Order of presentation had no effect on interpretation ($F(2,37)=1.06$, NS). Measures of pain intensity, both at the time and at worst that week, and pain duration significantly predicted pain patients' interpretation of the homophones as pain related ($F(3,16)=3.96$, $p<0.05$), and accounted for 44.19% of the variance in their scores.

Analysis of variance on subjects scores in the free recall task was carried out after the appropriate transformation (Box-Cox, 1964). Pain patients recalled significantly more pain related homophones than controls ($F(1,38)=3.91, p<0.05$). The only significant predictor of pain patients' proportion of pain related homophones recalled was the maximum pain intensity rating for the previous week ($F(1,118)=5.71$, $p<0.05$) which accounted for 24% of the variance. The proportion of homophones interpreted as pain related did not, however, predict the recall of pain related words: a regression analysis yielded an F value smaller than 1, and accounted for less then 7% of the variance of the recall scores.

The results confirm the prediction that chronic pain patients will impose a negative health related interpretation on ambiguous information. It is also clear that this is not due to emotional state, such as depression or anxiety; although pain patients score higher on these measures than controls, they do not reveal the correlation found in anxious groups between anxiety and interpretation of ambiguous words as threatening. The significant predictor of the proportion of negative health related interpretations in the current study was the amount of pain patients were in at the time.

The paradigm can be criticised for its failure to account for response bias. It is possible that all subjects perceive both interpretations, but that pain patients actively select pain related interpretations while controls select a more neutral interpretation whenever possible. Indeed, in this study most subjects in both groups reported that they were aware of the fact that some words had more than one interpretation. Recall of the ambiguous words did not differ between the groups; this appears to indicate that it was not the degree of awareness of ambiguity that differed between groups, but rather their choice of interpretation at the point where both options are available. An attempt to control for this was carried out repeating the analysis on data minus the ambiguous words recalled; this did not affect the pattern of results. However, even if results are viewed primarily as a response bias, and as a volitional act on the part of pain patients, rather then an automatic processing bias, they still present a picture which has clinical implications. The matter needs clarifying using improved methodology: Recent research in the field of anxiety has refined the paradigm to include a modified lexical decision task (Macleod and Curtis, in preparation) which allows control for response bias.

A further criticism concerns the possibility of a frequency bias, where pain patients are exposed to negative health words more often than controls, and therefore acquire a reduced threshold for these words. However, results from experiments 1 and 2 suggest that although a frequency effect might account for some of the variance in the results, the bias is primarily independent of frequency, and related rather to the implications of the information. Furthermore, a recent study investigating the effect of frequency on the processing of pain information by pain patients, employing a lexical decision task, shows no evidence for a frequency effect (Edwards and Pearce, in preparation).

Results also confirmed past findings of a recall bias for negative health words in pain groups, but failed to show a relationship between these two processing biases; the prediction that higher scores on interpretation of ambiguous words as negative health related would be positively related to recall bias for such materials was not confirmed. It appears that although pain patients on the whole exhibit information processing biases towards pain related material, different patients reveal different biases, and these are quite independent from each other. The implications of this finding suggest that schema theory, as described by Beck (Beck, et al., 1985) will need extending. However, developments of this theory have already suggested that different mechanisms may lie behind different information processing biases, and that the existence of a particular bias in any group does not necessary mean that the same group will exhibit other biases (Williams, et al., 1988). It is one step further to suggest that even when several biases are exhibited within a group, they may be quite independent of each other. As outlined in the preceding chapters, priming (integration) and elaboration may results in different biases in the same group. It is not clear whether interpretation of ambiguous stimuli falls in to integration or elaboration: there is evidence to suggest that anxious groups, who are associated with biases in integration, exhibit interpretation bias towards threat related words. On the other hand, pain patients, who have shown little evidence to suggest priming biases appear to exhibit marked interpretation bias towards pain related information. The interpretation of ambiguous stimuli may include elements of both priming and elaboration; alternatively, theories may need extending to account for interpretation as a special case of processing.

In summary, pain patients appear to selectively respond to ambiguous stimuli as pain related. The psychological implications of such a bias would be to increase awareness of pain, and therefore maintain distress. A further leap, which can not be concluded from this evidence would suggest that this bias may be an indication of a sensory processing bias, in which mild sensations, or ambiguous sensation are interpreted as painful (Pennebaker, 1982). The next stage in the investigation of information processing biases in pain should research the effect of such biases on prognosis and test the efficacy of psychological interventions in reducing such biases.

Table 10: Interpretation of ambiguous homophones: means of age, Mill-Hill, mood and pain ratings across groups.

	Pain patients	Control subjects	F (df=1,38)	p
Age	47.6 (11.12)	48.7 (10.26)	<1	NS
Mill-Hill	31. 9 (4.63)	33.85 (3.73)	<1	NS
Depression	8.55 (3.86)	2.7 (2.2)	25.23	<0.001
Anxiety	11.85 (4.97)	5.1 (3.39)	34.66	<0.001
Pain Now	52.89 (20.3)			
Worst Pain	75.74 (14.84)			
Pain duration	4.47 (2.12)			

* Sd in brackets

Table 12: Interpretation of ambiguous homophones: means of proportion of pain related interpretation across groups:

	pain group	control group
Mean of PRI	78.35 (14.42)	59.1 (9.61)
Adjusted with anxiety and depression as covariates	77.65	59.8

*PRI= proportion of pain related interpretations

*Sd in brackets

Chapter 4: Memory bias for self-referential pain stimuli in pain patients

Abstract

The effect of self-reference on recall bias for pain stimuli was compared in chronic pain patients and controls. Subjects were tested in two conditions. The first condition (self-referential) involved encoding a list of words constructed from sensory pain, affective and neutral words. Elaboration at the encoding stage was achieved by asking subjects to imagine <u>themselves</u> in situations involving these words. Subjects were also asked to rate the likelihood of these situations occurring on a scale of one to five (from 'will not happen' to 'certain to happen'). The second condition (other-person reference) repeated this task in reference to another person with a matched list of words. A 2x2x3 factorial analysis of variance (Group x Reference (self and other) x Word type (sensory, affective and neutral) was carried out on recall scores, with the likelihood ratings as a covariate. Results reveal a significant three way interaction; while pain patients show an increase in recall of sensory words and a decrease in recall of neutral words when these are encoded in reference to themselves, control subjects show no difference in recall of these word types regardless of the encoding condition. The results support the notion that pain patients selectively recall more pain associated words in comparison with other word types. However, this effect is only true for stimuli encoded in reference to themselves.

Introduction

Chapters two and three investigated early stages in information processing, and suggested that although an interpretation bias towards pain stimuli are indicated in pain patients, it is unlikely that they selectively attend to such stimuli. This chapter aims to investigate processing that is associated with elaboration; described as slower and more strategic (Williams, et al., 1988), and tested through tasks involving recall. Specifically, this study aims to extend past findings of a recall bias towards pain stimuli in pain patients by manipulating the encoding reference. The question under consideration is therefore: do pain patients process information that has been associated with themselves differently than information associated with others?

The notion of the self as a separate structure of knowledge stored in long term memory, which interacts with incoming information and subsequently affects recall, was suggested by Rogers, Kuiper and Kirker (Rogers, et al., 1977). They demonstrated that recall for material encoded in a self-referential condition is superior to material encoded in reference to others. The authors assumed that the enhancement in memory performance in the self-referential condition was due to an elaboration procedure occurring at the time of encoding, via activation of a specific structure, the 'self-schema'. Although there is no evidence to support the idea of the self-schema as a separate cognitive structure, it is now clear that information can be processed selectively when it is encoded or retrieved in reference to the self. Evidence also suggests that patients with emotional disorders that are associated with a negative self-image exhibit information processing biases towards related negative information.

Evidence for negative information processing biases in depressed patients emerged from the work of Derry and Kuiper (Derry, et al., 1981). In a comparison between patients diagnosed as clinically depressed, patients diagnosed as non-depressed but with other psychiatric disorder, and subjects who were neither depressed or psychiatric, Derry and Kuiper tested the hypothesis that there would be selective processing of negative material in depressed patients. All three groups were presented with a task which involved encoding lists of words under three conditions: making physical/structural decisions about the word, eg. upper, lower case (small letters?), making semantic decisions (means the same as xxx?) and self-referential (describes you?) decisions. The material consisted of adjectives which had either a negative-depressed connotation, or adjectives with a neutral emotional connotation. On a subsequent free recall task, depressed patients demonstrated enhanced recall for depressed words, while non-depressed subjects showed selective recall for non-depressed material, but only for words which had been encoded in the self-referential condition.

Similarly, Mathews and Bradley (Mathews, et al., 1983) found that depressed patients demonstrated a recall bias for negative words only in a self-referential encoding condition (describes you?), but not in the other-person referential condition (describes your best friend?). Although some authors are careful to point out that this data does not necessarily constitute evidence for the self-schema concept, and could be attributed also to encoding or retrieval strategies (Williams, et al., 1988), it is clear that depressed groups process information differently when relating it to themselves.

The idea that consistent biases for negative information associated with the self could act to maintain and exacerbate emotional disorders, has implications for the understanding of pain patients: it is possible that chronic pain patients could have acquired a tendency to selectively process negative, pain associated material, through repeated exposure to pain. Such processing would include close monitoring of physical sensations coupled with a tendency to label physical sensations as painful, and a sense of vulnerability and dependence. In this study it is hypothesised that chronic pain patients will selectively process pain-associated material, resulting in recall bias for such stimuli. Hypotheses based on the theory of self-schema predict not only a recall bias for material encoded in self-referential conditions, but specifically state that congruence between the content of the self-schema and the incoming information should result in enhanced recall for this material (Williams et al., 1988). This content-specific hypothesis would lead to the prediction of a recall bias for pain associated stimuli in comparison with stimuli with no pain association in chronic pain patients, when they were encoding information in reference to themselves. However, the same pain associated stimuli should not be recalled any better than non-pain stimuli when encoded in reference to others. A non-pain control group should not show a recall for pain stimuli in either of the encoding conditions.

Previous investigations (Edwards, et al., 1992; Pearce, et al., 1990) have demonstrated that chronic pain patients show a bias towards pain associated material in general. These authors have argued that this can be seen as evidence for the involvement of a pain schema in the selective processing of pain associated information. The current experiment sets out to investigate the hypothesis that selective recall in pain patients does not include all pain associated information, but rather pain associated information encoded in reference to themselves only. It is therefore the self-concept of pain patients, and particularly the concept of themselves as pain patients that is responsible for a bias in recall for pain associated information.

The current investigation was based on the work of Mathews and Bradley (1983), although certain aspects of their methodology had to be altered, due to the differences in the materials presented. Pain associated stimuli are usually derived from the McGill Pain Questionnaire (Melzack, 1975), which consists of a list of adjectives and verbs describing pain sensations and associated affect. The prompt 'describes you?', which has been used to form a self-referential encoding condition is not appropriate for much of the pain stimuli, which describes the pain, not the person experiencing it (for example evaluating the words 'punishing', 'gruelling' and 'pricking' in response to the prompt 'describes you?' acquires a meaning that differs from the original concept). We preferred to use stimuli that have previously been shown to produce a recall bias in pain patients (Edwards et al., 1992) and change the cue question, rather than presenting the cue question and changing the stimuli. Therefore, the encoding procedure consisted of the instruction 'imagine yourself in a situation in which something or someone is...'which enables the original concept of the pain stimuli to be maintained and elaborated in reference to the self.

The other-person encoding condition involved further difficulties. First, the use of the best friend, as employed in previous research (Mathews & Bradley, 1983; Greenberg & Alloy, 1989) would result in a difficulty in relation to the stimuli. Negative affect words are easily related to any person, who might experience negative mood states at some point in time. However, pain associated words are quite clearly associated only with certain specific situations. Furthermore, the most common situation involving pain material that a healthy 'best friend' would be involved in, is probably in relation to the pain patients themselves. This would confound the results by effectively creating a self-reference in the so called 'other-person' referential condition. To overcome this complication we decided to use a fictional character who is likely to be in situations which involve pain, with whom the patients were very familiar. Therefore we instructed patients to select a medical character from their favourite television programme.

Finally, instead of the 'yes/no' response during encoding, in answer to the probe 'describes you?' subjects were asked to rate the likelihood of each situation occurring. These ratings were then used as a covariate in an analysis of covariance in order to eliminate the possibility of a self-referential bias for pain words in the pain group being due to their perception of the enhanced likelihood of being in situations involving these pain words.

Method

Design

A three way factorial design was used, with one between group factor (pain group and control group) and two within group factors; reference (self and other) and word type (sensory, affective and neutral). Subjects completed 24 trials in each referential condition, with 6 words in each word-type condition, in a random order, with the limitation that the same word type would not appear twice in succession. To these were added 3 neutral adjectives at the beginning and at the end of each reference condition to control for primacy and recency effects (see Edwards et al., 1992). Subjects were told the experiment involved a memory task, and were asked to recall as many adjectives as they could after each referential condition. To control for any possible changes in encoding strategy after the first condition, the order of the conditions was randomised across subjects.

The recognition test consisted of half the words presented in each referential condition (i.e., three of each word type per condition) together with an equal number of previously unseen words of each word type (making up 24 possible targets, and 24 possible distractors). It was presented after a two minute filler task following the free recall of the second encoding condition.

Subjects

21 pain patients attending the rheumatology clinic at the Whittington Hospital were compared with 21 non-pain subjects, recruited through a local community centre. Subjects were measured for the average daily amount of time they spent watching television (mean for pain patients 3.2 hours, mean for controls 2.4 hours). Sex ratio was matched between the groups, with 8 men and 13 women in each group. The age range in the pain group was 27-67, and in the controls 20-69. Mean age and scores on the Beck Depression Inventory are presented in table 13. All subjects spoke English as their first language, and none had a history of mental illness. All pain patients had suffered pain for at least 6 months, with a mean of 4.1 years (sd=9.1) pain duration across the group. The mean score for the intensity of the pain at the time of completing the experiment was 29 out of 100 (sd=9.3), and the mean for the worst pain they had suffered all week was 53 out of 100 (sd=14.6). At the time of completion four of the pain patients reported no pain on a scale of 1-100, where 1 is defined as no pain and 100 is described as the worst possible imaginable pain (Jensen et al., 1986).

Table 13: Self referential recall: mean age and BDI scores for each group

	Pain patients	control group	F	p
Mean age	43.9 (12.33)	50.7 (15.97)	2.39	0.13
BDI	6.19 (5.38)	7.95 (6.85)	F<1	ns

* Sd in brackets

Materials

The list of words presented in each condition is presented in table 14. The words are identical to those used by Edwards et al., (1992), with sensory and affective words taken from the McGill Pain Questionnaire, and neutral words matched as closely as possible for word frequency.

Table 14: self referential recall: stimuli

Self-reference condition:

Sensory: Scalding / Stabbing / Pressing / Pounding
Tender / Pricking /

Affective: Unbearable / Discomforting / Horrible /
Fearful / Cruel / Punishing

Neutral: Windswept / Imprecise / Amazing / Educated
Polished / Straight

Other person reference:

Sensory: Pinching / Throbbing / Crushing
Tugging / Hurting / Tingling

Affective: Gruelling / Miserable / Distressing
Troublesome / Terrifying / Vicious

Neutral: Selective / Legal / Leaking
Promising / Quiet / Regular

Fillers: Careful / Marked / Interesting / Original / Modern / Popular
Flexible / Colourful / Wooden / Powerful / Useful / Short

Procedure

All subjects were told that the experiment concerned language and self-image, and would involve a memory task. Subjects were presented with a booklet, with the following instructions on the front page:

"In the pages ahead you will be asked to imagine yourself in situations involving certain words. For example, a situation where something or someone is short. Then you will be asked to rate how likely this is to happen. There are no right or wrong answers. You do not have to write anything down, just circle the description that says how likely it is that this situation will happen."

Each word was cued with the instruction: ***"Imagine yourself in a situation in which something, or someone is***": (target word). Subjects were asked to rate the likelihood of this situation happening using the following scale: will not happen/ unlikely/ possible/ likely/ certain to happen. Subjects were asked to make sure they have a good picture in their mind for every word, and include themselves in each situation.

For the other-person reference subjects selected a character of a doctor or nurse from their favourite television programme. Instructions were identical to those above, replacing the word 'yourself' with the term 'your chosen character'. Subjects were asked to imagine their character in a situation involving a matched set of words, and to rate the likelihood of these situations happening. They were told that the situations they imagined could be inside or outside of the surgery, and could involve situations they remember as well as those they made up.

After completing each booklet subjects were asked to recall as many words as they could, and on completion of the second booklet a recognition test was administered. This involved the presentation of a list of words (see design section for details) in random order, with each word followed by the words 'yes' and 'no'. Subjects were asked to indicate whether they had seen each word previously in either of the booklets by circling the yes/ no responses. This was followed by completion of the Beck Depression Inventory and the McGill Pain questionnaire. Finally subjects received an explanation of the aims of the research.

Results

To reduce positive skew evident in the raw recall scores and to stabilize the variances a square root transformation of the data was carried out prior to analysis (Winer 1962). A 2x2x3 analysis of variance was performed on the data with group (pain patients/controls) as a between subjects factor, and reference category (self/other) and word type (sensory/affective/neutral) as within subject factors. The means and standard deviations for the transformed data are presented in table 15.

Table 15: self referential recall: mean recall of word type in each reference condition across both groups.

reference	word type	pain patients	control group
self	sensory	1.418 (0.511)	1.498 (0.516)
	affect	1.276 (0.462)	1.598 (0.378)
	neutral	1.250 (0.482)	1.627 (0.492)
other	sensory	1.172 (0.363)	1.493 (0.362)
	affect	1.127 (0.436)	1.315 (0.396)
	neutral	1.586 (0.427)	1.725 (0.499)

*Sd in brackets

The analysis revealed an overall group effect ($F(1,40)=6.99$, $p=0.01$) indicating that non-pain subjects recalled more words then pain patients. The main effect of self/other reference was not significant ($F(1,40)=1.17$, $p=0.28$), while the main effect for word type showed a significant difference between sensory, neutral and affective words for both groups ($F(2,80)=5.97$, $p=0.03$). The interaction between type of word and reference was significant ($F(2,80)=8.81$, $p=0.003$). However, this two way interaction must be interpreted with caution as the three way interaction approached significance ($F(2,80)=2.70$, $p=0.07$).

Since pain patients are more likely to be in situations involving pain, the scores on the likelihood of the imagined situations happening (in the form of likelihood ratings on a scale of 1 to 5) were incorporated as covariates (Mathews & Bradley 1983), and the analysis of variance on transformed recall data repeated. With likelihood ratings as a covariate, the general pattern of results remained the same; a main group effect ($F(1,39)=9.6$, $p=0.003$), a main word type effect ($F(2,79)=4.96$, $p=0.0119$), but no self/other reference effect. However, the three way interaction between group, reference and word type was now significant ($F(2,79)=3.2$, $p=0.045$).

To clarify the differences between the groups in the three way interaction, contrast analysis was carried out on individual means. These contrasts test the hypothesis that self-other differences exist for pain words in the pain group, but not in the control group. Results indicate that while pain patients recall significantly more sensory words in self reference than in other person reference ($F(1,118)=5.61$, $p=0.019$), there was no such difference in the control group ($F<1$). Similarly, while pain patients recalled significantly less neutral words in self reference in comparison with other person reference ($F(1,118)=10.41$, $p=0.001$), the control group showed no difference between recall in the two referential conditions ($F<1$). Thus, pain patients alone significantly differ in their processing of sensory and neutral information, depending on whether they have encoded the information in reference to themselves or in reference to others.

Further analysis revealed that while control subjects show a significant difference in recall of affective words, depending on the encoding reference ($F(1,118)=7.37$, $p=0.007$), pain patients do not differ in their recall of affective words regardless of the encoding reference ($F(1,118)=2.06$, $p=0.153$). However, the analysis of the recall of affective words must be treated with caution, because of the presence of possible confounding variables, as noted in the discussion section.

In order to analyze the results from the recognition test, a measure of sensitivity (d') and bias (beta) were derived for each subject (McNicol, 1972). The pattern of results was the same for both measures: there was no main group effect ($F<1$), but a significant effect of self/other reference ($F(1,39)=16.04$, $p=0.0003$ for d', and $F(1,39)=7.90$, $p=0.007$ for beta scores) showing both better recognition memory and a shift in response criterion for the self referential condition. Both groups also showed better memory and a response bias towards sensory words ($F(2,76)=2.78$, $p=0.001$ for d', and $F(2,78)=4.84$, $p=0.01$ for beta), in comparison with neutral and affective words. However, the three way interaction (group by reference by type of word) both for d' and beta scores was not significant ($F<1$).

Discussion

The results of this study confirm the hypothesis that pain patients show different patterns of recall of pain related material encoded in reference to the self and to others, than do non-pain control subjects. Pain patients recall more sensory pain descriptors encoded in reference to themselves compared with sensory words encoded in reference to others, while control subjects show no such difference in recall of pain words. The possible explanation of these findings in terms of a frequency effect reflecting pain patients greater exposure to pain material is unlikely since the patterns of recall of the same material across the two referential conditions are different. self-schema theory (Beck & Clark, 1988) suggests that, rather than an elaborated pain associated schema operating to produce a recall bias for pain associated material in general, it is only in reference to the self that this bias takes place in pain patients. Knowledge about the self in pain patients, possibly in the form of a self-schema, might therefore contain highly elaborated concepts and propositions concerning pain. However, the results cannot be interpreted as evidence supporting the concept of self-schema, and other explanations, such as encoding and retrieval strategies could also account for the results.

The other-person condition was designed to control for pain patients high probability of being in pain associated situations, by selecting a doctor as the imagined character. Most of the imagined situations for this character in both groups were highly likely to have pain associated material incorporated in them. However, analysis showed that the pain patients recall significantly fewer sensory words in this condition than those recalled in reference to themselves. It appears that pain patients show opposite trends in recall of sensory and neutral words between the referential conditions.

The implications of these findings for the experience of pain are not clear: some models of pain processing (Leventhal, et al., 1979) would hypothesise that selectivity in attention and recall acts to reinforce and strengthen pain schema, which results in the selectively processing of congruent features in incoming information. This pattern takes place at a preconscious level of processing, and there is an interaction with sensory information to produce somatization and the misinterpretation of mild body sensation as painful. The implications of this bias in clinical terms, might be the enhancement of emotional distress and anxiety, which could encourage pain behaviour and place further limitations on the quality of the life of pain patients. Further research is needed to discover whether these processing biases can be affected by cognitive-behavioral therapy. It is most likely that improvement depends on the extent to which pain associated concepts are incorporated into the individual's self-schema, and their motivation to change.

Some discussion is needed concerning the limitations of this investigation. This experiment did not control for time exposure differences, and if pain patients spent more time processing pain words, this could have led to deeper encoding and easier subsequent retrieval. Reaction time, similarly, was not measured. Schema theory hypothesises that reaction time to schema congruent information will be faster, but evidence is as yet ambiguous: Mathews and Bradley (1983) failed to find significant differences in reaction time to negative and neutral stimuli between depressed and control subjects, although the depressed group showed a significant recall bias for the negative stimuli. Greenberg and Alloy (1989), on the other hand, found significant differences in patterns of reaction time to depression associated, neutral, and anxiety associated material between depressed groups, anxious groups and controls. The task on both experiments involved pressing a button to indicate positive and negative responses to the cue question 'describes you?' followed by an adjective. However, the results from the Greenberg and Alloy investigation (1989) suggest that schema congruent information results in shorter reaction time, and can be taken as evidence against a positive correlation between processing time and recall. Mathews and Bradley, in any case, state firmly that their evidence does not support the hypothesis that depressed groups would be relatively faster than controls in making confirmatory decisions concerning self-referent negative material. Similarly, there is no theoretical reason to believe that reaction time to such stimuli in these groups would be significantly slower. The relationship between reaction time to schema congruent material and recall of such information has yet to be clarified.

Further problems arise in the interpretation of the affective word category. It is not clear that these words are interpreted similarly by both groups, as the words may have pain associations for the pain group, but not for the control group. Future work should be careful to distinguish between depression related stimuli and affective pain-distress stimuli. The results obtained in this study suggest that the affective word category was salient to control subjects, but not to pain patients, since they recalled significantly more affective words in the self-referential encoded condition. However, taking into account the shortcomings outlined above, these results must be viewed with caution.

In summary, our findings suggest that pain patients show a recall bias towards pain associated information which has been encoded in reference to themselves. They do not show this bias in their recall of information encoded in reference to other people, even when these are imagined in circumstances that are likely to evoke pain associations. Whether or not these results are interpreted as evidence for self-schema in pain patients, or are explained in terms of attention and resource allocation or as a result of search and retrieval strategies, they have important implications for therapeutic interventions. The investigation of the effect of changes in self-image and coping strategies on information processing biases in pain patients would be the next step forward from these findings. In addition, further investigations of biases for pain stimuli in other types of recall, such as cued recall and implicit memory are needed to achieve a full picture of selective recall in pain patients.

Chapter 5: Implicit memory and cued recall of pain stimuli in pain patients

Abstract

Pain patients and control subjects were tested on their implicit memory and cued recall of neutral, positive, affective and sensory words. The encoding stage consisted of an imagery task, followed by pleasantness ratings of the imagined scenes. The two tests, both consisting of three letter stem completions, were presented in counter balanced order. In the implicit memory task subjects were asked to complete the stems with the first word that came to their mind. In the cued recall task they were required to complete the stems with words they had seen in the encoding stage. Results revealed no differences between the groups on either of the memory tasks, although pain patients rated sensory and neutral words less pleasant than control subjects at the encoding stage. It is argued that these results represent further evidence that pain patients do not exhibit processing biases in processes associated with priming.

Introduction

The following experiment is aimed at clarifying the question of integration and elaboration processing in pain patients by comparing explicit and implicit memory for pain related stimuli. Implicit memory is defined as 'memory for information that was acquired during a specific episode and that is expressed on tests in which subjects are not required, and are frequently unable to deliberately or consciously recollect the previous studied information or episode itself (Schachter, 1990a, p338). Explicit memory, on the other hand, involved strategic, conscious effort to retrieve learned information. Explicit memory can be tested using tasks such as free recall, recognition and cued recall, while implicit memory is tested using tasks such as fragment completion (E_e_h_nt for elephant), and stem completion (Ele_____ for elephant), accompanied by instructions to complete the word with the first word that comes to mind. Implicit memory is also tested by perceptual identification, where material is presented visually for very short durations, e.g., 30ms. Specifically, the difference between the tasks lies in the conscious attempt to retrieve previously encoded data in explicit tasks, while no such attempt is required in implicit tasks.

A distinction between implicit memory biases and explicit memory biases has been observed repeatedly in various populations. Evidence has accumulated both in normal groups, where encoding and retrieval have been manipulated, and in clinical groups, consisting mainly of amnesic patients. For example, manipulations that increase memory in explicit tasks, such as providing semantic cues, have shown no effect on implicit tasks involving the same information (Graf, et al., 1984; Mandler, Graf &

Kraft, 1986). Similarly presenting interfering lists between encoding and retrieval has been shown to effect only explicit recall (Graf & Schachter, 1987). Implicit memory appears to be unaffected by other variables that have been shown to affect explicit recall, such as age (Graf, 1990) and alcohol (Hashtroudi, Parker, DeLisi, Wyatt & Mutter, 1984). The evidence accumulated in amnesic groups is equally impressive, and is reviewed in Shimamura, (Shimamura, 1986): for example, Jacoby and Witherspoon (Jacoby, et al., 1982) tested a group of amnesic patients using ambiguous homophones, and found that subjects tended to interpret the stimuli in line with exposure to words during encoding although they had no recall of such exposure.

Two theories have attempted to account for the distinction between implicit and explicit memory: one is based around the idea of modularity, or distinct brain systems (Schachter, 1989), while the other focuses on differences in cognitive processing (Roediger III, 1990; Roediger III & Blaxton, 1987; Roediger III, Srinivas & Weldon, 1989; Mandler, 1980).

The idea of distinct brain systems for explicit and implicit memory is based on the findings in amnesic patients, and disassociation in normal populations. Brain damage has been shown to selectively affect memory: thus, for example, declarative memory systems (responsible for verbalised knowledge) can fail where procedural memory systems (responsible for skilled behaviour which does not necessitate conscious control) continue to operate. The neurological approach (Squire, 1987) places the declarative system in the limbic system and holds it responsible for explicit memory. The procedural system, on the other hand, is responsible for priming, motor skills, classical conditioning and implicit memory.

In contrast, the non-modular view argues that the dissociation between implicit and explicit memory reflects the different cognitive procedures required by the tests. The transfer-appropriate procedures approach (Roediger III, 1990) is based on the principal that congruence between cognitive operations at encoding and retrieval positively effect the latter. Implicit and explicit memory tasks require different retrieval operations, and therefore benefit from different types of processing during encoding. Explicit tasks are sensitive to conceptual elaboration while implicit memory tasks are sensitive to perceptual surface features. Some evidence has been found to support this hypothesis (Blaxton, 1989); by crossing encoding and retrieval in a 2x2 factorial design, thus splitting both the encoding and the recall tests into conceptually and data-driven. The results indeed show a beneficial relationship between congruent encoding and recall tasks. However, the evidence from amnesic patients seems to contradict this hypothesis, as they appear to preserve priming (implicit memory) on tasks involving conceptual (elaborated) encoding (Graf, et al., 1984).

An attempt to combine the two approaches has been made by Tulving and Schachter (Tulving & Schachter, 1990), by incorporating transfer-appropriate processing into several memory systems. However, the compromise may compromise parsimony; Roediger (Roediger III, 1990) points out that three separate memory systems are now required to account for priming effects alone.

A version of the non-modular approach is generally proposed as the theoretical background for the findings concerning implicit and explicit memory biases in emotional disorders. Most commonly, this involves the distinction between internal schematic activation (integration or priming) which results in automatic accessibility of certain types of stimuli, and activation between different schematic structures (elaboration) which results in better recall due to better retrieval cues (Mandler, 1980; Graf, et al., 1987).

The need for the adjustment in the non-modular approach stems from the discrepancy between the evidence found in anxious and depressed groups and the transfer-specific theory. Anxious groups have been found to exhibit implicit memory biases towards threat related information, but show no explicit memory biases towards the same stimuli even when they are specifically encoded using elaborative procedures, such as self-referenced imagery (Mathews, Mogg, May & Eysenck, 1989;Mogg, et al., 1987). The results are interpreted by Mathews et al as suggesting that anxious subjects' processing biases result from integration processing, but not elaboration processing. In fact, one of the studies reported significantly **lower** scores for explicit recall of threat stimuli in a group of anxious subjects compared to control subjects. The authors reason that a cognitive defence mechanism is employed in anxious subjects, that acts to repress elaboration on anxiety related material (Mogg, et al., 1987). A further puzzle for the transfer-specific approach emerged from the work of Richard and French (Richards & French, 1991), who manipulated encoding in high and low anxiety students. The encoding involved either simple reading or self-referenced imagery of threat and neutral words, and subjects were tested both on implicit and explicit memory. The explicit memory test showed no difference between the groups, regardless of the encoding strategy. However, the implicit memory task showed a cross-over effect, in which high anxiety subjects showed an implicit memory bias towards threat words only if they were encoded using self-referenced imagery, while low anxiety subjects showed a similar bias, but only on the reading encoding condition.

A different pattern of results has recently emerged from studies on depressed patients. It has long been established that depressed groups show a marked memory bias towards negative information, and that this bias is further affected by self-reference at the encoding stage (Mathews, et al., 1983; Williams, et al., 1988; Greenberg, et al., 1989).

In a direct comparison between the performance of depressed subjects in explicit memory tasks and implicit memory tasks, Denny and Hunt (Denny & Hunt, 1992) found a bias towards depression related words on a free recall task compared to a control group, but no differences emerged between the groups on a fragment completion task. Hertel and Hardin (Hertel & Hardin, 1990) found no effect of mood state on homophone spelling, although depressed subjects recognised more negative valanced words. Similar results were obtained by Watkins et al (Watkins, Mathews, Williamson & Fuller, 1992) using cued recall as the explicit memory task. The latter is considered as being powerful evidence for a lack of an implicit bias towards negative information in depressed groups even when an explicit bias has been demonstrated, because the methodology employs the same cues for both tests, with the instructions alone varied. Although there has been some contradictory evidence (Elliot & Greene, 1992) in which both implicit and explicit biases towards negative stimuli have been produced in depressed groups, Roediger and McDermott (Roediger III, 1990) consider that 'the consistent results from the other experiments showing intact priming in depression more likely depict the true state of affairs' (pp589).

It is generally argued that depressed patients score more poorly on explicit memory tasks than controls because they have fewer cognitive resources available for processing non-congruent information (Williams, et al., 1988). Similarly, it can be argued that pain patients concentrate processing resources towards pain related stimuli, resulting in an explicit memory bias towards pain stimuli. Such a bias has been recorded in various studies (Pearce, et al., 1990; Edwards, et al., 1992; Pincus, Pearce, McLelland & Turner-Stokes, In press). This explicit bias is considered to be a result of elaborative processing; studies that have investigated integration (priming) of pain stimuli in pain patients have not demonstrated a similar bias (Moses, unpublished MSc thesis,1988, Pincus, unpublished Msc thesis, 1988). A review of this area is presented in chapter two of this thesis. Implicit memory is hypothesised to be affected by integrative processing; therefore, in the following experiment it is predicted that pain patients will not differ from the control group in their scores on the implicit memory task, regardless of the content of the stimuli. Thus pain patients and control will complete equal numbers of sensory and affective words, when asked to complete stem-words with the first word that comes to their mind. However, in the explicit memory task, when asked to complete word-stems with words seen during encoding, pain patients are predicted to complete more sensory and affective words, in comparison with control subjects.

Method

Design

Two groups of subjects (24 pain patients and 24 control subjects) were presented with a list of sensory, affective, positive and neutral adjectives, and were required to perform a self-referential encoding task. They then completed a cued recall and word completion task, given in counter-balanced order across subjects. Two tasks were carried out (representing two dependent variables), testing explicit and implicit memory for the encoded stimuli. The design for each task was a factorial 2x4 (group by wordtype) mixed design, where group and wordtype represent the independent variables. The design controls for response bias (in which pain patients complete more pain words regardless of previous exposure) by presenting to each subject a list of previously unseen three-letter stems combined with the target stems (Mathews, et al., 1989).

Subjects

The pain group consisted of 24 chronic pain patients, recruited at the pain clinic at St. Charles Hospital. All subjects had suffered from pain for more than 6 months. Their mean pain intensity rating for the worst pain they had all week on a scale of 1-100 (Jensen, et al., 1986) was 73, with a standard deviation of 17.

The control group (n=24) consisted of volunteers from the general public, recruited through advertisements. The groups were matched for age (mean=44.08, sd=10.35 for pain group, mean=39.83, sd=13.7 for control group, $F(1,46)=1.47$, $p=0.23$) and sex (m=9, f=15). All were fluent English speakers and none had a history of mental illness.

Materials

Stimulus words and order design:

15 sensory and 15 affective words were extracted from the McGill Pain Questionnaire (Melzack, 1975). A further 15 positive words and neutral words were taken from previous studies carried out on anxious groups (Mathews, et al., 1989). Thus a pool of 60 words was constructed, with frequency balanced across the wordtypes (see table 16). Each of the 60 words had a unique three-letter stem. In addition, for each word there was at least one other word (not presented to subjects) which had the same three-letter stem and a higher frequency score than the stimulus word.

The words were then divided into 3 sets, each comprising 5 of each wordtype (lists A,B and C). The lists were matched for word length and word frequency. According to precedents (Mathews, et al., 1989), subjects within the groups were divided into three. In the encoding stage each sub-group was presented with one of the three possible combinations of two of the lists (i.e., A+B, B+C AND C+A). In the memory testing stage, half of these sub-groups received the word completion task first and the other half received the cued recall task first. Of these, half the subjects received one of the combined list that was presented in the encoding stage (ie, list A of combined list A+B), and the other subjects were presented with the remaining list (ie, list B of combined lists A+B). The order was therefore balanced within each of the groups and across groups. For example, a subject might have been presented with words from the combined lists of A and B in the encoding stage. They would have then been tested in the cued recall task for either list A or list B, and in the word completion task they would have been presented with word stems from lists A and C (if previously tested on list B) or B and C (if previously tested on list A).

Memory tests:

Three versions of each memory test were prepared using the three lists (A,B and C). Each version of the cued recall task consisted of the three-letter stems of the 15 words from **one** of the lists. The stems were printed in a pre-randomised, fixed order, with the constraint that no two words from one wordtype appeared in succession. In the word completion task, word stems from **two** of the lists (one seen previously, the other unseen) were combined in a pre-randomised, fixed order, with the same constraint as above.

Procedure

Encoding task: Subjects were presented with two sets of the stimuli (i.e., A and B). The words were presented on the screen of a Toshiba portable computer, in a pre-randomised fixed order, with the constraint that no two words of one wordtype would appear in succession. Subjects were told the task concerned their imagination and that words would be presented one by one on the screen. For each word they were asked to imagine themselves in a scene involving the word. As soon as they had imagined the scene, they were to press the space bar. A message then appeared on the screen instructing them to continue to imagine the scene for a further 8 seconds. They were then asked to score each word for pleasantness, by adjusting the position of a horizontal line between the words pleasant and unpleasant (Mathews, et al., 1989). Six neutral words were presented in a practice session, to ensure that subjects understood the task, followed by a further 3 fillers, and the 40 target words, made of a combination of two of the stimuli lists. Three neutral fillers were added at the end of these, to avoid a recency effect.

Memory tests: Following the encoding task, subjects performed a distractor task for two minutes, by counting backwards in threes from 3000. Subjects then carried out either the cued recall task followed by the word completion task, or vice versa, according to the balanced design. In the cued recall task subjects were instructed to complete the stems with words they had seen previously in the encoding stage. They were given 5 minutes to complete this task. In the word completion task subjects were asked to complete each stems with the first word that came to mind. Subjects completed this task within 5 minutes. All subjects then completed the Hospital Anxiety and Depression Scale and pain ratings were taken from the pain patients. Subjects were then debriefed about the purpose of the investigation and were given a chance to ask questions.

Table 16: Implicit and cues recall: stimuli

Words and Frequency

Sens	Affect	Neutral	Pos
Scalding .5	Unbearable .7	Windswept .6	Cherish .8
Stabbing .1	Torturing .1	Imprecise .1	Enchanting .6
Pressing 11.3	Fearful 11.8	Spending 11.1	Devoted 10.7
Pounding 13.3	Dreadful 7.6	Shopping 12.8	Generous 8.9
Tingling .7	Punishing .5	Selective .7	Confident .6
Throbbing 1.5	Annoying 2.4	Chanting 2.1	Superb 2.2
Crushing 4.2	Troublesome 6.1	Promising 5.2	beloved 5.3
Hurting 2.0	Vicious 2.8	Angular 2.4	Truthful 1.1
Beating 20.3	Suffered 14	Polished 14	Merry 14
Shooting 22.3	Miserable 7.1	Spreading 12.4	Clever 21.6
Pricking .1	Exhausting .2	Reputable .1	Serene 1.6
Drilling 3.5	Terrifying 2.2	Regarding 2.3	Triumphant 3.4
Searing .3	Horrible 5.4	Informal 4.8	Applause 4.9
Splitting 2.8	Wretched 2.4	Stimulate 2.5	Gracefully 2.4
Stinging 2.3	Frightful 2.3	Participate 2.4	Comforting 2.2

Results

Scoring: Each subject was scored on the explicit test for the number of words from each category (sensory, affective, positive and neutral) they had successfully recalled. The implicit test was scored both for words that had appeared in the encoding stage, and for words from the list NOT seen by the subject previously. For example, subjects who encoded a combination of lists A and B, were tested for explicit recall on list A, Implicit recall on list B and response bias on list C. The final score for each subject on the implicit memory task was computed by subtracting the number of words from the unseen list in each category from the number of words produced in each category that had been seen in the encoding stage (Mathews, et al., 1989).

Analysis: A 2x4 (group x wordtype) factorial analysis of variance was carried out on the scores for explicit recall. Means and standard deviations are presented in Table 17. The analysis revealed no group effect ($F(1,46)=2.56$, $p=0.116$), but a main effect for wordtype was found ($F(3,138)=15.04$, $p<0.001$). The interaction between group and wordtype was not significant ($F<1$).

A factorial analysis of variance (2x4, group by wordtype) was carried out on the scores for implicit priming. The scores were transformed (square root+0.5) to achieve homogeneity of variance (Howell, 1987), and the transformed means are presented in Table 17. Results showed no main group effect ($F<1$), but a significant difference in completion of different wordtypes was observed across the groups ($F(3,138)=139.6$, $p<0.0001$). The interaction between group and wordtype was not significant ($F(3,138)=1.53$, $p=0.208$).

The mean pleasantness rating for each wordtype was computed for each subject; these are presented in table 17. Analysis of variance (2X4, group by wordtype) revealed a group effect ($F(1,46)=14.64$, $p<0.001$) and a wordtype effect ($F(3,138)=381, p<0.0001$). The interaction between group and wordtype approached significance at the 0.06 level ($F(3,138)=2.48$). Simple effect analysis revealed no differences between the groups on affective and positive words, but significant differences emerged on neutral words ($F(1,183)=8.15$, $p<0.01$) and sensory words ($F(1,183)=9.66$), $p<0.001$). Both were rated more pleasant by the control group.

Subjects mean latency to respond to each wordtype at the encoding stage were computed and are presented in table 17. One subject had to be excluded from analysis as her scores were beyond 3 standard deviations from the mean of the group. Analysis of variance was carried out on the remaining 23 pain patients and 24 controls, revealing no group effect ($F<1$), a significant wordtype effect ($F(3,135)=11.51$, $p<0.0001$) and an interaction at the 0.09 level ($F(3,135)=2.15$). Since the interaction did not approach significant further analysis was not carried out. However, the means, presented in table 17, seem to indicate that all subjects were slower to respond to neutral words, and the pain group shows a trend for a higher latency to respond to sensory words. These observation must be viewed with caution, since analysis failed provide statistical evidence to support them.

The groups differed significantly in measures of depression ($F(1,46)=16.59$, $p<0.001$) and approached significance in anxiety scores ($F(1,46)=3.44$, $p=0.07$). The means for depression were 6.04 in the pain group (sd=2.9) and 2.8 in the control group (sd=2.3).

For anxiety in the pain group the mean score was 9.6 (sd=3.9) and in the control group 7.5 (sd=4.02). Depression ratings were therefore incorporated as a covariate and the analysis of variance repeated both for the explicit and implicit memory scores. For both, the pattern of results remained the same, with wordtype emerging as the only significant factor. Similarly, pleasantness ratings and latency to respond did not alter the pattern of results in either implicit or explicit recall when they were incorporated as covariates: no group effect or interaction was found for either, but a wordtype effect was found in both.

Finally, an analysis of variance on response bias scores was carried out between the groups (i.e., the number of words in each category that were produced in the implicit memory task, but that had not been seen before). This revealed no significant effects, with the critical interaction between group and wordtype producing an F ratio smaller than 1.

Table 17: means of cued recall, implicit memory scores, pleasantness and response time across groups.

Pain patients:

	sensory	affective	positive	neutral
explicit	1.33 (1.27)	2.29 (1.57)	1.62 (1.20)	1.12 (1.22)
implicit*	2.16 (0.3)	1.6 (0.1)	2.2 (0.3)	3.8 (1.4)
pleasant	22.3 (10.4)	18 (11.9)	83.04 (12.9)	58.5 (7.8))
rt	66.12 (17.79)	60.24 (13.51)	61.51 (17.07)	69.87 (17.27)

Control group:

	sensory	affective	positive	neutral
explicit	2.08 (1.44)	2.75 (1.44)	2.12 (1.22)	1.25 (1.18)
implicit*	2.2 (0.3)	1.6 (0.1)	2.2 (0.3)	4.2 (1.2)
pleasant	31.54 (10.3)	22.87 (10.5)	81.83 (9.2)	66.9 (8.5)
rt	62. 21 (19.18)	61.12 (19.6)	56.58 (15.24)	63.87 (17.27)

*=transformed data Sd in brackets

Rt=latency to respond pleasant=pleasantness ratings

Discussion

There appears to be no indication of an implicit memory bias towards pain related stimuli in pain patients. Contrary to expectation, results also failed to show an explicit bias towards such stimuli. Subjects portrayed no difference in their latency to respond to stimuli across the two groups, although they did rate the pleasantness of the imagined scenes differently: pain patients rated scenes involving sensory words as less pleasant than control subjects. An attempt will be made to explain these negative findings in the light of theories of information processing in general and memory in particular, drawing on previous findings to illustrate major points.

The negative findings concerning implicit memory bias for sensory words in pain patients are in line with the predictions specified in the introduction. Primarily, these predictions are based on the difference in definition between integration (priming) and elaboration. Previous studies have not found evidence for priming in pain patients; the studies so far have employed emotional stroop (see chapter 2), dot-probe paradigms (Pincus, unpublished MSc, 1988), and lexical decision tasks (Edwards, unpublished PhD thesis,1992). Implicit recall falls into the category of integration, in that it is described as automatic, non-volitional processing (Roediger III, 1992). The results are taken as a further indication that any bias towards pain related stimuli in pain patients will appear mainly in elaborative processing. Implicit memory biases for salient stimuli, and other biases related to integration have been found in anxious groups (Mathews, et al., 1985; Mathews & Macleod, 1986; Mathews, et al., 1989), but not in depressed groups (Roediger III, 1992). Depressed groups and pain groups appear to exhibit biases towards salient stimuli only in tasks involving elaboration. This could be due to a different emphasis in the focus of resources in these groups; anxious groups on the whole focus resources towards external stimuli, while depression and pain might be regarded as internally focused. It appears probable that pain patients at least dedicate resources to internal monitoring in their physiological vigilance in an attempt to avoid further pain and injury. Some support for this explanation is found in the finding that post traumatic stress disorder patients exhibit **both** explicit and implicit memory biases towards combat related stimuli (Zeitlin & McNally, 1991). It can be argued that the resources of these patients are both externally and internally focused; externally, because that is where the threat originated from, and internally, because the threat can be founds only in the internal representation, or memory, of past events.

Pain patients did not differ from controls in their response bias in the implicit task; they did not spontaneously produce more pain related words. This could be because of the strict scoring system, in which words were only accepted if they belonged to the list previously unseen by the subject. This restriction was imposed to avoid the problem of high negative scores on the neutral category in the implicit task during the calculation of previously seen words in each category minus the unseen words, and was based on previous research (Mathews, et al., 1989). There is some evidence to suggest that pain patients do in fact produce more pain related words to three-letter stems when these are produced without the encoding context (Edwards, unpublished PhD thesis, 1992).

More puzzling, however, is the failure to replicate an explicit memory bias for pain stimuli in pain patients. This does not appear to be the result of poor encoding, since differences emerged in pleasantness ratings which appear to indicate that pain patients do find sensory words less pleasant to process than control subjects. It is possible that the explanation lies in the explicit task itself: differences between recognition, cued recall and free recall have been noted in normal groups (Tulving, 1985). Previous studies that have demonstrated free recall bias for pain stimuli in pain patients did not reveal a similar bias on a recognition task (Pincus, et al., In press; Edwards, et al., 1992). Perhaps this is due to a ceiling effect resulting from the ease of the task. Mandler et al (1990), however, argue that stem completion is not purely an explicit memory test; they present evidence to suggest that stem completion is sensitive to priming effects (Mandler, Hamson & Dorfman, 1990). It can be argued from these findings that stem completion directly after encoding involves processing more similar to integration, and that the same task carried out after a time lapse, allowing for priming to fade, would measure processing associated with elaboration. If this is the case, we may only find biases towards pain stimuli in pain patients on cued recall tasks after a time interval, but not directly after encoding; the encoding results in priming (integration), which will obscure any biases due to semantic processing of the words.

Response time did not differ between the groups. This could be regarded as further evidence that the processing that results in a response bias to salient stimuli in pain patients is a slow and elaborative process, rather then one taking place at the very early stages of processing.

In light of these findings, it appears that further extensions of the present paradigm are necessary to clarify the results: on the one hand, a repetition of the experiment with the inclusion of a free recall test, in balanced order, would clarify whether the bias for pain stimuli in pain patients is unique to free recall. On the other hand, an extension of the cued recall test repeated after several days would clarify whether this test involves integration when presented immediately after encoding, but proceeds to involve elaboration over time.

In conclusion, although the findings from the present study present problems for the assumption that pain patients' memory bias for pain related stimuli will emerge on all explicit memory tests, they present further support for the argument that processes involving priming (integration) do not result in such a bias. Pain patients, therefore, do not appear to exhibit an implicit memory bias towards salient stimuli.

Chapter 6: Endorsement and recall of pain and depression stimuli in pain patients

Abstract:

This study investigates information processing in chronic pain patients and compares depressed pain patients, non-depressed pain patients and non-pain control subjects. Each subject contributed two scores: endorsement of adjectives as descriptors of themselves and their best-friends and free recall of the presented words. The stimuli consisted of depression related, pain related and neutral control adjectives, and each content category was split into negative and positive valence. The four way interaction between group,reference, content and valence was significant both in the recall data and the endorsement data. Further analysis revealed that depressed pain patients exhibited a bias towards self-referential negative pain words, but not towards self-referential negative depression information. These results are interpreted in line with content specificity theory of information processing and have implications for targeting cognitive interventions with pain patients.

Introduction

This chapter describes the last in a series of experiments investigating information processing biases in pain patients. The evidence so far suggests that information processing biases are present in the processing of chronic pain patients. Investigations have been based on theories postulated by Leventhal (Leventhal, et al., 1979; Leventhal, 1984), Beck (Beck, et al., 1979) and Williams et al (Williams, et al., 1988), described in chapter 1. The theories specific to pain, such as those postulated by Leventhal (Leventhal, et al., 1979) and Pennebaker (Pennebaker, 1982) suggest that processing biases occur at a pre-conscious level and can result in maintaining, exacerbating or even re-introducing pain experience. Methodologically, investigations have adopted paradigms employed in the investigation of information processing in emotional disorders. Three paths have been investigated: evidence in favour of an attention bias towards pain stimuli in pain groups appears to be the weakest, with conflicting data on the emotional stroop paradigm (see chapter 2) and negative results on the dot probe paradigm (Pincus, unpublished MSc thesis, 1989, Moses, unpublished MSc thesis, 1988). Evidence for an interpretation bias of ambiguous stimuli shows support for a bias in pain groups, both in the spelling of ambiguous homophones and in generating associations to ambiguous cues (See chapter 3). However, the strongest evidence to date arises from the investigation of recall bias towards pain stimuli in pain groups (see chapter 4).

Two separate studies have found a recall bias towards sensory and affective words taken from the McGill Pain Questionnaire in chronic pain patients compared with non-pain controls (Pearce, et al., 1990; Edwards, et al., 1992). Edwards et al (1992) also found a relationship between measures of depression in the pain group and their recall of affective pain words. Furthermore, the bias appears to be specific to self-referent information: when presented with identical stimuli in two conditions, self-referent and in reference to a known other, pain patients show a bias towards recall of sensory pain words in the self-referent condition and a bias towards recall of neutral words for the other person (see chapter 4).

The relationship between pain, mood and memory was investigated by Eich et al., (Eich et al., 1990), who measured recall of autobiographical memories. Subjects produced these memories twice; when suffering menstrual pain and when pain free. They subsequently rated the memories for pleasantness. The authers concluded from their findings that the effect of pain on autobiographical memory only takes place when the pain is accompanied by negative mood. When pain is accompanied by an increase in unpleasant affect, more negative and less pleasant events are recalled.
The current experiment was designed to further investigate the link between depression and pain in reference to recall bias.

Recent work on emotional disorders has moved towards the investigation of the hypothesis of content specificity; i.e., the assumption that distinct groups can be differentiated on the basis of the specific content of their information processing biases. Thus, anxious and depressed groups differ in the content and level of their processing biases. It has been established that anxious groups typically exhibit an attention bias towards threat stimuli, while depressed patients show a recall bias towards negative self-referent material (Williams, et al., 1988).

In an attempt to clarify the issue further, Greenberg and Alloy (Greenberg, et al., 1989) compared depressed patients, anxious patients and controls. Patient's endorsement (describes you? Yes/No) and speed of response to a list of adjectives were measured. The list included positive and negative adjectives in three content groups: depression related, anxiety related and a content control list. Subjects responded to half of these in reference to themselves, and half in reference to a known other. The results indicate differences between the groups: depressed patients alone endorsed negative and positive adjectives equally, and anxious patients endorsed more negative anxiety adjectives in the self referent condition.

Greenberg and Beck (Greenberg, et al., 1989) carried out a similar experiment, incorporating a recall task. They tested depressed, anxious and psychiatric controls on their responses to depressed and anxious content. The results indicated differences between the groups, where depressed patients selectively recalled more negative depressed adjectives while anxious patients recalled more negative anxious adjectives.

The current investigation was conducted to explore content specific biases in chronic pain patients. The two paradigms above were combined, to produce two measures; endorsement, and recall. Response time was measured to account for different processing times across subjects obscuring results. Pain patients were divided according to their measure of depression; the rational behind this was an attempt to differentiate between biases due to depression and those due to pain: non-depressed pain patients should respond selectively only to pain specific adjectives, while depressed pain patients should respond both to pain and depression content adjectives. Two reference conditions were included, self reference and known other, in an attempt to replicate previous findings for self-referent bias (Pincus, et al., In press).

Method

Design and procedure

The experiment was designed as a 3x3x2x2 factorial design, with one between group factor, group (pain-depressed, non-depressed pain and control subjects), and 3 within subject factors, content (pain content, depression content and control content), valence (positive and negative) and reference (self and other). Each subject was exposed to 144 (72 trials repeated twice) experimental trials, 10 practice trials, and three trials at the beginning and end of the exposure, to avoid recency and primacy effects. In each trial an adjective was presented on the screen of a Toshiba lap top computer. Of the 72 experimental adjectives (which were repeated twice), 24 belonged to each context category. The 24 consisted of 12 positive and 12 negative adjectives. Six of these were presented in each reference. Subjects were asked in alternating order "describes you?" or "describes your best friend?". These cue questions (3 second presentation) were followed by a gap of 500 msec and the appearance of the target adjective. Subjects were asked to respond by pressing buttons marked Yes or No, their response terminated the display, and a gap of 3.5 sec then preceded the next cue question (Greenberg, et al., 1989). Half of the subjects in each group completed the task with Yes positioned as the right response button. The computer generated a random order in each referential condition for each subject, with the restriction that no two words from the same category (i.e., negative/depression/self) are presented in succession. Two dependent variables were measured: endorsement of each trial, and a free recall task, which followed a two minute interference task directly after completing all trials.

Response time to each trial was measured by the computer. Subjects then completed the Beck Depression Inventory and gave ratings on pain intensity at the time and at maximum that week, on a scale of 1-100 (Jensen, et al., 1986). Further measures of damage and activity were given by a physician for each pain patient on a 5cm visual-analogue scale.

Subjects

Subjects from all three groups were matched for age ($F<1$), and sex (12 females and 7 males in each group). All pain patients were recruited at random from the rheumatology clinic at the Middlesex Hospital. They were later divided according to their scores on the Beck Depression Inventory (BDI) into depressed (12+) and non-depressed patients (below 9). The criteria for inclusion in the study were fluent use of English, no history of mental illness and at least 6 months' history of pain. Group 1 (depressed pain patients) included 14 rheumatoid arthritis patients and 5 Osteoarthritis patients. Group 2 (non-depressed pain patients) included 15 rheumatoid arthritis patients and 4 osteoarthritis patients. Details of age, pain intensity means, mean length of pain history, mean estimation of damage and mean estimation of activity are presented in Table 18.

19 control subjects were recruited through local community centres and local advertisements. Inclusion criteria stipulated fluent English, no history of mental illness and no history of chronic illness or pain experience. Subjects were asked about the latter only after completing the experiment, to avoid response bias; those who did not fulfil the inclusion requirements were excluded from the analysis. Over all, a

further 13 subjects were excluded: six control subjects reported they had suffered chronic pain for the past 6 months, and another six control subjects scored higher than nine on the BDI. One rheumatoid arthritis patient reported never to have suffered any pain.

Materials

The depressed and neutral stimuli adjectives were taken from previous research (Greenberg, et al., 1989), with the exception of a few adjectives that may have been as applicable to pain as to depression (such as 'lively' 'energetic',and 'weak'). The Pain related adjectives were generated by researchers at the pain research unit, University College London. The adjectives consisted of words that appeared to be at the centre of the concerns of chronic pain patients attending the pain management course COPE. (See table 19). The computer used to present and store responses was a Toshiba T3100SX with an attached hand set, consisting of two buttons, marked 'yes' and 'no'.

Results:

Endorsement

The raw data from each subject provided 12 data points for each cell, the mean of which was entered in a factorial analysis of variance. The four way interaction between group, reference, context and valence was significant ($F(4,108)=6.56$, $p<0.0001$). To further explore these results, two separate three way analyses of variance were carried out, first on self referential endorsement, then on the endorsement scores for the 'other' reference. There was no significant difference between the groups in the other condition, but in the self referential scores the three way interaction was significant ($F(4,108)=11.52$, $p<0.0001$). All further analysis therefore concentrated on the endorsement scores in the self referential condition only. The analysis of variance showed no significant main effect for the group factor ($F<1$). A group by valence analysis was carried out in each context domain, revealing that for control and depression related stimuli all groups responded similarly ($F<1$ for both). However, in the pain domain the interaction between group and valence was significant ($F(2,54)=17.24$, $p<0.001$), indicating that pain patients endorsed more negative pain words than the other groups. Means are presented in table 20.

Contrast analysis further revealed that for negative pain stimuli, there was a significant difference between pain-depressed patients and the other two groups, who did not differ from each other (Pain depressed v Pain group: $F(1,174)=25.43$, $p<0.0001$, Pain depressed v Controls $F(1,174)=38.74$, $p<0.0001$, Pain group v Controls $F(1,174)=1.4$, NS.). This pattern of results was repeated for the positive pain stimuli: pain depressed patients endorsed less positive pain words than pain patients ($F(1,174)=15.52$, $p<0.0001$) and less than controls ($F(1,174)=16.15$, $p<0.0001$), but pain patients and controls showed no difference in their endorsement of such stimuli ($F<1$).

Memory scores

As above, means from 12 data points per cell were calculated for each subject, and entered in an analysis of variance. The memory scores were severely skewed, and no appropriate transformation could be found to normalize the distribution. However, since the distributions were similar in shape, and the largest variance was less than four times the smallest, we proceeded with an analysis of variance (Howell,1987, p297). The analysis of variance carried out on the raw data revealed a significant four way interaction between group, reference, context and valence ($F(4,108)=2.68$, $p<0.05$). Previous research has demonstrated that people are more likely to recall words that have been endorsed in the encoding procedure. This presents a problem for the analysis of the recall scores, since there was a significant difference between the responses of the groups to the stimuli, depending on its valence. Previous research has employed different solutions to overcome the problem (see Greenberg and Beck, 1989 for a full discussion). One method employed is to take into account only recalled words that have been previously endorsed. This, however, results in different amounts of data in each cell for the different groups, especially on negative words for the controls. Not only does this method result in possible zero scores in cells which should have positive scores if a subject has actually recalled (but not endorsed) words belonging in the cell, it also biases towards the hypothesis. A correlation matrix of our results revealed that endorsement of negative pain words was significantly related to recall of such words ($r=0.317$, $df=56, p<0.05$), although no other significant relationships were found between endorsement and recall. Therefore we decided to use the endorsement scores as a covariate, and repeat the analysis of variance. If the covariance does not alter the interaction and is not significant then endorsement does not account for a significant proportion of the recall variance. The four way interaction, with endorsement scores for each category incorporated as a covariate remained significant ($F(4,107)=3.55$, $p<0.01$), and the covariate was not significant ($F(1,107)=2.7$, $p=0.10$).

As before, two separate analyses of variance were carried out on the self and other references. The three way interaction in the self referential condition between group, context and valence was significant ($F(4,108)=5.3$, $p<0.05$). However, the same interaction for recall scores in the other reference condition did not reach significance ($F(4,108)=1.73$, $p=0.14$). There was no main effect for group ($F<1$), and a group by valence analysis in each context domain revealed a significant difference only for pain related material ($F(4,108)=5.52$, $p<0.01$). All groups responded similarly to depressed stimuli ($F<1$) and control stimuli($F<1$).

Contrast analysis across groups on their recall of negative pain stimuli in the self referential condition revealed a significant difference between pain depressed patients and non-depressed pain patients ($F(1,208)=7.22$, $p<0.001$) and between pain depressed patients and controls ($F(1,208)=7.22$, $p<0.001$), but no difference between non depressed pain patients and controls ($F<1$). For the positive pain related stimuli, however, there was no difference between the two pain groups ($F<1$), or the non-depressed pain group and the controls ($F(1,208)=1.68$, $p=0.09$); however, there was a significant difference between the pain depressed group and the controls ($F(1,208)=3.78$, $p<0.01$. The three way interaction and subsequent contrast analysis can be summarised in a cross over effect between the pain depressed group and the controls on their recall of negative and positive pain stimuli. The means are presented in table 21.

The relationship between pain ratings and endorsement and recall of negative pain words was analyzed in both pain groups. In the non-depressed pain group, the endorsement of self-referential negative pain words was significantly correlated to the rating of pain at the time of the experiment ($r=0.43$, $df=18$). Recall of self-referential negative pain words in this group was highly correlated with ratings of damage, given by the physician ($r=0.624$, $df=18$). Regression analysis on the recall of self-referential negative pain words indicated that the two pain ratings, pain at the time and maximum pain that week, damage ratings and length of time subjects had suffered pain accounted for 56% of the variance ($F(4,13)=4.2$, $p<0.05$).

However, in the depressed pain group there was no significant correlation between endorsement of self-referential negative pain words and pain intensity ratings, damage and activity ratings or length of time they had suffered pain. This group also exhibited a negative correlation between the recall of self-referential negative pain words and pain at the time ($r=-0.3$, $df=18$), maximum pain that week ($r=-.45$, $df=18$) damage ($r=-.49$, $df=18$) and activity ($r=-.60$, $df=18$). These five variables failed to predict a significant amount of variance in either recall of self-referential negative pain words or endorsement of such words in a regression analysis ($F<1$).

The two pain groups differed significantly in their ratings of pain at the time; depressed pain patients rating their pain intensity higher than non-depressed pain patients ($F(1,34)=8.68$, $p<0.01$). Physicians also rated the depressed pain patients as having higher activity levels than non-depressed patients ($F(1,33)=4.92$, $p<0.05$). The groups did not differ in their ratings of maximum pain ($F<1$), length of time they had had pain ($F<1$), and in the damage ratings given by the physician ($F(1,36)=1.87$, $p=0.17$).

The mean response time in each cell for each subject was analyzed in a factorial analysis of variance, after the appropriate transformation was carried out to avoid skewness (see table 22). This revealed that depressed pain patients were slower on the whole ($F(2,54)=6.39$, $p<0.01$), that all subjects were slower to respond to adjectives in reference to themselves ($F(1,54)=6.28$), $p<0.01$) and that all subjects were faster to respond to neutral adjectives ($F(2,54)=32.84$, $p<0.001$). A significant group by content interaction ($F(4,108)=19.122$, $p<0.001$) was further analyzed using contrasts. This revealed that within all three groups subjects showed a tendency to respond slower to depressed adjectives (pain-depressed group: $F(1,108)=21.77$, $p<0.001$, pain group: $F(1,108)=17.53$, $p<0.001$, control subjects: $F(1,108)=5.46$, $p<0.05$). However, only the pain-depressed group exhibited a significant increase in response time to pain adjectives in comparison with depressed adjectives ($F(1,108)=6.61$, $p<0.01$). The non-depressed pain subjects revealed no difference in their responses to the depressed and pain adjectives ($F(1,108)=1.13$, $p=0.289$), and the control subjects revealed the opposite tendency; their decrease in response time to pain stimuli in comparison with depressed stimuli approached significance ($F(1,108)=3.57$, $p=0.06$)

Table 18: Endorsement and recall: means of age, depression, pain ratings, and damage and activity across groups

	pain depressed	pain	controls
age	49.05 (12.03)	49.00 (12.28)	48.50 (9.92)
beck scores	15.68 (4.47)	4.15 (2.31)	4.68 (2.56)
pain at time	36.05 (26.89)	15.47 (13.56)	
maximum pain	49.46 (27.72)	40.29 (23.28)	
length of pain	13.31 (14.67)	11.1 (10.11)	
damage ratings	2.6 (1.22)	2.15 (1.16)	
activity rating	2.29 (0.98)	1.55 (0.98)	
Ratio of F/M	12/7	12/7	12/7

* Sd in brackets

Table 19: Endorsement and recall: stimuli

Self reference:

Control, negatives:	Crude, discourteous, nosy, phoney, thoughtless, uncivil.
Control, positive:	Congenial, cooperative, genuine, polite, scrupulous, tactful.
Depression, negative:	Efficient, inadequate, lazy, boring, guilty, withdrawn.
Depression, positive:	Lovable, motivated, outgoing, valuable, worthy, potent.
Pain, negative:	Hurting, vulnerable, agonized, suffering, ill, uncomfortable.
pain, positive:	Healthy, active, self-sufficient,flexible, healing, well.

Other reference:

Control, negative:	disrespectful,immoral, obnoxious, rude, ungrateful, unprincipled.
control, positive:	amiable, cordial, ethical, honest, mannered, nice.
depression, negative:	ineffective, insignificant,lowly, shameful, uninspired, unlikable.
depression, positive:	ambitious, eager, pleasant, enthusiastic, attractive, praiseworthy.
pain, negative:	aching, dependent, sore, tortured, disabled, stiff.
pain, positive:	strong, lively, assertive, athletic, wholesome, comfortable.

Table 20: Endorsement and recall: mean endorsement of adjectives for each group

	Pain-depressed	pain non-depressed	control subjects
O control negative	0.421 (0.768)	0.368 (0.683)	0.631 (0.955)
O control positive	10.842 (1.424)	10.105 (1.594)	10.315 (1.157)
O dep. negative	0.947 (0.970)	0.947 (1.470)	0.526 (0.841)
O dep. positive	10.263 (1.910)	9.578 (1.804)	10.263 (1.484)
O pain negative	2.315 (1.887)	2.157 (1.607)	1.421 (0.901)
O pain positive	9.052 (1.682)	9.000 (1.699)	9.368 (2.113)
S control negative	0.631 (0.955)	1.157 (1.384)	0.789 (1.228)
S control positive	10.421 (1.502)	10.578 (1.216)	10.368 (1.422)
S depress. negative	1.578 (1.923)	0.842 (1.302)	1.000 (1.374)
S depress. positive	7.736 (3.106)	9.842 (2.455)	9.368 (1.397)
S pain negative	5.894 (3.331)	3.157 (2.929)	2.210 (1.397)
S pain positive	6.894 (2.514)	9.684 (1.916)	10.842 (1.118)

*Depress=depression related content
*O=other person reference
*S=self reference

(Sd in brackets)

table 21: Endorsement and recall : **mean recall of word categories across groups**

	pain depress.	**pain**	**controls**
O cont. negative	0.368 (0.495)	0.842 (1.014)	0.526 (0.611)
O cont. positive	0.526 (0.772)	0.526 (0.696)	0.421 (0.606)
O dep. negative	0.263 (0.452)	0.000 (0.000)	0.157 (0.374)
O dep. positive	0.473 (0.611)	0.578 (1.017)	0.421 (0.692)
O pain negative	0.105 (0.315)	0.684 (0.885)	0.315 (0.477)
O pain positive	0.684 (0.582)	0.578 (0.606)	0.473 (0.611)
S cont. negative	0.526 (0.611)	0.736 (0.733)	0.578 (0.692)
S cont. positive	0.578 (0.768)	0.631 (0.683)	0.894 (0.875)
S dep. negative	0.421 (0.507)	0.210 (0.418)	0.421 (0.692)
S dep. positive	0.421 (0.768)	0.368 (0.683)	0.421 (0.507)
S pain negative	1.368 (0.760)	0.684 (0.582)	0.631 (0.597)
S pain positive	0.842 (0.898)	1.052 (1.078)	1.473 (0.348)

* O= other reference
* S=self reference
* cont.=control context
* dep. =depression content

(Sd in brackets)

Table 22:Endorsement and recall: mean reaction time of adjectives for each group

	Pain-depressed	pain non-depressed	control subjects
O control negative	1851 (912.7)	1392 (373.6)	1453 (575.7)
O control positive	1794 (749.8)	1442 (439.5)	1285 (374.6)
O dep. negative	2104 (1025.6)	1626 (499.2)	1455 (349.9)
O dep. positive	1721 (519.5)	1574 (425.5)	1353 (381.2)
O pain negative	1998 (745.8)	1530 (369.0)	1303 (284.8)
O pain positive	1785 (649.37)	1564 (493.0)	1317 (392.2)
S control negative	1711 (506.0)	1440 (335.7)	1326 (355.2)
S control positive	1809 (690.8)	1464 (406.6)	1319 (346.0)
S depress. negative	1905 (591.7)	1474 (364.1)	1399 (349.0)
S depress. positive	2060 (749.8)	1667 (638.6)	1445 (442.4)
S pain negative	2351 (851.3)	1723 (425.7)	1525 (501.4)
S pain positive	2032 (622.2)	1595 (523.9)	1282 (365.4)

*Depress=depression related content
*O=other person reference
*S=self reference

(Sd in brackets)

Discussion

The results confirm the hypothesis of a processing bias in depressed pain patients towards self-referent pain stimuli. This bias is apparent in endorsement, recall and in response time to pain stimuli. Several issues will be discussed further; the differentiation between depressed and non-depressed pain patients on the basis of their processing biases, content specificity of the bias in the depressed pain group and the implications of these findings for interventions.

Non-depressed pain patients do not appear to process negative pain information selectively. This is in contrast to previous evidence, which showed non-depressed pain patients to selectively recall sensory pain words (Edwards, et al., 1992; Pincus, et al., In press). However, the stimuli used in both the above experiment was extracted from the McGill Pain Questionnaire, and contained descriptions of pain, rather than personal adjectives. In the current study, adjectives were selected not for their representation of the sensory aspects of the pain experience, but rather for the representation of self-schema incorporating pain distress material. Indeed, Edwards et al (1992) found that depressed pain patients selectively recalled both affective and sensory words, while non-depressed pain patients recalled sensory words only. It is possible that long exposure to pain will result in a general processing bias towards sensory pain information, but for some pain patients this is further accompanied by processing biases towards pain-distress information, a negative self-image, and higher measures of depression. Further research is needed to ascertain how these last factors affect prognosis, and in turn, how they can be affected by psychological intervention.

Depressed pain patients selectively endorse and recall negative self-referent pain adjectives, but do not show such a bias towards self-referent depression content. This suggests that despite their high scores on the BDI, pain patients' depression is qualitatively different from that of other depressed groups. The concerns that are considered to be upper most in depressed groups, such as a self-image associated with being guilty and unlovable, are not shared by depressed pain patients. Their concerns are more to do with being dependent, and suffering. The implications of these findings for clinicians are substantial as they suggest a focus for cognitive intervention attempting to change self-image. Several studies have attempted to reveal the direction of the relationship between depression and chronic pain. It appears now that in most cases, chronic pain precedes depression, and depression is viewed as a response to chronic pain, rather than vice-versa (Brown, 1990). The findings from the current study are viewed as further evidence that depressed pain patients should be viewed as pain patients who are responding with negative emotions to their situation, rather than depressed patients who happen to have a physiological complaint, either independent of their mental state, or as a somatization.

Response time pain stimuli differed across the groups. All subjects showed a tendency to process emotive words slower, regardless of valence. However, depressed-pain patients alone showed increased response-time to health related stimuli, suggesting that these words might have become highly emotive. This appears to fit in with some previous studies (Greenberg, et al., 1989), but not with others (Mathews, et al., 1983). In any case, the results from the response time analysis did not mirror the results from endorsment and recall; both valence and self-reference failed to interact significantly with the group and content. In other words, response time was not affected by whether the words were positive or negative or by whether they were processed in reference to the self or not. This suggest that although some processing bias might be detected by response time, this processing is more 'primitive', i.e., generalized and automatic than the processing required for endorsment and recall.

The relationship between measures of pain and physical damage and processing biases towards negative pain stimuli in both groups of pain patients present a puzzle: non-depressed pain patients, who do not exhibit a significant bias towards such information nonetheless show a positive relationship, where pain and damage ratings predict the amount of negative pain stimuli endorsed and recalled. However, the significant biases towards this data exhibited by the depressed pain patients show a negative relation to levels of pain and damage, although their predictive power is not significant. This suggests that when pain patients are free of high levels of depression, their processing biases towards negative pain stimuli depend simply on the amount of pain they experience. However, in pain patients who are depressed the process becomes more complex, and other factors affect processing. Some support for the idea of pain-depression being a mediator in information processing is derived from the work of Eich (Eich et al., 1990) described above. Further investigations should aim to measure the predictive quality of various psychological factors in the development of processing biases in pain patients.

In summary, depressed pain patients selectively endorse and recall self-referent negative pain adjectives. This bias is specific to the stimuli; depressed pain patients do not show a similar bias towards depressed content. This suggest that their depression is qualitatively different from that of other depressed groups. Clinical interventions attempting to reduce depression in pain groups should address itself to their specific concerns, rather than those usually addressed in the treatment of depression.

Chapter 7: Summary

Information processing biases to pain related stimuli were investigated in chronic pain patients. Methodologies were adapted from related research, in an attempt to find out how pain patients compare with other groups, and whether hypotheses extracted from the theoretical framework of cognition and emotion can be applied to pain populations. Five questions were outlined in the introduction. Four of these concerned the presence of specific information processing biases in the processing of pain patients, and the last concerned the theoretical implications resulting from evidence supporting the existence of such biases. The summary will therefore constitute three sections: an outline of the experiments and the findings, a section describing how these results can be accounted for theoretically, and finally, a section discussing the clinical implications of the findings.

The experiments:

Four questions were proposed in the introduction, each addressing the existence of a specific information processing bias to pain related stimuli in chronic pain patients. These questions were based on research carried out on subjects from different groups, mainly anxious and depressed patients, where results have indicated specific information processing biases to salient stimuli.

Attention bias:

The first question queried the existence of an attention bias towards pain related stimuli in pain patients. Such a bias has been demonstrated in anxious groups towards threat related stimuli (as reviewed in chapter 2), and has been investigated using two methodologies, the dot-probe paradigm, and the emotional stroop. An emotional stroop task has also been presented to pain patients, with results suggesting that they show significant interference on colour naming of pain related words (Pearce, et al., 1989). Chapter two described two experiments, both employing the emotional stroop task, that compared response time between chronic pain patients and control subjects.

The first of the two experiments presented the stimuli on a VDU screen, in singular presentation. The stimuli consisted of sensory and affective words extracted from the McGill pain questionnaire, physical and social threat words, positive and neutral words, a classical stroop (contradictory colour and colour name) and a facilitating condition (congruent colour and colour name). The results did not support the hypothesis of a difference in the response times of the two groups when processing pain related material. Subsequent analysis that controlled for differences in depression between the groups revealed that an apparent trend towards the hypothesis was probably a bi-product of mood, rather than a processing bias related to pain.

The second experiment replicated the methodology employed by Pearce and Morley (1989) who found support for an interference bias in pain patients when processing words extracted from the McGill Pain Questionnaire. Stimuli were presented on cards, with eight stimulus categories; sensory and affective words, positive words, three matched neutral word lists, and the classical stroop. A threshold for each subject was calculated by presenting a colour naming condition. Subjects were presented with a free recall task after completing the stroop task. The results failed to replicated Pearce and Morley's findings: no differences were found between the two groups in their response times to the stimuli, although the free recall task indicated that pain patients recall more pain related words than control subjects. These results, taken together with results from former investigations employing the dot-probe methodology (as reviewed in chapter 2) seem to indicate that pain patients do not show an attention bias towards pain stimuli.

Interpretation bias

The second question queried the existence of an interpretation bias in pain patients, which would impose a pain related interpretation on ambiguous incoming information. Such biases have been indicated in anxious groups towards threat stimuli (see review in chapter 3). Chapter three described two investigations designed to explore interpretation biases in pain patients.

The first consisted of two experiments which employed a spontaneous association response task to ambiguous cues. In this task subjects were presented with interspersed ambiguous cues (such as 'terminal') and asked to respond with the first word that came to their mind. The first experiment compared the responses of pain patients, physiotherapists and non-pain controls. Results indicated an interpretation bias in the pain group, who produced significantly more pain related associations than either of the other groups. A frequency effect was considered unlikely since one of the control groups , the physiotherapists, should have been as familiar with pain words as the patients. The second experiment repeated the task on three groups, pain patients, osteopaths and non-pain students, this time measuring anxiety and depression during completion. The results showed support for the previous finding; pain patients produced significantly more pain related words than either of the other groups, and this effect was independent of differences in anxiety and depression.

The second investigation presented pain patients and control subjects with ambiguous homophones, each of which had two possible spellings, depending on the interpretation; one of these was pain related (e.g., 'pain'), the other neutral (e.g., 'pane'). The number of pain related interpretations was compared between the two groups, and a significant increase in these was found in the pain group. A further free recall task replicated past findings for a recall bias towards pain related words in pain patients. Overall, results from these three experiments appear to indicate that pain patients selectively process ambiguous information as pain related.

Recall bias:

Past experiments have provided evidence suggesting that pain patients selectively recall pain related information (see review in chapter 4). Further support for this hypothesis was found in chapters two and three. The issue of recall bias in pain patients was further addressed in chapters four, five and six, each concentrating on a different aspect of processing.

Chapter four investigated the question of self referential encoding, in comparison with encoding in reference to others, and its effect on recall bias in pain patients. Pain patients and controls were presented with sensory, affective and neutral words, and asked to imagine themselves in a situation involving these words. In a separate reference condition a list of matched stimuli was presented, and subjects were asked to imagine a fictional medical character in situations involving the words. A free recall test and a recognition test were presented after the completion of both encoding conditions. Results revealed a significant cross-over effect in which pain patients recalled significantly more sensory words and control subjects recalled more neutral words. More important, these results were unique to the self-referential encoding condition only. In contrast results from the recognition test did not reveal differences between the groups.

Chapter five investigated implicit and explicit memory bias in pain patients. Past findings suggest that anxious and depressed groups differ in their processing; anxious patients are characterized by an implicit memory bias for threat stimuli but no explicit memory bias for such stimuli, while depressed patients show a marked explicit recall bias towards negative information but no implicit memory bias towards such data (see review in chapter 5). The experiment presented pain patients and control subjects with sensory, affective, neutral and positive words on a VDU screen. They were asked to imagine themselves in situations involving these words and rate the situations for pleasantness. Two recall tests were presented to each subject on completion of the encoding stage. In one, the implicit task, subjects were asked to complete stem words with the first word that entered their mind. In the other, the explicit task, they were asked to complete stems with words that had been presented in the encoding stage. A response bias test was incorporated into the explicit task, and all conditions were balanced for order. Results indicated no differences between the groups on either implicit or explicit recall, although pain patients had rated situations involving sensory words as less pleasant than control subjects.

Chapter six investigated content specificity in recall bias in pain patients. Past experiments have found that anxious and depressed groups differ not only in the type of processing bias they exhibit, as indicated by the test tasks, but that these biases are specific to their salient concerns, as indicated by the content of the selected information (see review in chapter 6). In an investigation following these findings pain-depressed patients were compared to pain patients who were not depressed and to a control group (consisting of non-depressed, non-pain subjects). Subjects were presented with three types of stimuli; pain related, depression related and control stimuli. Each of these was further split into negative and positive valence. Subjects encoded the stimuli in two reference conditions, self and other. They were asked to indicate whether the words described them or their best friends (alternating between the two), and their response times and endorsement of the adjectives were recorded. A free recall test was administered at the end of the encoding condition. Results indicated significant differences between the groups. These difference were specific to the self-referential encoding condition only. More important, the differences were found only for the pain related information, but not for information related to depression, or to neutral information. Analysis revealed that depressed pain patients selectively endorsed and recalled more negative pain words than either of the other groups. Similarly, they endorsed and recalled less positive health related words than either of the other groups. The response times to these stimuli showed a similar pattern in that depressed-pain patients alone showed increased latency to respond to health related stimuli; however, this effect took place regardless of valence and reference.

Overall, the investigations of recall bias for pain stimuli in pain patients show consistent evidence for a bias in free recall of pain stimuli. This bias appears to be specific to stimuli that has been encoded in reference to the self. Furthermore, pain-depressed patients appear to show recall biases towards pain related information, but not towards depression related information, indicating that their salient concerns might be qualitatively different from those of other depressed groups. Tasks other than free recall, namely recognition and word completion, have not revealed evidence for a similar bias in pain patients. Nor has there been evidence to suggest that pain patients show an implicit memory bias towards pain stimuli. These apparent inconsistencies need to be reviewed in the light of theoretical frameworks that can suggest an explanation and describe how the above findings slot in to the wider picture of information processing biases in different groups.

Fitting the findings into a theoretical framework

There are many competing theories that attempt to account for the evidence of information processing biases in different groups. Of these, the theories quoted most often are Beck's schema theory, and Bower's associative network theory (outlined in chapter 1). There is little to choose between the theories in their predictions, although associative networks (Bower, 1981) have been criticised for their failure to differentiate between 'hot' and 'cold' cognitions (the difference between thinking about an emotion and experiencing it), and neither theories account for all the evidence. Specifically, the theories fail to explain why some groups are characterised by information biases associated with attention, but no bias in recall of the same stimuli, while other groups show the reverse pattern (see review in chapter 1). To account for these findings, Williams et al (Williams, et al., 1988) proposed an integrative model of processing, which differentiates between two types of processing; priming (integration) and elaboration. Chapter one described the characteristics of these two types of processing, and outlined how depressed groups appear to show biases associated with elaboration, while anxious groups appear to show biases associated with integration. One of the main aims of this investigation was to attempt to clarify where chronic pain patients would fit in, and which group they resemble more closely in terms of the processing biases they exhibit.

The evidence outlined above suggests that pain patients are characterized by a robust free recall bias and interpretation biases towards pain related stimuli. They do not appear to exhibit attention bias towards such stimuli, or show implicit memory and recognition bias towards it.

Pain patients appear to exhibit similar biases to depressed groups as far as free recall is concerned, and similar patterns to anxious groups as far as interpretation of ambiguous information is concerned. On the tasks clearly identified as testing integration, namely the dot-probe, emotional stroop and implicit memory tasks, pain patients show no selective biases towards pain stimuli. From the collective data on these tasks it appears safe to say that pain patients are not characterized by priming biases towards pain related information.

The picture of the tasks associated with elaboration is less clear. The tasks that have been described as testing elaboration include free recall, stem completion cued recall and recognition. Pain patients show a robust effect on free recall of pain related words, but fail to show evidence for a bias in recognition and recall. It is suggested in chapter four that recognition might not be sensitive enough to produce the effect, and chapter five described recent suggestions by Mandler (Mandler, et al., 1990), which argue that stem completion cued recall is at least partly affected by priming. Furthermore, the robustness of the free recall effect, replicated in this work alone four times, suggests that pain patients exhibit processing biases associated with elaboration.

Interpretation biases, as tested by the ambiguous homophone paradigm, might be associated with priming, as it is argued that priming raises the probability that a word will be produced when only some of its features are present (Williams, et al., 1988). However, the integrative model does not specify that interpretation biases are a result of priming. In the case of spontaneous association to ambiguous cues, one could argue that the processing involves elaboration, in that it requires a form of search, and explores connections **between** schemata. There seems a need to clarify the position of interpretation within the model. It is not clear whether the integrated model suggests modular processing, or sees integration and elaboration as a continuum. If the latter is the case, interpretation would naturally fall in the middle of such a continuum, as a process requiring some degree of both integration and elaboration, depending on the task. However, if a modular view of processing is taken, it could be the case that the two tasks presented to pain patients in this work test different processes; the ambiguous homophone experiment testing integration, while the spontaneous association experiment tests elaboration. In this case, pain patients processing biases in general would be mainly associated with elaboration, apart from their responses on one task, the ambiguous homophone task, in which they show integration processing bias. Pain patients will therefore be viewed as a group characterized by processing biases almost identical to depressed groups. This description appears somewhat forced, and obscures what might be an important distinction between the two groups. There is therefore a need for further refinement of the integrative model, to explain and define interpretation biases.

Table 23: Information processing biases in pain patients, anxious and depressed groups

	Pain patients	Depressed S's	Anxious S's
Dot-probe	No	No	Yes
Emotional stroop	Probably not	Probably not	Yes
Interpretation of ambiguous stimuli	Yes	No	Yes
Free recall bias	Yes	Yes	Probably not*
Implicit memory bias	No	No	Yes

* Although the evidence for memory bias for threat stimuli in anxious groups is contradictory, it appears to be the case that when found it is specific to groups where anxiety has been induced, rather than clinical populations, and that research that has demonstrated free recall bias in clinical groups have failed to control for depression and frequency effects (Eysenck, 1992).

Further work and clinical implications

The implications of the results for clinical interventions

The following section discusses the possible implications of this research for clinical interventions. Since the work did not include clinical trials, and the relationship between information processing biases in pain groups and the prognosis of the condition is unknown, this section is speculative. It should be seen as an attempt to link together experimental findings, theory, and clinical work. However, the true value of this research will only be known through further studies, with an emphasis on longitudinal monitoring and outcome. Some specification of possible future work will be described towards the end of this section.

Several of the experiments described above manipulated self-reference and other person reference as a condition during encoding, and found that the recall bias for pain stimuli in pain patients is specific to self-reference. This suggests that these biases are firmly connected with the patients' view of themselves, and might be interpreted as a bias resulting from a comparison between self and others. Although the results from the recall tests cannot be interpreted as evidence for the existence of a self-schema, they do show that pain patients selectively process pain information in reference to themselves; their view of themselves, or self-image is directly connected to their processing of pain information. The implications of these findings for clinical interventions are that it might prove beneficial to concentrate on patients' self-image instead of concentrating on the pain itself. This would involve attempts to create new associative paths between the concept of the self and other, more positive, concepts, such as 'myself as a coping person'. Although many of the interventions described above may contribute to such a process in a round about away, there may be a more direct route to these changes.

Pain-depression describes the negative affect of distress and despair experienced by many pain patients. It is usually measured using the Beck Depression Inventory (Beck, et al., 1979), or similar measures of depression that have been validated with groups of clinical depressed patients. Pain patients who score highly on these measures are described as 'depressed', and might be treated accordingly, either by the prescription of anti-depressants, or even by referral for psychological or psychiatric intervention. The results from chapter six suggest that these interventions may not be appropriate for pain patients; that their depression is qualitatively different from that of other depressed groups, involving different concerns and salient concepts. For example, chronic pain patients, unlike most depressed patients, failed to respond to words related to the concepts of guilt and worthlessness. Psychological interventions that focus on these concepts, as many interventions based on Beck's cognitive therapy do, would prove less beneficial for depressed pain patients than interventions that focus on the concept of physical helplessness, for example.

Finally, it seems reasonable to assume that the introduction of these findings as an educational tool would assist existing strategies in pain control. For example, if pain patients are presented with results indicating selective interpretation of ambiguous stimuli, they could employ this knowledge while attempting to monitor and re-categorise pain sensations as less distressful physiological signals. Presented with the fact that they impose pain interpretations on ambiguous words, they may become more open to the idea that the process can be employed in reverse.

In summary, the value of the present findings and the research in general in clinical terms could be described along two lines; (i) the development of a relatively objective tool of assessing change in the salience of emotional concepts after interventions, and (ii) in proving evidence for the need to focus on self-image, if long term cognitive shifts are to be achieved. Future work will establish whether information processing tests could also provide an effective diagnostic test of patients who are more suitable and would gain from cognitive interventions.

Future work

The current research has demonstrated that chronic pain patients selectively process pain information. This is particularly evident in free recall, in which it is specific to self-referential information, and in the interpretation of ambiguous stimuli. It is unclear whether these processing biases result from long term exposure to pain, or are vulnerability indicators that result in maintenance of pain states. In other words, do information processing biases contribute to the maintenance of pain, or are they simply a symptom, a psychological side-effect resulting from this condition? Research from depressed groups suggests that information processing biases, specifically ruminating on negative information contribute to the depression. It is possible that the pain experience and the information processing biases operate in a cyclical fashion, acting to maintain and strengthen each other. The relationship between processing biases and the prognosis of pain conditions should form the focus for future work. Ideally, research will follow patients from casualty wards, in situations involving acute pain, to see which patients develop chronic pain syndromes, and at what stage do processing biases become evident. Future work should also concentrate on recovered groups, as part of outcome studies. If information processing biases are no longer present once the pain has been reduced, the argument for innate vulnerability tendencies is considerably weakened. This work was aimed at providing evidence for the existence of information processing biases in pain patients. It is left to clinical psychology to interpret their presence and its implication for maintaining pain, and to establish whether mediation of these biases should become a target for clinical interventions.

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