Emotional Perception and Memory in Amnesia

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The authors examined whether perception of emotional stimuli is normal in amnesia and whether emotional arousal has the same enhancing effect on memory in amnesic patients as it has in healthy controls. Forty standardized color pictures were presented while participants rated each picture according to emotional intensity (arousal) and pleasantness (valence). An immediate free-recall test was given for the pictures, followed by a yes-no recognition test. Arousal and valence ratings were highly similar among the amnesic patients and controls. Emotional arousal (regardless of valence) enhanced both recall and recognition of the pictures, and this enhancement was proportional for amnesic patients and controls. Results suggest that emotional perception and the enhancing effect of emotional arousal on memory are intact in amnesia.

Many studies have indicated that emotional material is more memorable than neutral material (Christiansen & Loftus, 1987; Craik & Blankstein, 1975; Heuer & Reisberg, 1990; Matlin & Stang, 1978). The primary factor underlying the effect of emotion on memory appears to be emotional arousal, independent of whether the arousal is pleasant or unpleasant. In studies of nonhuman animals, emotional arousal has been demonstrated to affect memory through the interaction of peripheral adrenergic systems with cholinergic, opioid peptidergic, and GABAergic systems in the amygdala (McGaugh et al., 1993). The amygdala also has been implicated in fear conditioning (Davis, 1994; LeDoux, 1993).

Although emotional arousal also can benefit memory by its effects on cognition (e.g., increased attention, deeper elaborative processing), the enhanced memory associated with physiological arousal is independent of these cognitive factors and can be dissociated experimentally from them. Thus, a recent study in humans (Cahill, Prins, Weber, & McGaugh, 1994), involving memory for an illustrated story, demonstrated that the memory facilitation associated with emotional arousal was selectively abolished by propranolol, a β-adrenergic antagonist. Yet, participant ratings of the emotional arousal produced by the story were unaffected by the drug.

Several studies of experimental animals indicate that the amygdala is involved in the enhancing effects of emotion on memory (McGaugh et al., 1993). Findings from a patient with bilateral lesions apparently restricted to the amygdala (Cahill, Babinsky, Markowitsch, & McGaugh, 1995) are consistent with evidence from experimental animals. Using the same emotional memory task as in the study with the β-adrenergic antagonist (Cahill et al., 1994), this patient failed to benefit from emotional arousal, suggesting that the amygdala plays a crucial role in mediating the memory facilitation effect in humans.

Bradley, Greenwald, Petry, and Lang (1992) examined the effect of arousal (emotional intensity) and valence (pleasantness) on memory in college students, systematically examining the relative influence of each factor on memory. Stimuli were drawn from the International Affective Picture System (IAPS; Lang, Ohman, & Vaitl, 1988), a standardized set of color slides depicting a wide variety of naturalistic subjects that spans a wide range of affective reactions. The primary finding was that the effect of emotion on memory (both recall and recognition) was mediated by arousal rather than valence. Specifically, after the effect of emotional arousal had been partialed out, there was virtually no effect of stimulus valence (pleasantness) on memory. This study and others (Lang, Bradley, & Cuthbert, 1990; Russell, 1980) have validated the dimensional approach to measuring emotion (arousal and valence). We have adopted the same dimensional approach in the current study.

Here, we examined whether the effects of emotion on memory would be observed in patients with amnesia. Little is known about the effect of emotion on memory in amnesic patients or even whether the emotional reactions and emotional perceptions of amnesic patients are normal (however,
see Hamann et al., 1996). Reports of emotional reactivity in the amnesic syndrome have focused almost exclusively on patients with alcoholic Korsakoff’s syndrome (Rapaport, 1961; Talland, 1967). Although these reports concur in characterizing the emotional responses of patients with Korsakoff’s syndrome as abnormal, they differ in their descriptions of the patients. Some patients are described as having reduced reactivity to emotional stimuli (sometimes referred to as flattened or blunted affect), whereas other reports characterize other patients as overly irritable and hyperarousable. Similarly, the few experimental studies of emotional reactivity in amnesic patients with Korsakoff’s syndrome (Douglas & Wilkinson, 1993; Markowitsch, Kessler, & Denzler, 1986; Oscar-Berman, Hancock, Mildworf, Hutner, & Weber, 1990) have yielded inconsistent results. Some researchers have found their reactions normal (Douglas & Wilkinson, 1993), whereas others have found them either less reactive (Markowitsch et al., 1986) or more reactive (Oscar-Berman et al., 1990) than controls. The interpretation of these studies is complicated because different measures and materials were used to assess reactivity (e.g., self-reported ratings, skin conductance response, assessment only of negative emotions).

Apart from the issue of emotional perception in amnesia, the issue of whether the effect of emotional arousal on memory is normal or abnormal. A normal effect of emotional arousal on memory in amnesia would be consistent with two notions: First, the brain structures that mediate the effect of emotional arousal on memory (e.g., the amygdala) modulate declarative memory (McGaugh et al., 1993). Second, these modulatory brain structures are distinct from the medial temporal lobe structures important for declarative memory (Squire & Zola-Morgan, 1991). Alternatively, the effect of emotional arousal on memory may be abnormal in amnesia because the perception or expression of emotion is itself impaired in amnesia.

The purpose of the current study was to examine whether emotional perception is intact or impaired in amnesia and to determine whether amnesic patients, like normal individuals, exhibit better memory for emotionally arousing material than neutral material. Perceptions and memory was assessed using the standardized IAPS picture stimuli (Lang et al., 1988) in a group of 9 amnesic patients, 2 postencephalitic amnesic patients who were amnesic but also had damage to the amygdala, and two groups of controls. Participants rated 40 pictures individually for emotional arousal and valence and were given a free-recall test for pictures they had viewed, followed by a yes–no recognition test.

The first group of controls (n = 12) was administered the same test procedure as the amnesic patients (n = 9) and the postencephalitic patients (E. P. and G. T.). The second group of controls (control-delay; n = 12) was given a longer interval between the end of the study phase and the memory tests. The purpose of the delay was to bring the control-delay group’s level of memory performance into the amnesic patients’ range. This condition was important because it was possible that the effect of emotional arousal on memory would differ depending simply on whether the overall level of memory was high or low (e.g., in the control and the amnesic groups, respectively).

The first question of interest was whether the ratings of amnesic patients for the emotional stimuli would be normal or abnormal. The second question was whether the effect of emotional arousal on memory in these patients would be normal or abnormal. Another question concerned whether the patients with Korsakoff’s syndrome would exhibit abnormal emotional reactions, as previous reports have described, and whether their reactions would differ from those of other amnesic patients. This was of interest partly because patients with Korsakoff’s syndrome sometimes have frontal lobe dysfunction along with their memory deficits, and frontal lobe dysfunction has been linked to emotional deficits (Stuss, Gow, & Hetherington, 1992). Finally, the emotional reactions and the effects of arousal on memory were of particular interest in the case of the 2 postencephalitic amnesic patients with amygdala damage because of the links among amygdala, emotion, and emotional memory.

**Method**

**Participants**

*Amnesic patients.* Nine amnesic patients (6 men and 3 women) participated in this study. Four patients had Korsakoff’s syndrome. All 4 had participated in quantitative magnetic resonance imaging (MRI), which demonstrated reductions in the volume of the mammillary nuclei (for R. C., J. W., and P. N., Squire, Amaral, & Potter, 1990; for N. F., unpublished observations). A 5th patient (M. G.) sustained a bilateral medial thalamic infarction, which was confirmed by MRI. Of the remaining 4 patients, 3 had bilateral reduction in the size of the hippocampal formation confirmed by MRI (for P. H., Squire et al., 1990; for L. J. and H. W., unpublished observations). Patient P. H. had a 6-year history of 1- to 2-min attacks (of possible epileptic origin) in association with gastric symptoms and transient memory impairment. In 1989 he suffered a series of small attacks that resulted in marked and persisting memory impairment. Patient L. J. became amnesic gradually during 1988 and 1989 without any known precipitating event. Her memory impairment has remained stable since that time. Patient H. W. became amnesic gradually in 1987 and has remained stable for about 7 years. Slight declines in other cognitive functions were noted in 1994 and 1995, leading to a diagnosis of probable Alzheimer’s disease. The 4th patient (A. B.) was unable to participate in MRI studies, but the etiology of his amnesia (anoxia) is consistent with hippocampal damage. All 9 patients were well-characterized neuropsychologically (see Tables 1 and 2).

The patients’ mean age was 63.4 years at the beginning of the study, and they had an average of 13.6 years of education. Immediate and delayed (12-min) recall of a short prose passage averaged 4.0 and 0 segments, respectively (Gilbert, Levee, & Catalano, 1968; maximum number of segments = 21). Scores on other memory tests are shown in Tables 1 and 2. The mean score on the Dementia Rating Scale was 131.8 (Mattis, 1976; maximum score = 144), with most points being lost from the Memory subscale (mean points lost = 7.3). The mean score for the Boston Naming Test was 56.0 (Kaplan, Goodglass, & Weintraub, 1983; maximum score = 60). The number of categories completed on the Wisconsin Card Sorting Test (Heaton, 1995) for Patients R.C., N.F., P.N., J. W., M. G., H. W., A. B., P. H., and L. J. were 4, 5, 5, 4, 2, 5, 5, and 6, respectively. Scores for controls on these tests can be
found elsewhere (Janowsky, Shimamura, & Squire, 1989; Squire et al., 1990).

Patients E. P. and G. T. Two additional patients (E. P. and G. T., both postencephalitic patients) also were tested. These 2 patients are considered separately from the amnesic group both because their amnesia was more severe than that of the other amnesic patients and because both patients had sustained bilateral damage to the amygdaloid complex, which has been linked to emotion and emotional memory in humans and experimental animals (Cahill et al., 1995; LeDoux, 1993).

Patient E. P. sustained extensive bilateral medial temporal lobe damage, confirmed by MRI (Squire & Knowlton, 1995), which included the hippocampus, perirhinal and parahippocampal cortices, the amygdaloid complex, and the inferotemporal gyrus. Aside from his profound amnesia, E. P. also is anomic, scoring 42 of 60 on the Boston Naming Test (normal score > 50; Kaplan, Goodglass, & Weintraub, 1983). E. P. also exhibited some behavioral evidence of frontal lobe dysfunction: On the Wisconsin Card Sorting Test, 0 categories were sorted, and there were 51% perseverative errors (Heaton, 1995); on the FAS Test of Word Fluency, 18 words were produced, which fell below the 15th percentile (Benton & Hamsher, 1976).

G. T. sustained extensive bilateral temporal lobe damage confirmed by MRI (Hamann et al., 1996). The damage extended

Table 1
Characteristics of Amnesic Patients

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Lesion</th>
<th>WAIS-R</th>
<th>WMS-R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Attention</td>
<td>Verbal</td>
</tr>
<tr>
<td>R.C.</td>
<td>76</td>
<td>Dien</td>
<td>106 115</td>
<td>76</td>
</tr>
<tr>
<td>N.F.</td>
<td>57</td>
<td>Dien</td>
<td>94</td>
<td>91</td>
</tr>
<tr>
<td>P.N.</td>
<td>65</td>
<td>Dien</td>
<td>99</td>
<td>81</td>
</tr>
<tr>
<td>J.W.</td>
<td>56</td>
<td>Dien</td>
<td>98</td>
<td>104</td>
</tr>
<tr>
<td>M.G.</td>
<td>60</td>
<td>Dien</td>
<td>111</td>
<td>113</td>
</tr>
<tr>
<td>H.W.</td>
<td>77</td>
<td>HF</td>
<td>109</td>
<td>97</td>
</tr>
<tr>
<td>A.B.</td>
<td>55</td>
<td>HF</td>
<td>104</td>
<td>87</td>
</tr>
<tr>
<td>P.H.</td>
<td>70</td>
<td>HF</td>
<td>115</td>
<td>117</td>
</tr>
<tr>
<td>L.J.</td>
<td>55</td>
<td>HF</td>
<td>98</td>
<td>105</td>
</tr>
<tr>
<td>M</td>
<td>63.4</td>
<td>HF</td>
<td>103</td>
<td>101.1</td>
</tr>
<tr>
<td>G.T.</td>
<td>59</td>
<td>HF</td>
<td>92</td>
<td>120</td>
</tr>
<tr>
<td>E.P.</td>
<td>73</td>
<td>HF</td>
<td>103</td>
<td>94</td>
</tr>
<tr>
<td>M</td>
<td>66.0</td>
<td>97.5</td>
<td>107.0</td>
<td>57.0</td>
</tr>
</tbody>
</table>

Note. The WAIS-R and the WMS-R indexes yield a mean score of 100 in the normal population, with a standard deviation of 15. The WMS-R does not provide scores for those who score below 50. Therefore, the six scores below 50 were scored as 50 for calculating a group mean. WAIS-R = Wechsler Adult Intelligence Scale—Revised; WMS-R = Wechsler Memory Scale—Revised. Dien = diencephalon; HF = hippocampal formation; HF+ = hippocampal formation and additional brain structures.

Table 2
Memory Test Performance

<table>
<thead>
<tr>
<th>Patient</th>
<th>Diagram recall</th>
<th>Paired associates</th>
<th>% Word recall</th>
<th>% Word recognition</th>
<th>50 words</th>
<th>50 faces</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.C.</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>19</td>
<td>85</td>
<td>37</td>
</tr>
<tr>
<td>N.F.</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>36</td>
<td>76</td>
<td>28</td>
</tr>
<tr>
<td>P.N.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>29</td>
<td>83</td>
<td>31</td>
</tr>
<tr>
<td>J.W.</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>28</td>
<td>96</td>
<td>29</td>
</tr>
<tr>
<td>M.G.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>71</td>
<td>39</td>
</tr>
<tr>
<td>H.W.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>31</td>
<td>85</td>
<td>23</td>
</tr>
<tr>
<td>A.B.</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>33</td>
<td>83</td>
<td>32</td>
</tr>
<tr>
<td>P.H.</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>27</td>
<td>84</td>
<td>33</td>
</tr>
<tr>
<td>L.J.</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>93</td>
<td>33</td>
</tr>
<tr>
<td>M</td>
<td>3.2</td>
<td>0.2</td>
<td>0.3</td>
<td>1.4</td>
<td>30.7</td>
<td>84.0</td>
</tr>
<tr>
<td>G.T.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>70</td>
<td>27</td>
</tr>
<tr>
<td>E.P.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>65</td>
<td>19</td>
</tr>
<tr>
<td>M</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>22.0</td>
<td>67.5</td>
</tr>
<tr>
<td>Control</td>
<td>20.6</td>
<td>6.0</td>
<td>7.6</td>
<td>8.9</td>
<td>71</td>
<td>98</td>
</tr>
</tbody>
</table>

Note. The diagram recall score is based on delayed (12-min) reproduction of the Rey-Osterrieth figure (Osterrieth, 1944; maximum score = 36). The average score for copying the figure was 28.8, a normal score (Kritchevsky et al. 1988). The paired-associate scores are the number of word pairs recalled on three successive trials (maximum score = 10/trial). The word recall score is the percentage of 15 words identified correctly on five successive study–test trials (Rey, 1964). The word recognition score is the percentage of 15 words identified correctly by yes–no recognition across five successive study–test trials. The scores for words and faces are based on 24-hr recognition tests of 50 words or 30 faces (modified from Warrington, 1984; maximum score = 50, chance = 25). The mean scores for healthy controls and alcoholics shown for these tests are from Squire and Shimamura (1986).
through the anterior 7.0 cm of his left temporal lobe and the anterior 5.0 cm of his right temporal lobe. The lesion included bilaterally the hippocampus; entorhinal, perirhinal, and parahippocampal cortices; the amygdaloid complex; and the inferior, middle, and superior temporal gyri. In addition to his profound amnesia, G. T. is also anomic, scoring 18 of 60 on the Boston Naming Test (normal score > 50; Kaplan et al., 1983).

Patients E. P. and G. T. were 72 and 59 years of age, respectively, at the beginning of the study, and each had 12 years of education. Immediate and delayed (12-min) recall of a short prose passage averaged 1.5 and 0 segments, respectively (Gilbert et al., 1968; maximum number of segments = 21). Scores on other memory tests are shown in Tables 1 and 2. The mean score on the Dementia Rating Scale was 112.0 (Mattis, 1976; maximum score = 144), with most points being lost from the Memory subscale (mean points lost = 16.0).

Control groups. The control and control delay groups were employees or volunteers at the San Diego Veterans Affairs Medical Center or were recruited from the retirement community of the University of California, San Diego. The control group consisted of 6 men and 6 women who were selected to match the amnesic patients with respect to the mean and range of their ages, years of education, and scores on the Information and Vocabulary subtests of the Wechsler Adult Intelligence Scale—Revised (WAIS–R; Wechsler, 1981). They averaged 64.7 years of age (range = 55–73), 13.6 years of education, and 20.4 and 53.0 on the Information and Vocabulary subtests, respectively (amnesic patients = 18.1 and 51.4, respectively). Immediate and delayed recall of the short prose passage averaged 6.7 and 5.0 segments, respectively.

An additional control group (control-delay) was tested after a longer delay than that of the control group to bring their level of memory performance into the performance range of the amnesic patients. This group consisted of 6 men and 6 women selected to match the amnesic patients with respect to the mean and range of their ages, years of education, and scores on the Information and Vocabulary subtests of the WAIS–R. They averaged 63.2 years of age (range = 53–72), 14.6 years of education, and 21.9 and 54.6 on the Information and Vocabulary subtests, respectively (amnesic patients = 18.1 and 51.4, respectively). Immediate and delayed recall of the short prose passage averaged 7.1 and 6.3 segments, respectively.

Materials and Procedure

The experiment consisted of a ratings phase, in which participants rated the emotionality of 40 color slides; a free-recall test, in which participants attempted to recall the 40 slides they had seen; and a yes–no recognition test in which 20 of the slides they had seen were presented, together with 20 different distractor slides. Finally, ratings of emotionality were collected for the 20 slides that had served as distractor items in the recognition test.

Sixty color slides depicting various scenes and subject matter were selected from the IAPS (Lang et al., 1988) to sample a wide range of emotional content. The majority of these slides also had been used as stimuli in the Bradley et al. (1992) study. The procedure for the three groups was identical, except that the amnesic and control groups were tested in a single session and the control-delay group was tested with a 2-week delay between the ratings phase and the other tests. After the 2-week delay, those in the control-delay group were reminded that they had seen a slide presentation in the previous session 2 weeks earlier. They were also informed that the memory tests they would be taking would concern the slides presented in that session.

Ratings phase. Slides were presented on a carousel slide viewer. Participants were informed that they would be viewing a series of pictures and that they were to rate each picture according to the feeling they experienced while viewing it. No mention was made of the memory tests that would follow.

Participants rated each of the 40 slides on two dimensions, arousal (emotional intensity) and valence (degree of pleasant or unpleasant affect), using the self-assessment mannequin (SAM) rating system (Hodes, Cook, & Lang, 1985; Lang, 1980; see Figure 1). Arousal and valence each were assessed with the help of five mannequin figures. Participants recorded their ratings by placing an X on or between any of the five figures, which resulted in a possible range of responses from 1 to 9. In the case of the arousal dimension, the appearance of the corresponding SAM figures ranged from having an inactive body and eyes wide open to having an active body and closed eyes (see Figure 1). In the case of the valence dimension, the appearance of the corresponding SAM figures ranged from smiling with raised eyebrows to frowning with knitted eyebrows (see Figure 1). Participants’ ratings of emotion using these two self-report scales have been demonstrated to covary.

Figure 1. Scales used for arousal (top) and valence (bottom) ratings. For arousal, the scale assessed the degree of emotional intensity. For valence, the scale assessed the degree of pleasant or unpleasant affect.
The two ratings scales were displayed on each page of a ratings booklet (one page for each of 40 slides). For half the participants, the upper scale assessed the arousal dimension and the lower scale assessed the valence dimension; for the other half, the scales were reversed. Because few ratings were placed between the mannequin figures, the 9-point scale was transformed into a 5-point scale for scoring, as described by Bradley et al. (1992).

Practice was given in the ratings procedure using two slides that did not otherwise appear in the study (a slide of an umbrella and a slide of a chocolate bar). Participants were informed that for each slide they would have 12 s to make both ratings and that they should attempt to record their initial emotional reaction to each picture. It was emphasized further that they should try to use the whole range of the ratings scale and that each rating should be made on the basis of their true feelings.

To begin, the first practice slide was presented. After 12 s had elapsed, the projector was advanced to a blank slide until the participant was ready to rate the second practice slide. After the two practice slides were rated, and additional instruction in the ratings procedure was given if needed, the ratings phase proceeded in the same manner as the practice phase. A card explaining the arousal and valence ratings scales was always in view. In addition, the amnesic patients were reminded periodically during the ratings phase of the ratings procedure about the meaning of the ratings scales.

For the ratings phase, the 40 slides were presented in a different random order for each participant. Slides always were presented for the full 12 s, even when both ratings were completed quickly. In the few cases in which the ratings were not completed within 12 s, the projector was advanced to the blank slide and the participant completed the ratings.

Recall test. When the ratings phase ended, participants were tested for recall of the slides. They were instructed to write down in any order a word or phrase describing each picture they remembered. They were told that they would be given 5 min to complete this test.

Recognition test. After the free-recall test, a recognition test was given in which 20 of the pictures presented in the ratings phase were presented again as recognition targets together (in a pseudorandom order) with 20 new distractor pictures that matched the targets with respect to arousal, valence, and subject matter (using the values for arousal and valence reported by Lang et al., 1988). All 40 pictures in the recognition phase were digitized and presented on a Macintosh Color Classic II computer. Each picture measured 12 x 8 cm.

Participants were told that pictures would appear one at a time on the computer screen, some of which had been presented in the earlier ratings phase. If the picture had appeared in the ratings phase, they were to press the button labeled yes (the z key for half the participants and the / key for the other participants). Otherwise, they were to press the button labeled no (the / key for half of the participants and the z key for the other participants). Participants were instructed to attempt to be as accurate as possible but to respond as soon as they had decided because response times were being recorded. The recognition test began approximately 7 min after the end of the ratings phase. Each picture remained on the screen until the participant pressed the yes or no key. Pressing either key replaced the picture with a blank screen, which, after 2 s, was followed by the next picture.

Final ratings phase. After the end of the recognition test, the 20 slides that had served as distractor items in the recognition test were rated for arousal and valence, using the same procedure as in the initial ratings phase.

Results

Arousal and Valence Ratings for the 60 Slides

The arousal and valence ratings for the 60 slides were evaluated for the amnesic group, Patients E. P. and G. T., the control group, the control-delay group, and a normative sample of 87 undergraduates reported previously (Lang et al., 1988). First, correlations were calculated between groups for both arousal and valence ratings to determine whether the groups gave the 60 slides the same pattern of ratings. All correlations were significant at the .0001 level (df = 58). Correlations were obtained by first calculating the mean rating given each slide by all participants in each group and then calculating for each pair of groups the correlation between the mean ratings given the 60 slides. The Pearson product-moment correlations for mean arousal ratings among the amnesic, control, control-delay, and normative sample groups ranged from .63 to .74, and the correlations for the mean valence ratings ranged from .81 to .93. Patients E. P. and G. T. gave arousal and valence ratings similar to the other groups (the correlations for mean arousal ratings between E. P. and G. T. and the other groups ranged from .35 to .49, ps < .01; for valence, the correlations ranged from .78 to .84, ps < .0001). Although the groups assigned similar patterns of ratings to the 60 slides, these groups (except for the control-delay group) rated the 60 slides slightly higher on the arousal dimension than did the normative sample (see Tables 3 and 4), t(59) = 8.87, p < .0001, for the amnesic group; t(59) = 7.91, p < .0001, for Patients E. P. and G. T.; and t(59) = 2.11, p < .04, for the control group. These differences may be because the participants in the current study were older than the undergraduates in the normative sample. In addition, the amnesic group rated the 60 slides slightly higher on the arousal dimension than did the control group or the control-delay group (see Tables 3 and 4), t(59) > 6.84, ps < .0001. For the valence dimension, the amnesic group rated the 60 slides similarly to the normative sample group, t(59) = 0.05, and the control-delay group, t(59) = 0.84, but higher than the control group, t(59) = 2.47, p < .02. Patients E. P. and G. T. rated the 60 slides similarly to the ratings of the amnesic group, t(59) < 1.53, for arousal and valence.

Recall of 40 Slides

Free-recall responses were scored by comparing each participant’s written descriptions with the characteristics of the 40 target recall slides. Two independent judges rated a response correct if it could be linked clearly to a particular slide that had been shown. Responses were not scored as correct if they matched more than one slide (i.e., if the response was not sufficiently specific to identify one particular slide). The majority of responses (87%) were scored as correct or incorrect by both judges. Scoring conflicts between the two judges (13% of the responses) were resolved by a third independent judge.
The recall results were analyzed according to the arousal score given each slide. The 40 target recall slides were rank ordered for each participant according to each participant's arousal ratings. (The ranks for slides given identical arousal ratings by the participant were decided on the basis of the arousal means for the participant's group.) Figure 2 shows the results for the amnesic, control, and control-delay groups. Neither E. P. nor G. T. was able to recall any studied slides. Table 3 shows the mean arousal ratings that corresponded to each arousal quartile in Figure 2.

A mixed-factorial analysis of variance (ANOVA) was first conducted with group (amnesic vs. control) as the between-subjects variable and arousal quartile as the within-subjects variable. The proportion of correctly recalled slides was the dependent variable. There was an effect of group, $F(1, 19) = 64.29, MSE = 0.022, p < .0001$, and of arousal, $F(3, 57) = 8.10, MSE = 0.012, p < .0001$, but no interaction between group and arousal, $F(3, 57) < 1$. Thus, the amnesic group was impaired relative to the control group, and both groups showed a similar beneficial effect of arousal on recall.

Next, the same analysis was conducted between the amnesic group and the control-delay group. There was an effect of arousal, $F(3, 57) = 7.09, MSE = 0.010, p < .001$, but no effect of group, $F(1, 19) = 1.52, MSE = 0.015, p > .23$, and no interaction between group and arousal, $F(3, 57) < 1$. The failure to find a Group × Arousal interaction argues against the possibility that the absence of the same interaction in the amnesic versus control group comparison was attributable to the markedly different levels of recall.

Next, the effect of arousal on recall was examined separately in each group across arousal quartiles. For the amnesic group, the effect of arousal on recall was not significant, $F(3, 24) = 1.84, MSE = 0.013, p = .17$. A test for the presence of a linear trend across arousal quartiles for recall in the amnesic group fell short of significance ($p < .09$). The effect of arousal on recall was significant for both the control group, $F(3, 33) = 8.03, MSE = 0.012, p < .001$, and the control-delay group, $F(3, 33) = 7.05, MSE = 0.009, p < .001$.

Recognition of 20 Slides

The recognition data were analyzed according to whether a slide belonged to the low- or high-arousal category. The 20 target and 20 distractor recognition test slides were rank ordered for each participant according to each participant's arousal ratings. (The ranks for slides given identical arousal ratings were decided on the basis of the arousal means for the participant's group.) The 10 slides in each set (target or distractor) given the highest ratings were designated as high-arousal slides; the other 10 were designated as low-arousal slides. The recognition data were partitioned into two arousal categories (low and high arousal) rather than into quartiles (as with the recall data), so that the same number (10) of slides were in each arousal category for both the recall and recognition data.

Figure 3 shows the proportion of recognition hits and false alarms (FAs) for the amnesic, control, and control-delay groups as a function of arousal score. Table 4 shows the mean arousal ratings that corresponded to the low- and high-arousal categories in Figure 3.

Three mixed-factorial ANOVAs were conducted with group (amnesic vs. control) as the between-subjects variable, arousal (low vs. high) as the within-subjects variable, and proportion of hits, FAs, and corrected recognition scores as the dependent measures, respectively. The amnesic group was impaired relative to the control group on all three measures. For all three measures, there was an effect of
Figure 2. Recall scores for 40 slides obtained by the control (CON; n = 12), amnesic (AMN; n = 9), and control-delay (CON-DELAY; n = 12) groups as a function of the arousal score given each slide (first, second, third, or fourth quartile). Error bars indicate the standard error of the mean.

Next, the same analysis was conducted between the amnesic group and the control-delay group. Memory performance was similar in both groups. There was no effect of group for hits, FAs, or corrected recognition scores, F(1, 19) < 1.60. The effect of arousal was significant for hits and corrected recognition scores, F(1, 19) > 8.3, and there was no Group × Arousal interaction (F(1, 19) < 1.02). The absence of a Group × Arousal interaction argues against the possibility that the absence of the same interaction in the amnesic versus control group comparison was attributable to differing levels of recognition performance or to ceiling effects in the control group.

After these group comparisons, the effect of low versus high arousal on hits, FAs, and corrected recognition was examined separately in each group. For the amnesic group, there was a marginal effect of arousal on hits, t(8) = 1.94, p < .09, no effect on FAs, t(8) = 1.64, p > .14, and an effect on corrected recognition scores, t(8) = 2.64, p < .05. For the control group, there was a marginal effect of arousal on hits, t(11) = 2.16, p < .054, no effect on FAs, t(11) = 1.60, p > .14, and a marginal effect on corrected recognition scores, t(11) = 2.06, p < .06. For the control-delay group, there was an effect of arousal on hits, t(11) = 2.20, p < .05, no effect on FAs (p > .1), and an effect on corrected recognition scores, t(11) = 3.36, p < .01.

Recognition performance for Patients E. P. and G. T. was near floor, at an overall level only marginally above chance (hit rates and FAs were converted to d'): mean d' = .54, t(1) = 3.92 against 0, p < .08 (one-tailed test). The mean hit rate was .40 ± .00 and .55 ± .05 for the low- and high-arousal slides, respectively; the corresponding FA rates were .10 ± .00 and .45 ± .05, respectively. In contrast to the amnesic, control, and control-delay groups, who showed a memory benefit from arousal, the corrected recognition scores of Patients E. P. and G. T. were (nonsignificantly) lower for high-arousal slides than for low-arousal slides (.10 ± .10 and .30 ± .00, respectively).

Effects of Valence

Valence had virtually no effect on memory, independent of arousal scores. This result is understandable given the
Reaction Time Analysis

To analyze the recognition reaction time data, for each arousal and valence ratings for the high- and low-valence slides were obtained. In previous studies (Bradley et al., 1992; Lang et al., 1988). Specifically, both highly unpleasant (low-valence) and highly pleasant (high-valence) slides were rated as being more arousing than neutral slides.

As a result, when the slides in each arousal category (four arousal categories in the case of the recall test and two in the case of recognition) were partitioned for each participant into equal numbers of high- and low-valence slides, the arousal ratings for the high- and low-valence slides were the same. Moreover, when valence was included as a variable in the ANOVAs that had been carried out to analyze the recall and recognition test results, no main effects of valence were obtained. In addition, there were no interactions involving valence and the group variable.

Perception and Memory in Amnesia

Table 5

<table>
<thead>
<tr>
<th>Group</th>
<th>Low arousal</th>
<th>High arousal</th>
<th>Low arousal</th>
<th>High arousal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1,119 ± 206</td>
<td>963 ± 84</td>
<td>1,052 ± 86</td>
<td>1,178 ± 100</td>
</tr>
<tr>
<td>Control-delay</td>
<td>1,427 ± 110</td>
<td>1,663 ± 145</td>
<td>1,843 ± 115</td>
<td>2,269 ± 178</td>
</tr>
<tr>
<td>Amnesic</td>
<td>1,360 ± 149</td>
<td>1,292 ± 122</td>
<td>1,435 ± 143</td>
<td>1,722 ± 192</td>
</tr>
<tr>
<td>Patients E. P. and G. T.</td>
<td>3,282 ± 1,277</td>
<td>2,256 ± 176</td>
<td>3,101 ± 1,888</td>
<td>2,739 ± 1,511</td>
</tr>
</tbody>
</table>

Note. Numbers are means and the standard errors of the means. The low- and high-arousal categories were constructed by rank ordering slides according to each participant’s arousal ratings. Each arousal category contained 10 slides. Only reaction times for correct responses (hits and false alarms) were analyzed.

Comparison of Patients With and Without Korsakoff’s Syndrome

The performance of the 5 patients with Korsakoff’s syndrome on emotional ratings of the 60 slides and on the recall and recognition tests was compared with the performance of the 4 non-Korsakoff amnesic patients. The two groups rated the 60 slides similarly overall for both arousal (3.53 ± .11 vs. 3.66 ± .08 for the Korsakoff and non-Korsakoff patients, respectively), t(59) = 1.60, p > .11, and for valence (3.16 ± .16 vs. 3.15 ± .15 for the Korsakoff and non-Korsakoff patients, respectively), t(59) < 1. Furthermore, the pattern of ratings across the 60 slides was highly similar between the two groups (rs = .71 for between groups on arousal ratings, p < .0001, and .83 for valence ratings, p < .0001).

To compare memory performance between the two groups, we conducted four mixed-factorial ANOVAs with proportion correct recall, recognition hits, FAs, and corrected recognition score as the dependent variables. The between-subjects variable for each ANOVA was subject group, and the within-subjects variables were arousal and valence. The Korsakoff amnesic patients performed similarly to the non-Korsakoff patients on each measure, with no effects of group or interactions involving group and the arousal or valence variables. The exception was a three-way interaction of group, arousal, and valence for recognition hits, F(1, 7) = 28.64, MSe = 0.004, p < .01. This interaction reflected the fact that the amnesic patients with Korsakoff’s syndrome in general had a slightly lower proportion of hits than the non-Korsakoff patients, except for highly arousing, pleasant slides. For these slides, the patients with Korsakoff’s syndrome outperformed the non-Korsakoff patients (.84 ± .08 vs. .65 ± .17 correct, respectively).

General Discussion

We examined whether perception of emotional stimuli is normal in amnesia and whether emotional arousal has the same enhancing effect on memory in amnesic patients as it has in healthy controls. With respect to perception of emotional stimuli, the amnesic group, as well as amnesic Patients E. P. and G. T., rated the 60 slides similarly to our controls and the normative sample originally reported by Lang et al. (1988). The amnesic group and Patients E. P. and...
G. T. did tend to give higher arousal and valence ratings to the slides than did controls and the normative sample group, but these differences were small (see Tables 3 and 4) and the overall pattern of slide ratings was remarkably similar across all groups. The finding that Patients E. P. and G. T., who have bilateral damage to the amygdala, gave normal emotionality ratings is consistent with the previous finding that Patient B. P., a patient with bilateral amygdala damage resulting from Urbach-Wiethe disease, was unimpaired in rating the arousal associated with an emotional story (Cahill et al., 1995).

Arousal improved recall and recognition performance in all groups except Patients E. P. and G. T., who exhibited little or no detectable memory for the slides. Although the amnesic patients were severely impaired on both recall and recognition compared with the control group, their memory was enhanced by high arousal in proportion to the enhancement exhibited by the control group. In addition, when the amnesic group was compared with the control-delay group, which had been matched to the performance of the amnesic group by testing after a long delay, the two groups exhibited the same memory enhancement as a function of arousal. Indeed, for recognition, the amnesic group exhibited numerically more benefit from arousal than the control-delay group. For recall, the groups also benefited similarly from arousal, and there was no interaction with arousal in any group comparison. For the recall measure, the test for a linear trend for an arousal effect did not reach significance when the amnesic group was examined by itself (p < .09), likely because of floor effects in the amnesic group. Our results for free recall are consistent with previous findings that patients with left unilateral temporal lobectomy exhibit the same benefit in free recall for emotional versus neutral words as controls, despite an overall recall deficit for the patients (Phelps, Ziv, & Labar, 1995). Thus, the memory enhancement effect associated with arousal appears to be intact in amnesia, and this effect extends to both recall and recognition memory.

The lack of a memory enhancement effect in Patients E. P. and G. T. cannot easily be interpreted. Both E. P. and G. T. have bilateral damage to the amygdala, and when bilateral amygdala damage is present emotional arousal may not enhance memory (Cahill et al., 1995). However, the recognition performance of these patients was also near floor, which would have made it difficult to detect an enhancement effect. Either or both of these variables could account for the lack of a memory enhancement effect in these 2 patients.

The comparison between recall and recognition performance in the amnesic and control-delay groups also is notable. To our knowledge, this is the first demonstration that free recall and recognition of pictorial information are impaired in amnesia proportional to their difficulty for controls (see Figures 2 and 3). Previous work (Haist, Shimamura, & Squire, 1992) established that free recall and recognition are impaired equivalently in amnesia when word lists were used. The current finding provides further evidence that recognition in amnesia is not being supported by memory systems (such as priming) that are intact in amnesia (also see Squire & Knowlton, 1995). The deficit in recognition was about what it should have been given the deficit in free recall.

The effect of valence was minor in the current study once the effect of arousal on memory had been accounted for. This result is understandable, given that valence and arousal ratings for the 60 slides were correlated highly. The effect of valence was limited to slightly higher corrected recognition performance for low-valence items in the control and control-delay groups (there was no effect in the amnesic group), and an interaction between arousal and valence for FAs in the amnesic versus control group comparison. The minor effect of valence on recall and recognition in the current study accords well with similar findings by Bradley et al. (1992) for recall and recognition in college students.

Reaction time to recognition items was relatively insensitive to the effects of emotional arousal. Bradley et al. (1992) did report an effect of emotional arousal on reaction time in picture recognition. Specifically, hit responses to high-arousal slides were faster than hit responses to low-arousal slides, and correct rejections were slower for high-arousal slides than for low-arousal slides. Perhaps in the current study participants emphasized accuracy over speed.

The results of the current study suggest that emotional judgments are intact in amnesia, even in patients with bilateral damage to the amygdala. Previous clinical and anecdotal reports have suggested that patients with Korsakoff's syndrome often are abnormal in their emotional responses (Rapaport, 1961; Talland, 1965). However, our 5 patients with Korsakoff's syndrome rated the emotional arousal and valence of slides highly similarly to the non-Korsakoff patients, and the beneficial effect of emotional arousal on memory was similar in both groups. As considered previously (Shimamura, Jernigan, & Squire, 1988), alcoholic Korsakoff's syndrome is variable with respect to the severity of memory impairment, frontal lobe signs, and other neuropsychological signs of cortical dysfunction. Our patients were selected because they had a memory impairment disproportionate to any other intellectual impairment.

In summary, amnesic patients experienced the same memory enhancement from emotional arousal as healthy controls. The results suggest that the emotional arousal effect is modulated by brain structures that are intact in amnesia. The amygdala, which is spared in all the amnesic patients except Patients G. T. and E. P., is a prime candidate for the source of the emotional arousal effect, based on evidence from both animals and humans (Davidson & Sutton, 1995; McGaugh, 1989).

References


PERCEPTION AND MEMORY IN AMNESIA


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