THE EFFECT OF PAIN ON MEMORY FOR AFFECTIVE WORDS

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ABSTRACT

Memory is a key cognitive variable in pain management, but lacks extensive research. This study is a replication and extension of Seltzer and Yarczower's (1) investigation of pain's influence on memory for affective words, which found fewer positive words and more negative words recalled if subjects were in acute pain (versus no pain). In the present study, two experiments were conducted: one with a recall memory test and one with a recognition memory test. One hundred sixty undergraduate subjects were randomly placed in one of four groups: two groups had the same condition (pain or no pain) for both the encoding task and memory test, and two groups had mixed conditions (pain at encoding–no pain at memory test or no pain at encoding–pain at memory test). Pain was induced by 0°–2°C water immersion. At encoding, subjects categorized words by judging them as either positive or negative. Results of both experiments show that pain impairs memory. In neither experiment were differences found on memory for positive and negative words. These results do not support Seltzer and Yarczower's discriminative effects of pain on word category, but they are consistent with other research using acute pain manipulations and chronic pain populations, suggesting that pain interferes with memory. It is hypothesized that pain depletes scarce attentional resources, thereby interfering with concurrent cognitive tasks such as thinking, reasoning, and remembering.

INTRODUCTION

Seventy million people in the United States experience chronic pain, leading to over 50 million disabled workers and costs for disabilities exceeding 10 billion dollars per year (2). Treatments for chronic pain rely on an interdisciplinary team process that includes medical, physical, and psychological therapies. Key to the success of this process is the patient's ability to pay attention, comprehend, remember, and comply with the various treatment guidelines. Therefore, an accurate depiction of the factors that influence these important cognitive processes as they relate to pain is essential. Memory as it relates to pain is a key cognitive variable in pain management.

Most of the existing research on memory and pain has focused on the accuracy of memory for pain intensity (see 3 for a review). Few research studies have investigated the impact of pain on memory for material learned during the experience of pain. Among those studies assessing memory for something other than pain, memory for words has been a major focus. Pearce et al. (4) investigated the effect of cold pressor pain on memory for words in healthy volunteers. Subjects who were exposed to the same pain “state” during the recall condition as in the encoding condition remembered more words than subjects exposed to a non-congruent stimulus during recall (i.e. cold/warm, warm/cold).

On a practical level, chronic pain patients' ability to encode and retrieve important therapeutic information is essential to their recovery and/or maintenance of their health. Turner (5) reported that family practice physicians in her study gave an average of eight instructions to the pain patient within the last minute of a four-minute initial office visit. Assuming that pain interferes with memory, it is likely that these patients would have difficulty remembering, and thereby complying with, at least some of the physician instructions. Livengood et al. (6) provide some support for this notion; they report that chronic pain patients fail to remember their treatment instructions, thereby delaying recovery. We assert, then, that an examination of pain's impact on cognitive functions such as memory is crucial to understanding and treating the chronic pain patient.

One of the ways pain could interfere with memory is by eliciting a negative affective state. It has been demonstrated that subjects' moods (happy or sad) during the learning phase of a task influence the emotional content of their memory at the retrieval phase (i.e. a “mood-congruity” effect) (7). Bower also demonstrated that subjects who were tested in the same mood in which they learned the material demonstrated better memory than subjects who had unmatched moods at learning and retrieval (i.e. a “state-dependency” effect). Seltzer and Yarczower (1) investigated whether the affective state induced by experimental acute pain would similarly induce mood-congruity and state-dependency effects on memory. Results showed that memory for words with a negative connotation was facilitated by pain experienced during recall. Memory for words with a positive connotation was hindered by pain experienced at the point of word exposure. Thus, a type of mood-congruity effect was observed. However, since memory was not improved when subjects were in pain at both exposure and recall, Seltzer and Yarczower concluded that a state-dependency effect was not found.

In the Seltzer and Yarczower (1) study, only a recall memory test was used. Clark and Bennett-Clark purport that “recognition memory is the most sensitive way to determine the amount of material that has successfully entered long-term memory” (8, p. 196). Recognition memory tests contain a list of previously viewed “old” words and randomly mixed “new” distracter words. The subject scores a “Hit” by selecting a word that was previously viewed, and the subject scores a “False Alarm” by selecting a distracter word. One way that memory is calculated is by comparing the number of hits to the number of false alarms.

The present study sought to replicate and extend the Seltzer and Yarczower (1) study. A recognition memory test was incorporated into the research design. Additionally, the present study employed a semantic orienting task during encoding, whereas in

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METHOD

Design

Two experiments were conducted for this study. Experiment 1 employed a 2 (pain versus no pain during word exposure) x 2 (pain versus no pain during recall memory test) x 2 (positive versus negative word category) repeated measures design. Experiment 2 employed a 2 (pain versus no pain during word exposure) x 2 (pain versus no pain during recognition memory test) x 2 (positive versus negative word category) x 2 (memory for old words versus new distracter words) repeated measures design. For both experiments, subjects were randomly assigned to between-subjects groups of either pain or no pain during word exposure and pain or no pain during the memory test.

Subjects

One hundred sixty subjects were utilized (80 subjects in each experiment): 140 Caucasian, 18 African-American, and 2 Other; mean age was 19 years old. Ten subjects, who were either unable to tolerate the cold stimulus for the specified amounts of time or who did not follow instructions for the recognition memory test, were replaced by new subjects to preserve equal numbers per group. Gender distribution was proportional within each group and equally maintained across the groups (13 females and 7 males), for a total of 104 females and 56 males. Exclusionary criteria (medical conditions such as hypertension, dermatitis, diabetes, arthritis, migraine headaches, cardiovascular disease, Raynaud’s disease, previous trauma to the arm, and/or current use of pain medication) did not rule out any subjects.

Materials

Cold Pressor Apparatus: The cold pressor unit utilized in this study is modeled after the apparatus described by Turk et al. (11) who demonstrated it to be a valid pain induction technique [see Williams and Thorn (12) for a detailed description]. Water temperature was maintained at 0°C to 2°C for participants in the pain condition and 25°C to 27°C for participants in the no pain condition.

Computer Apparatus: An IBM-compatible computer with an amber monochrome monitor was used for stimulus presentation and response collection. Stimulus words were displayed in black print (5 mm in height) within an illuminated rectangle (3 cm in height and 5.2 cm in length) centered on the screen.

Stimuli: The present study used 30 positive and 30 negative words chosen from Anderson’s (13) likableness norms for trait adjectives. The positive words selected ranged from 4.71 to 5.73 on a 0-6 Likert scale. The negative words selected varied from 0.26 to 1.53 on this same scale. These stimulus words were divided into two lists containing 30 words each (15 positive and 15 negative). Participants were randomly assigned to one of the two lists for exposure during the orienting task, each subject receiving a different randomized order of the 30 words. For the recall memory test, stimulus words were not presented. For the recognition memory test, all sixty words were presented: 30 old words viewed during word exposure and 30 new distracter words from the alternative list.

Measure

Pain intensity was measured using the 101-point Numerical Rating Scale (NRS-101) (14) administered to all participants immediately after word exposure and again after the memory test. Subjects entered their pain intensity rating on the computer using a scale from 0 (“no pain”) to 100 (“pain as bad as it could be”). The NRS-101 has established reliability and validity demonstrated by its positive correlations with other measures of pain intensity (15) and its relationship to treatment outcome (16).

Procedure

Each participant, tested individually, engaged in three tasks: (a) a semantic orienting task where subjects were exposed to the word list during the first cold pressor trial, (b) a distracter task between cold pressor trials, and (c) a memory test during the second cold pressor trial.

Semantic Orienting Task: Participants were instructed that they would see a series of words and would be required to judge whether each word meant something positive or negative. For each word, participants were instructed to press the green-coded key on the number pad of the keyboard if the word was positive in nature or press the red-coded key if the word was negative in nature. Participants were not informed that they would have to remember the words later in the experiment. They then engaged in a series of four practice trials, followed by a 10-second hand submersion cold pressor pretrial. During word exposure, participants’ non-dominant hands were submerged in the cold pressor and 30 stimulus words (15 positive and 15 negative) from one of the two word lists were presented on the computer one at a time. Each word was shown for 1.5 seconds, with a 2-second interval between words, for a total task time of 1 minute and 45 seconds. The experimenter was not present during this task. Immediately after word exposure, participants removed their hand from the cold pressor and completed the pain rating scale.

Distraction Task: To deter rehearsal of stimulus words, participants were engaged in a 10-minute structured discussion, followed by another 10-second submersion pretrial. They were then given instructions for either a recall or recognition memory test for the words previously viewed during word exposure.

Memory Test: Participants’ hands were resubmerged in the cold pressor for 2 minutes and 30 seconds during the memory test. For the recall memory test, participants were given a pen and sheet of paper and asked to freely recall as many of the words presented...
TABLE 1
Means and Standard Deviations ( ) for Memory for Positive, Negative, and Total Word Categories Across Pain and No Pain Conditions at Word Exposure and Recall

<table>
<thead>
<tr>
<th>Word Exposure</th>
<th>Pain</th>
<th>No Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>Pain</td>
<td>1.10</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>(1.07)</td>
<td>(1.29)</td>
</tr>
<tr>
<td>No Pain</td>
<td>1.45</td>
<td>1.55</td>
</tr>
<tr>
<td></td>
<td>(1.19)</td>
<td>(1.36)</td>
</tr>
</tbody>
</table>

earlier as possible. For the recognition memory test, 60 stimulus words were presented, one at a time, on the computer monitor located in front of the participants. Each word was shown for 1 second, with a 1.5 second interval between words, for a total task time of 2 minutes and 30 seconds. For each word, participants were instructed to press the green-coded key on the number pad of the keyboard if the word had appeared earlier or press the red-coded key if the word had not appeared during word exposure. The experimenter was not present during either memory test. Immediately following the memory tests, participants removed their hands from the cold pressor and completed the pain rating scale.

RESULTS

Separate repeated measures analyses of variance were performed for the recognition and recall memory tests. When appropriate, post hoc analyses were performed using Fisher’s least significant difference (LSD) procedure. Harmonic interpolation was used to determine the critical t value when necessary (17). Effect sizes were obtained using Omega squared. Word List (1 versus 2) was tested as a factor in the following analyses but was not found to be significant. It was therefore eliminated as a factor.

Pain Manipulation Efficacy

Across all conditions, the mean pain rating in the pain condition was 74.11, and the mean pain rating in the no pain condition was 1.10. The distributions of these pain ratings across conditions were non-overlapping, suggesting that the pain manipulation was robust.

Experiment 1—Recall Memory Test

A 2 (pain versus no pain during word exposure) x 2 (pain versus no pain during recall memory test) within 2 (positive versus negative word category) repeated measures analysis of variance was performed for the number of words accurately recalled. A significant main effect was obtained for pain versus no pain at word exposure, $F(1,72) = 13.07, p = 0.001$, effect size = 0.11. Participants who were in pain at word exposure correctly recalled 1.75 fewer words than participants who were not in pain at word exposure. A main effect for pain versus no pain at recall was not obtained, although there was a non-significant trend in the expected direction. Word category (positive versus negative) did not differentially affect memory. There were no significant three-way or two-way interactions. Table 1 lists means and standard deviations for positive, negative, and total words recalled across conditions.

Experiment 2—Recognition Memory Test

For the recognition memory test, memory was defined as hits (words correctly recognized) minus false alarms (distractors recognized as words previously seen). This discrimination index (hits - false alarms) is suggested for use in recognition memory studies that assume a "two-high-threshold model," which makes the operational assumption that the two possible discrimination thresholds ("old recognition threshold" and "new recognition threshold") are equal (18, p. 38). A 2 (pain versus no pain during word exposure) x 2 (pain versus no pain during recognition memory test) within 2 (positive versus negative word category) repeated measures analysis of variance was performed for the number of words accurately recognized. Word category did not differentially affect memory, but exposure to pain influenced recognition. The analyses revealed a significant interaction between pain versus no pain at word exposure and pain versus no pain at the recognition memory test [$F(1,72) = 5.38, p = 0.023$, effect size = 0.12]. Post hoc analyses revealed that subjects in the no pain condition at both word exposure and recognition memory test had significantly better memory than those subjects in the other three conditions ($p < 0.05$, effect size = .05). There were no other significant interactions. Figure 1 illustrates that pain at any time during Experiment 2 diminishes memory. Table 2 lists the means and standard deviations for positive, negative, and total words accurately remembered (hits - false alarms) across conditions. Table 3 lists the means and standard deviations for hits for positive, negative, and total words across conditions. Note that memory accuracy for the no pain/no pain condition was determined mostly by fewer false alarms rather than by more hits as in the other conditions.

DISCUSSION

Pain adversely affects memory. Participants who experienced pain at any time (during word exposure or during memory test) recognized fewer words than those subjects who experienced no pain at all during any part of this study. These findings are consistent with other research using acute pain manipulations and research on chronic pain populations (4,6).

Regarding previous research investigating mood on memory by both Bower (7) and Seltzer and Yarczower (1), the results of our study found little evidence to support these models. Although our participants tended to recall and recognize fewer positive words when in pain than when not in pain during word exposure, they also tended to recall and recognize fewer negative words in this condition. Neither trend was significant. Similar to our findings, Salovey et al. (19) failed to find effects for mood influences on acute pain reporting in a normal (non-chronic pain) population. Also, Pearce et al. (4) reported that pain state did not differentially affect memory for negative and/or pain-related words in cold pressor subjects. Any reader would most likely agree that pain consists of more than just a negative mood. As such, the effects of pain on memory would be expected to be more complex than, and perhaps different from, the effects elicited from experimental manipulation of mood on memory.

Although our results do not show a clear state-dependent memory effect, the interference with processing caused by pain is not simply additive. Seltzer and Yarczower (1) found no evidence for state-dependent memory using a recall memory test. Our results using a recognition memory test suggest the possibility of a state-dependent memory effect in addition to the diminished attention effects reported. If the reduced attention effect of pain
FIGURE 1: Pain at any time during Experiment 2 (Recognition Memory Test) diminishes memory.

TABLE 2
Means and Standard Deviations (SD) for Memory (Hits Minus False Alarms) for Positive, Negative, and Total Word Categories Across Pain and No Pain Conditions at Word Exposure and Recognition

<table>
<thead>
<tr>
<th>Word Exposure</th>
<th>Pain</th>
<th>No Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Words</td>
<td>7.05 (2.70)</td>
<td>6.80 (3.49)</td>
</tr>
<tr>
<td>Negative Words</td>
<td>7.25 (2.65)</td>
<td>7.25 (3.34)</td>
</tr>
<tr>
<td>Total Words</td>
<td>14.30* (4.23)</td>
<td>14.05* (6.06)</td>
</tr>
<tr>
<td>Recognition</td>
<td>6.55 (3.62)</td>
<td>9.60 (3.91)</td>
</tr>
<tr>
<td>Positive Words</td>
<td>7.60 (3.91)</td>
<td>9.75 (4.07)</td>
</tr>
<tr>
<td>Negative Words</td>
<td>14.15* (6.75)</td>
<td>19.35** (4.07)</td>
</tr>
</tbody>
</table>

Note: Subjects in pain at any time during the experiment (*) recognized significantly fewer words relative to subjects in no pain (**), p < .05.

State-dependency notwithstanding, we propose that the task of processing pain is a demanding one, draining from a limited pool of attentional resources. Pain at either encoding or retrieval decreases memory performance, suggesting that some important mental process involved in memory is at work. These components of memory require mental effort or attention. The major theories of attention suggest that persons have a limited capacity or pool of attention; if extra attention is given to one stimulus, there is less available to devote to a concurrent task. Our interpretation of these data is that pain is a very powerful stimulus that demands attention, leaving fewer resources available for encoding words into memory and fewer resources available for searching memory during retrieval. This phenomenon would cause impaired memory in both conditions.

Experiments on divided attention (DA) have demonstrated that engaging in simultaneous tasks adversely affects one's performance on these tasks (10,20). Most DA studies use tasks other than pain processing as one of the competing tasks, two exceptions being Walker (21) and Eccleston (22). Eccleston found that patients with high-intensity chronic pain showed a detriment in performance on a numerical interference task when compared to non-pain control subjects or patients with low-intensity chronic pain. Walker used experimentally manipulated pain concurrently with a perceptual motor distraction task to explore whether the distracter would influence pain perception. She found that although the distracter task did not affect pain perception, performance of the task was impaired when subjects were experiencing pain.

It is yet unclear whether the intensity of perceived pain has a direct relationship to task interference. Eccleston (22) used chronic pain patients and therefore did not manipulate pain intensities. Walker (21) experimentally manipulated pain, but did not correlate the level of perceived pain intensity with perceptual–motor task...
A regression analysis of our data using pain ratings as the predictor variable and memory as the criterion variable demonstrated a significant negative correlation ($r^2 = -0.335, p = .002$). Thus, perceived pain intensity may interfere, in a dose-response fashion, with competing task performance.

The nature of the relationship between pain and competing task performance is worthy of further research. Studies which demonstrate that pain interferes with the ability to process information (e.g., to think, remember, reason) would provide converging evidence for the hypothesis that pain depletes scarce attentional resources. It is premature to imply that the results of this study speak to the mechanisms behind the cognitive and behavioral dysfunction suffered by individuals experiencing chronic pain. Indeed, it is not yet known whether memory impairment experienced by chronic pain patients is unique to the pain state itself or common to the experience of patients with chronic medical problems. Nonetheless, the results of this study provide further clarification of the effects of acute pain on memory and point to the need for more research using clinical pain populations.

REFERENCES