JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 22, 633–649 (1983)

Arousal Cues Arousal-Related Material in Memory: Implications for Understanding Effects of Mood on Memory

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Evidence is presented that (1) arousal acts as a cue for arousal related material in memory, and (2) this effect may partially underlie mood cuing mood-related material from memory. Specifically, two studies are presented showing that material people learn when in a high arousal state and material they learn when in a normal arousal state is subsequently best recalled when they are in a similar arousal state. Then a brief review of literature and a third study are presented supporting the claim that arousal acting as a cue for arousal-related material in memory may provide a partial explanation for why moods cue similarly toned material from memory. The literature review reveals that positive mood inducers elicit elevated autonomic arousal and the third study shows that elevated arousal in combination with a positive mood enhances the effect the positive mood has on subsequent judgments, whereas arousal by itself has no impact on judgments. Finally, it is suggested that arousal acting as a cue for arousal-related material in memory may account for such previously observed phenomena as state-dependent memory effects produced by alcohol and drugs, "misattribution" of arousal, "excitation transfer," and effects that arousal has been shown to have on self-focus and humor.

Recently, the idea that moods may cue similarly toned material in memory, causing that material to be more likely to come to mind and to influence judgments and behavior, has received much attention and support (e.g., Bartlett & Santrock, 1979; Bower, Monteiro, & Gilligan, 1978; Isen, 1975; Isen, Shalker, Clark, & Karp, 1978; Leight & Ellis, 1981; Teasdale & Fogarty, 1979). However, this research leaves some important questions unanswered. Among those is the following: Just what is it that is stored representing mood in memory and is subsequently cued when the mood reoccurs?

In this paper we will present a case that storage of information about changes in autonomic arousal that accompany moods may be part of how a mood is stored in memory and that changes in arousal that reoccur with subsequent moods may be part of what primes affectively toned material stored earlier. Our case will be made using positive moods as an example, but we believe our argument applies to negative moods as well. Before making our arguments, though, a brief review of some previous work on the effects of positive moods on memory and judgments is necessary.

This research was supported by a grant from the Ford Motor Company Research Fund to the first author. We thank Gina Fleitman, Jeanne Jessup, and Barbara Waddell for their help in conducting Study 3, and Gordon Bower, Sheldon Cohen, Eric Johnson, Henry Ellis, Lynne Reder, and Michael Scheier for their helpful comments on this research. Correspondence regarding this paper should be addressed to Margaret S. Clark, Dept. of Psychology, Carnegie–Mellon University, Pittsburgh, Pa. 15213.

Positive Moods Prime Positive Material from Memory

There is now considerable evidence that material stored in a person's memory linked with a positive feeling will be more likely to come to mind (e.g., Isen et al., 1978) and will come to mind *faster* (Teasdale & Fogarty, 1979) when a person is in a positive feeling state than when he or she is not. Further, this evidence has been considered important by social psychologists because it provides an explanation for why positive moods increase attraction (Gouaux, 1971), helping (Isen, 1970), expectations of future positive events (Masters & Furman, 1975),

0022-5371/83 $3.00

and the perceived pleasantness of scenes (Forest, Clark, Isen, & Mills, 1979; Isen & Shalker, 1982). Specifically, if being in a positive mood increases the likelihood of thinking of positive aspects of other people, helping, future events, and everyday situations, these thoughts may increase helping, attraction, expectations of future success, and perceived pleasantness of situations (Isen, 1975; Clark & Waddell, 1983).

Isen et al. (1978) and Clark and Isen (1982) have discussed in some detail the question of through what processes increased accessibility of similarly toned material *might* come about. One possibility is that when information is stored in memory, feelings experienced at the same time are also stored, linked to that information. Given this, the accessibility effect may be produced by a process of "spreading activation" (Collins & Quillian, 1972; Collins & Loftus, 1975). This involves several assumptions. First, current moods may activate nodes representing moods in memory and activation may spread to other material in memory linked to those nodes. Second, the longer the mood nodes are stimulated the longer activation spreads to connected material. Third and finally, this activation may vary in quantity and nodes at intersections of a network will fire, bringing the material to awareness when activation surpasses a threshold. Consequently current moods may cause mood-related material in memory to be more likely to come to mind than usual.

As noted above, however, this leaves unanswered the question of how moods are represented in memory. We began to answer this question by asking what effects the diverse events that induce positive moods have in common. We suspect it might be information about these events that is stored in memory, constitutes "storage of a mood," and is reactivated later when a new event induces a similar mood. Since a change in autonomic arousal seemed to be one effect various positive mood inductions might have in common, this strategy led to the proposal that information about changes in arousal that accompany positive moods may be stored in memory, and that this information and material linked to it may be primed when later positive mood inducers once again produce similar states of arousal.

Before going on, it should also be noted that our argument need not imply that arousal accompanying positive moods should make negatively toned material in memory (which may also be stored with arousal) more likely to come to mind or vice versa. While positive and negative mood inducers may *both* elicit changes in arousal, they *also* elicit other reactions that are distinct from one another. Positive and negative mood inducers, for example, produce distinct facial expressions, physical postures, and evaluations of how fortunate one is or how "nice" the world is. Information about such events may also be stored in memory providing links between past and present affectively toned material. Thus, when one is in a positive mood, positive facial expressions, positive postures, and positive evaluations, as well as arousal may contribute to priming positive material, while only arousal may prime negative material. The positive material should therefore receive the *most* priming and should be *most* likely to come to mind (Clark, 1982a).

At this point it is also important to note that although arousal is discussed throughout this paper as if it were a general state, we do not mean to imply that the arousal accompanying different emotional states is undifferentiated. There is considerable evidence to the contrary (e.g., Ax, 1953; Funkenstein, 1956; Lacey, 1967; Schwartz, Weinberger, & Singer, 1981). Instead our arguments are based on the idea that *information* stored in memory *about* the arousal states that accompany different emotions and exercise may be quite similar. This information may be similar either because different patterns of arousal *still* have much in common and/or because people's phenomenal experience of different pat-

terns of arousal is very similar (Cannon, 1927; Mandler, 1975).

To make a case that arousal is one element linking present moods to similarly, affectively toned material in memory requires a three-part presentation. First, evidence that positive moods *are* accompanied by changes in arousal is needed. This evidence is presented in the remainder of the introduction. Second, support must be found for the idea that information about a change in arousal can be stored in memory and can serve as a retrieval cue. This support is provided by our first two studies. Finally, the idea that arousal may contribute to the priming of *emotional* material in memory must be supported and our third study does so. We turn now to the first part of our argument.

Are Positive Moods Accompanied by Arousal?

Fortunately for the present argument, several studies have established that "everyday" positive experiences of just the sort psychologists have often used to induce positive moods—i.e. success (Isen, 1970), free gifts (e.g., Isen, Clark & Schwartz, 1976), funny movies (e.g., Averill, 1969; Gouaux, 1971), and imagining happy or sad thoughts (e.g., Cialdini & Kenrick, 1976; Masters & Furman, 1976)—*are* accompanied by elevations in autonomic arousal. Specifically, using such diverse measures of autonomic arousal as heart rate, systolic blood pressure, adrenaline excretion in urine and palmar conductance, Mueller and Donnerstein (1981) and Patkai (1971) have provided evidence that success and free gifts are accompanied by elevations in arousal, Averill (1969) and Levi (1972) have shown that humorous movies elicit elevated arousal, and Schwartz et al. (1981) have shown that thinking happy thoughts produces elevations in arousal. Given this evidence, we may turn to the second part of our argument. That is that arousal may serve as a retrieval cue for arousal-related material in memory.

Testing the Idea that Arousal Can Serve as a Retrieval Cue

Our first two studies examined the idea that information about arousal can be stored in memory and that subsequent arousal can serve as a retrieval cue for material presumably linked to that information. We hypothesized that (1) material learned when one is experiencing high arousal will be best recalled when one is once again experiencing high arousal (this is important because positive moods are associated with enhanced arousal and we want to argue that enhanced arousal when one reexperiences a positive mood may cue that earlier material), and (2) material learned when one is experiencing a resting level of arousal will be best recalled when one is once again experiencing that resting level of arousal.

Study 1

Method

Overview. Under the guise of a study on learning under distracting conditions, subjects learned a list of phrases while experiencing enhanced arousal and a second list while experiencing normal arousal. Later, they were given a recall test for phrases on both lists when they were experiencing *either* enhanced arousal or normal arousal.

Subjects. Subjects were 37 college students enrolled in their first psychology class. They partially fulfilled a course requirement by participating.

Stimulus materials. Two lists of phrases were prepared for use in this study. To construct them, a large number of two-word phrases consisting of an adjective and a noun were generated (e.g., failed exam, wide road). Then 8 judges rated how abstract and how emotionally toned each phrase was. Finally, 20 phrases were selected for each of 2 lists, hereafter referred to as List A and List B, such that the average abstractness and emotionality ratings of the phrases on each list did not differ.

Procedure. Upon each subject's arrival, the experimenter said she was testing the

effects of various types of distraction on learning. Subjects would try to learn phrases following exercise, a visual distraction, and a noise distraction, as well as following relaxation (the supposed control condition). Each subject expected to be run in all conditions but, it was explained, the conditions would not be run one right after the other. Rather, there would be two sessions of two conditions each. First the relaxation and exercise conditions would be run. Then there would be a break during which subjects would perform some analytical tasks, followed by the visual and noise distraction conditions.

At this point half the subjects started the study with the relaxation task (normal arousal) and half with the exercise task (high arousal). Those assigned to perform the relaxation task simply sat in a lounge chair for 7 minutes and relaxed. Those assigned to the exercise condition stepped up and down on a cinder block for 7 minutes.

After this the first learning task took place under the same conditions (with the exception of the subject's arousal level) regardless of the preceding task. The subject was seated and listened to a list of 20 phrases being read aloud by the experimenter. The experimenter presented 1 phrase every 4 seconds. Then the experimenter repeated the list a second time, and asked the subject to recall the phrases aloud. Finally the experimenter repeated the list a third time, and as subjects recalled the phrases aloud a second time the experimenter recorded recall. They were given 3 minutes for recall. Subjects' recall at this point will later be referred to as their original learning. (Half the subjects who had exercised immediately thereafter learned List A and half learned List B. Half the subjects who had relaxed immediately thereafter learned List A and half learned List B.)

At this point, a questionnaire asking about aspects of the preceding task was given to achieve some spacing between conditions. After subjects filled out the questionnaire, approximately 25 minutes had elapsed since the subjects had originally exercised or relaxed (a time period that we had established to be sufficient for the exercise subjects' arousal to return to baseline). Next subjects who had originally exercised performed the relaxation task (normal arousal) and subjects who had originally relaxed performed the exercise task (high arousal). Then each group learned the list of phrases to which *they* had previously *not* been exposed in the same manner they had learned the first list. Thus arousal at learning was a within-subjects variable.

After the second learning session, all subjects worked on some "spatial and analytical tasks" for approximately 15 minutes, after which the experimenter apologetically, and with some embarrassment, said an error had been made. One of the previous conditions would have to be run again. For a randomly chosen half of the subjects the condition to be run again was the exercise condition. For the remaining half it was the relaxation condition. All subjects repeated the required condition, and once again sat down expecting to learn a new list of phrases. Instead the experimenter unexpectedly asked the subject to recall as many phrases as possible from the two lists previously learned. (Half the subjects who had learned List A first and half the subjects who had learned List B first recalled the two lists in the order in which they had been learned. The remaining subjects recalled the lists in the reverse order.) Thus arousal at recall was a between-subjects variable. Subjects were given 5 minutes for recall and responses were recorded.

Finally subjects were probed for suspicion and debriefed. One subject in the High Arousal at Recall condition did not believe an error caused the necessity for repeating the task. His data were excluded from all analyses. Four subjects who had taken a course in which various aids to memory had been taught reported using the "method of loci" to store and to recall the phrases. Since it seemed likely that use of this tech-

nique would obscure the usefulness of arousal as a retrieval cue, it was decided, prior to examination of the data, to exclude these subjects' data from the analyses. Two were in the High Arousal at Recall condition and two were in the Normal Arousal at Recall condition.

RESULTS

Manipulation Checks on Arousal

No direct manipulation check on arousal was taken during the course of the study. However, six additional subjects were asked to step up and down on the cinder block for 7 minutes and to relax in a lounge chair for 7 minutes. (A 25-minute break was allowed between tasks.) Half performed the exercise task first, and half performed the relaxation task first. Results supported the effectiveness of the arousal manipulation. Exercise produced significantly greater increases in pulse from pre- to post-task (mean change = +45) than did relaxation (mean change in pulse = −0.15), $t(4) = 8.1$, $p < .001$).

Dependent measures. The primary measure was the number of phrases recalled relative to the number originally learned, expressed as a proportion. The means for this measure clearly fell in the predicted pattern. For subjects who were highly aroused at recall this proportion was greater for phrases originally heard when experiencing high arousal (85%) than for phrases originally heard when experiencing normal arousal (70%). For subjects who were experiencing normal arousal at recall this proportion was greater for phrases originally heard when experiencing normal arousal (91%) than for phrases originally heard when they were experiencing enhanced arousal (69%). These results are depicted in Figure 1.

A 2 × 2 mixed ANOVA, with arousal at learning (normal or high) as the within-subjects variable and arousal at recall (normal or high) as the between-subjects variable, revealed no effect of arousal at learning,

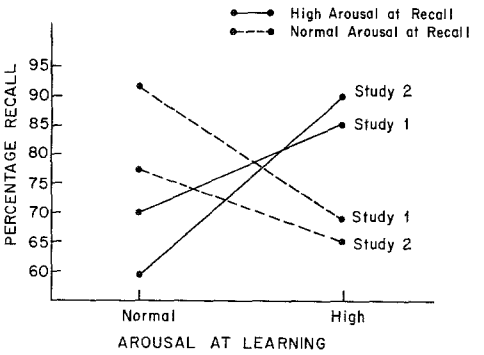

FIG. 1. Percentage of phrases recalled as a function of arousal at time of learning and at time of recall.

$F(1,31) = .39$, NS, no effect of arousal at recall, $F(1,31) = .78$, NS, and a significant interaction between arousal at learning and arousal at recall, $F(1,31) = 23.48$, $p < .0001$. A planned comparison indicated that when subjects were highly aroused at time of recall, recall of material heard when highly aroused was significantly greater than recall of material heard when normally aroused, $t(31) = 7.9$, $p < .01$. A second planned comparison indicated that when subjects were experiencing normal arousal at recall, recall of material heard when normally aroused was significantly greater than recall of material heard when highly aroused, $t(31) = 15.6$, $p < .01$.[1]

Since the "emotional tone" of phrases on both lists had been prerated, it was possible to examine whether arousal at recall enhanced recall of material prerated as "emotional," as some might expect, given our theorizing. To accomplish this, the 10 phrases in each list which received the highest emotionality ratings were classified as "emotional" phrases and the 10 phrases receiving the lowest emotionality ratings were classified as "nonemotional." A 2 × 2 mixed ANOVA was conducted with emotionality of phrases as one variable, arousal at recall as the second independent vari-

[1] It should be noted that when the four subjects who used the "method of loci" as a memory aid are included in the analyses, neither the results of the overall analysis nor of the two planned comparisons are changed.

able, and percentage of phrases recalled as the dependent variable. There were no significant effects.

Discussion

Our first study supports the hypothesis that level of arousal serves as an effective retrieval cue for material previously stored with information about similar levels of arousal. Material learned when in a high or low arousal state was subsequently best recalled when subjects were again in a similar arousal state. In other words, level of autonomic arousal appears to serve as a retrieval cue in much the same way as positive moods have been shown to serve as effective retrieval cues in recent studies. Indeed, we suggest it is in part *because* arousal serves as an effective retrieval cue that positive moods serve as effective retrieval cues. The plausibility of this argument is supported by the present study in combination with the research cited in the introduction showing that events known to induce moods have also been shown to elicit arousal.

In this study arousal did *not* enhance memory for the phrases prerated as being most emotional, relative to other phrases. We do not find this to be surprising. The fact that our judges could, when required, prerate some phrases as being more emotional than others (e.g., "failed exam" was rated as more emotional than "wide road"), does not mean those phrases were actually stored with enhanced arousal in our subjects' memories. Most students do *not,* in fact, fail exams, for example. Consequently, there is no reason why they should have arousal information stored along with the phrase "failed exam" although they may *recognize* that it would be an emotional experience if they did. Indeed, we suspect that in the present study most of what was learned was not stored with any affective information and that that accounts for the failure of arousal to enhance memory for words prerated as being emotional.[2]

Before going on to show that arousal may *enhance* priming of positive material by positive moods, we felt it necessary to replicate the findings of the first study using manipulations of arousal at recall which were distinct from those used at learning. Although in the first study there were no differences between conditions except in arousal at the time subjects actually sat down to learn and to recall phrases, there *is* an alternative explanation for the results of that study. Cues associated with the arousal and relaxation tasks *other* than level of arousal may have been associated with the phrases learned *following* those tasks. For example, posture and movement varied between the two arousal tasks. Further, while the arousal tasks ended *prior* to actual learning and recall, Smith (1979) has shown that recalling a *prior context* can serve as a retrieval cue. It is not a far step from that finding to assume our subjects may have been thinking about the immediately preceding situations while learning and recalling word phrases and that aspects of those prior situations *other* than arousal produced the state-dependent effects we observed. Therefore in our second study, level of arousal at learning was manipulated in a manner distinct from the way it was manipulated at recall.

Study 2

Method

Subjects. Sixteen college students participated. They were either paid or partially fulfilled a departmental requirement by participating.

Procedure. The word lists and procedure were the same as in the first study with the exception of the manipulation of arousal *at*

[2] Upon reading this explanation, one reviewer argued that it does not fit well with some findings previously reported by Isen et al. (1978, Study 2). In that study positive moods were shown to be effective retrieval cues for previously stored positive trait words. However, while the majority of subjects in psychology experiments may not have encountered the specific experiences described by our phrases, they *have,* no doubt, encountered many manifestations of positive and neutral personality traits.

recall. That manipulation took place as follows. The experimenter began the study by telling the subject there were three rather than four distraction conditions—relaxation, exercise, and visual distraction. Furthermore, when it came time for the third condition, the visual distraction condition, she did not tell the subject she had erred and one of the previous conditions would have to be repeated. Instead, she stayed with her original story that the third task would involve visual distraction. This task turned out to be watching a film. Half of the subjects, those assigned to the High Arousal at Recall condition, watched a sexually explicit film depicting a heterosexual couple engaging in various sexual acts.[3] The remaining subjects, those assigned to the Normal Arousal at Recall condition, watched a film about a chimpanzee learning sign language. Each film lasted approximately 6 minutes. Here it should be noted that many studies provide evidence that films depicting sexual encounters increase both self-reports and physiological indices of autonomic arousal (e.g., Baron & Bell, 1977; Byrne, Fisher, Lamberth, & Mitchell, 1974; Zillmann, Bryant, Comisky, & Medoff, 1981; Zillmann, Mody, and Cantor, 1974). After viewing the erotic or nonerotic film, subjects in the second study were given a surprise free recall task for the two lists of phrases learned earlier.

Results

As in the first study, the primary dependent measure in the second study was number of word phrases recalled relative to the number originally learned, expressed as a proportion. Once again, as can be seen in Figure 1, the means for this measure clearly fell in the predicted pattern. For subjects who were highly aroused at recall this proportion was greater for phrases originally heard when experiencing high arousal (88%) than phrases originally heard when experiencing normal arousal (60%). In addition, for subjects experiencing normal arousal at recall this proportion was greater for phrases orginally heard when experiencing normal arousal (77%) than phrases originally heard when experiencing high arousal (65%).

A 2 × 2 mixed analysis of variance was performed on these data with arousal at learning (normal or high) as the within-subjects variable and arousal at recall (normal or high) as the between-subjects variable. This analysis revealed a marginally significant effect of arousal at learning, $F(1,14) = 4.31$, $p < .06$, such that subjects tended to recall more phrases learned when aroused (76.5%) than phrases learned when not aroused (68.5%), no effect of arousal at recall, $F(1,14) = .39$, NS, and a significant interaction between arousal at learning and arousal at recall, $F(1,14) = 26.49$, $p < .0001$.

A planned comparison indicated that when subjects were highly aroused at recall, recall of material heard when aroused was significantly greater than recall of material heard when *not* aroused, $t(14) = 26.27$, $p < .01$. A second planned comparison indicated that when subjects were not highly aroused at recall, recall of material previously heard when *not* aroused was significantly greater than recall of material heard when aroused, $t(14) = 4.72$, $p < .01$.

As in the first study, a second 2 × 2 mixed analysis of variance was conducted with emotionality of phrases and arousal at recall as the independent variables, and number of phrases of each type recalled relative to the number learned as the dependent variable. As in Study 1, this analysis revealed no significant effects.

Discussion

The results of the second study closely parallel the results of the first study and provide additional support for our hypothesis that level of arousal serves as an effective retrieval cue for material stored in memory. Again, material learned when ex-

[3] All subjects were called and told that the study might involve viewing some sexually explicit material prior to agreeing to participate. They also were informed they could leave the study at any time and still receive full credit or pay.

periencing a given arousal state was subsequently best recalled when subjects were in a similar arousal state. Furthermore, since the two sets of arousal manipulations in this study had little in common *except* for the ability to elicit arousal, the results of this study seem to rule out the possibility present in the first study that something about the arousal manipulations *other* than arousal produced the effects observed.

We tend to believe that the marginally significant effect for phrases learned when highly aroused to be better recalled than phrases learned when experiencing normal arousal that was observed in this second study was due to chance. This effect did not approach significance in the first study. Indeed, in that study there was a slight tendency in the *opposite* direction.

Testing the Idea that Arousal is One Link between Present Mood States and Similarly Toned Material in Memory

Our next step in this program of research was to conduct a study to support the idea that arousal priming similarly toned material from memory may account in part for mood priming similarly toned material from memory. Specifically the third study was designed to demonstrate that additional arousal at the time a person is experiencing a positive mood will enhance priming of positive material from memory. If arousal acting as a retrieval cue for arousal-related material in memory underlies the effect of mood on memory, then additional arousal at the time one experiences a positive mood induction should enhance the effect of that mood induction on judgments for one or both of the following reasons: (1) arousal persists over time and thus may prolong the priming of similarly-toned material from memory, resulting in *more* of this material coming to mind, and (2) the more extremely positive material is in memory, the more intense the arousal tied to it may be (Clark, 1982a). Thus, enhanced arousal along with a positive mood induction may result in a different, more extremely positive set of material coming to mind than would otherwise have been the case.

As noted above, enhanced arousal accompanying a positive mood should *not* make material linked with the opposite (in this case negative) feeling tone more likely to come to mind. Since *other* aspects of the positive mood (e.g., facial expressions, posture, evaluations) are also priming positive material, the positive material will receive the *most* priming and be most likely to come to mind. Furthermore, once positive thoughts do come to mind they (in combination with continuing arousal, facial expressions, and global evaluations), should prime additional positive thoughts, prolonging the positive mood.

On the basis of the above reasoning, the following specific predictions were tested in Study 3: (1) as Isen has suggested and found (Isen, 1975; Isen et al., 1978), a positive mood should cause people's judgments of something about which they have stored varied, affectively toned memories (in this case their university) to become more positive, and (2) this effect should be enhanced by increased arousal which accompanies, and presumably prolongs and/or intensifies, a positive feeling state. No prediction was made about the effect of arousal in the *absence* of positive feedback. Without knowing what mood subjects are in when they begin the study, it is impossible to make such a prediction. For subjects in positive moods to begin with, positive associations to the university should already be "primed." Additional arousal may provide another cue to the same material, causing it to "come to mind" and making judgments more positive. However, subjects who are in negative moods to begin with should already have *negative* associations to the university "primed," and further arousal may provide another cue to *that* material, causing *it* to "come to mind" and making judgments more *negative*. Finally, for subjects in no particular feeling state, the position taken thus far makes no predictions regarding the effects of further

arousal. Although there is some evidence that extremely intense, unexpected arousal may produce negative feelings (Marshall & Zimbardo, 1979; Maslach, 1979), there is no evidence that less intense arousal states have the same effects. Less intense elevations in arousal, such as those involved in the studies in this report, may in the absence of a mood inducer cause *both* positively and negatively toned material to be more likely than usual to come to mind. These thoughts may then cancel out each other's effects on judgments. Thus, as stated above, no prediction about the effect of arousal in the absence of a mood manipulation was made.

Study 3

Method

Overview. Under the guise of a study on distraction and memory, subjects listened to a story while either stepping up and down on a block (High Arousal) or stringing cardboard disks together (Normal Arousal). Afterwards, all subjects took a memory test. Half the subjects from each arousal condition were then told they had done well (Positive Feedback conditions); half were told that their test had not yet been scored (No Feedback conditions). Finally, all subjects filled out a survey about their university.

Subjects. Forty-four college students participated. They partially fulfilled a class requirement by participating or were paid $3.00. Each was randomly assigned to one of the following conditions: (1) High Arousal–Positive Feedback, (2) High Arousal–No Feedback, (3) Normal Arousal–Positive Feedback, or (4) Normal Arousal–No Feedback.

Procedure. Upon arrival the experimenter greeted the subject saying that she was a research assistant and reminded the subject that the study concerned memory and distraction as had been indicated on the sign up sheet. Each subject would perform a distracting task while listening to a story on tape. Afterwards they would be given a memory test. The Normal Arousal subjects were exposed to a manipulation modeled after one used by Zillmann and Bryant (1974). They were told their distracting task was to slide disks with holes onto a string. The experimenter pointed to a large cardboard carton with two holes for the subject's arms. The disks and string were inside. The subject was to put his or her hands into the box and string the disks together. The High Arousal subjects were told that their task involved stepping up and down on a cinder block.

Next, all subjects were told that since some conditions involved physical exercise, and (in the Normal Arousal conditions) that because everyone had to be run through the same procedure, all subjects were to sign a consent form. Also, each subject's blood pressure and pulse had to be taken before and after the distracting task. Subjects then signed the form and had their blood pressure and pulse taken. At this point all subjects began their assigned task while listening to a taped story about a student's first day at law school. The tasks and tapes lasted about 7 minutes.

Upon completion, all subjects immediately wrote down as many things from the story as they could remember. Ninety seconds later, although the subjects were still writing, the experimenter stopped them. She said the study was over, that the only thing left to do was to take the final measure of blood pressure and pulse to make sure they were back to normal before leaving. Before that, though, she said she wanted to take their memory results into her supervisor's office "because she likes to have a look at them after each person is finished."

The first experimenter took the results across the hall to the second experimenter's office. Upon returning, the first experimenter took the subject's blood pressure and pulse for a second time, assured the subject he or she was "back to normal," when in fact subjects in the High Arousal condition were not, and sent the subject to the second experimenter's office to be paid or to pick up a credit slip.

The second experimenter, who was unaware of the subject's arousal condition, introduced herself and asked for the subject's name. She picked up the subject's memory results and in the No Feedback conditions simply said, "Barb gave your memory results to me, but I really haven't had a chance to look at them, so I can't tell you how you did." In the Positive Feedback conditions she had circled individual facts from what the subject had recalled and had put a "memory score" at the bottom of the sheet. In these conditions she picked up the sheet, showed it to the subject and said, "Barb gave your memory results to me, and I've had a chance to look them over. You really did very well! Your score is way above the norm. Most people have a very difficult time just remembering a couple of facts while they are distracted, and you did *much* better than that. You ought to be very pleased because the ability to remember things when you're distracted is related to general intelligence."[4]

The second experimenter asked if the subject was doing the study for credit or pay and said she would give it to the subject shortly. First, though, she wanted the subject to do one more thing. Since the study took such a short time, she was asking everyone to help out her research assistant. The research assistant had been sick the previous semester, had an "incomplete" in a research methodology class, and was now conducting a survey to finish the course. The survey was short, and the second experimenter asked the subject to fill it out. No subject objected, and all were directed back to the first experimenter.

[4] A very similar manipulation was used by Clark and Waddell (1983). In that study additional subjects were run solely to check on the effectiveness of the manipulation. Those subjects received success or no feedback from one experimenter, then entered another experimenter's room who was blind to conditions. That experimenter first judged their moods (unobtrusively) then, under the guise of a pretest for a separate study, asked them to rate their own moods. Both checks provided evidence for the effectiveness of our manipulation.

The first experimenter, who was unaware of the feedback conditions, repeated the second experimenter's explanation of why she was conducting the survey, and handed subjects a survey on campus attitudes. She told them to give their first reactions to each question.

The survey asked subjects to rate (a) the quality of teaching in general at the university, (b) the quality of teaching in their major, (c) how worthwile required courses outside their major had been, (d) how concerned with students faculty in their department were, (e) the quality of the campus libraries, (f) the friendliness of students at the university, and (g) how pleasant the campus was. The ratings were made on scales ranging from -4 (indicating an extremely negative attitude) to $+4$ (indicating an extremely positive attitude).

Finally, the subjects reported back to the second experimenter, who started to fill out their credit form or to pay them. Before she finished she casually said, "By the way, there's more to my study than I explained so far. I'm curious as to whether you have any idea of what it is?" Four subjects expressed suspicion. Two thought the survey was a part of the actual study, one did not believe the positive feedback, and one expressed suspicion about both the survey and whether arousal was being studied. One of the first two subjects was in the Normal Arousal–No Feedback condition, the other was in the Normal Arousal–Positive Feedback condition. The third subject was in the High Arousal-Positive Feedback condition, and the fourth was in the High Arousal–No Feedback condition. Data from these subjects were not included in any of the analyses. Finally, all subjects were thoroughly debriefed, given pay or credit, and dismissed.

Results

Manipulation Checks on Arousal

The change in subjects' blood pressure and pulse from just before the distraction task to $2\frac{1}{2}$ minutes after the task was the

manipulation check of arousal. In the High Arousal condition subjects' systolic and diastolic blood pressure increased +3.5 and +1.8, respectively. Pulse was also elevated (mean increase = +6.4). In contrast, in the Normal Arousal conditions, subjects' systolic blood pressure dropped (mean decrease = −2.4) as did their pulses (mean decrease = −1.25). This presumably was due to having an opportunity to sit down after having walked up three flights of stairs to the room in which the experiment took place. There was very little change in their diastolic blood pressure (mean change = +.3). The difference between changes in systolic blood pressure between the two groups was significant, $t(16) = 2.5, p < .02$, as was the difference between changes in pulse, $t(16) = 4.0, p < .001$. The difference between changes in diastolic pressure was not significant, $t(16) = 1.45, p < .16$.

Dependent measures. The dependent measure was the sum of the subject's answers to all seven questions. Scores could vary from +28 to −28. The results on this measure are presented in Figure 2.

As can be seen, as predicted, scores in the Positive Feedback conditions were higher than scores in the No Feedback condition. In addition, and also as predicted, in the Positive Feedback conditions, arousal seems to have heightened the effects of the positive feedback.

A 2 × 2 (Arousal × Feedback) analysis of variance on these ratings revealed the predicted significant effect of the Feedback manipulation, $F(1,36) = 4.30, p < .05$. Subjects who received positive feedback gave their university higher ratings than did others. The interaction between Arousal and Feedback approached significance, $F(1,36) = 3.11, p < .09$, and there was no main effect for Arousal.

The second hypothesis, that arousal would cause the Positive feedback subjects to become even more positive, was directly tested by comparing subjects' evaluations in the Normal Arousal–Positive Feedback condition with their evaluations in the High Arousal–Positive Feedback condition using a planned comparison. As predicted, the High Arousal–Positive Feedback subjects rated the university as being significantly more positive than the Normal Arousal–Positive Feedback subjects, $t(36) = 4.78, p < .001$. A second planned comparison between the Normal Arousal–No Feedback and the High Arousal–No Feedback conditions revealed no significant difference, $t(36) < 1$, NS.

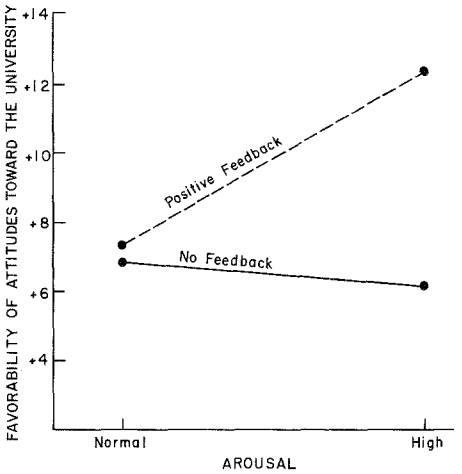

FIG. 2. Favorability of attitudes toward the university as a function of arousal and type of feedback received.

Finally, the blood pressure and pulse increase for each subject were correlated with the positivity of their judgments regarding their university separately for each of the four conditions. None of these correlations was significant.

DISCUSSION

The results of the third study supported both predictions. At least in the presence of arousal, a positive feeling state, induced by success, enhanced the favorability of subjects' ratings of their university. The results also supported our new prediction—that if something positive happens to a person, arousal, in addition to that which we assume the person feels as a result of the mood state induction, will enhance the impact of that mood on judgments. Subjects experiencing high arousal who re-

ceived success feedback expressed significantly more favorable attitudes toward the university than did subjects experiencing lower arousal who received success feedback. We believe this occurred because information about arousal is *part* of what is stored when people store memories of positive experiences. Consequently extra arousal at the time of a positive mood may result in a greater number of positive memories coming to mind and/or more intensely positive memories coming to mind. In contrast to this explanation, one might argue that (1) arousal is not part of a mood, (2) arousal and moods independently prime positive material from memory, and (3) the increase in favorability of judgments between the Normal Arousal–Positive mood condition and the High Arousal–Positive mood condition simply represents an effect of arousal being added to an effect of mood. However, the fact that arousal, by itself, had no effect on the favorability of judgments makes such an argument implausible.

Since, as we have pointed out earlier, simply experiencing a positive event has been shown to produce arousal as well as other changes which should prime positive material from memory, an unexpected outcome of the third study was that the subjects in the Normal Arousal–Positive Feedback condition did not rate their university significantly more favorably than did the subjects in Normal Arousal–No Feedback condition. At first this may seem contrary to the findings of Isen et al. (1978) that a positive feeling state improves subjects' judgments about familiar objects even though arousal was not manipulated in that study. However, perhaps the positive mood manipulation was not as "strong" (by itself) as was the positive mood manipulation in the Isen et al. study precisely *because* it was accompanied by less arousal than was the manipulation in that study. Why? First, receiving a free gift in a shopping mall is, no doubt, more surprising than receiving positive feedback on a test one has just taken, and surprise, by itself, increases arousal (e.g., Berlyne, Craw, Salapatek, & Lewis, 1963). Second, subjects in the Isen et al. study had been walking in a shopping mall immediately prior to receiving the gift, whereas the Normal Arousal subjects in the present study had been sitting still for approximately 10 minutes prior to receiving success feedback. Thus, the subjects in the Isen et al. study may have been more like the subjects in our High Arousal conditions than those in the Normal Arousal conditions.

In connection with the fact that we observed no effect of our positive mood manipulation in the low arousal condition, it is interesting to note that in a recently reported study by Bartlett, Burleson, and Santrock (1982, Study 1), the authors had subjects go through a relaxation technique prior to experiencing a mood induction. They expected this to *enhance* the effects of their mood inductions and hence the magnitude of the mood state dependent memory effect they had observed in a previous study (Bartlett & Santrock, 1979). In fact, they were surprised to discover that the relaxation technique eliminated that state-dependent learning effect, and when they *dropped* the relaxation technique and repeated the study, they once again observed a mood state-dependent memory effect.

The above should not be taken to mean that we believe enhanced autonomic arousal is always necessary for positive experiences in the present to cue memories from the past. Even though in Study 3 the Normal Arousal–Positive Feedback subjects were not significantly more positive than the Normal Arousal–No Feedback subjects, it nonetheless seems possible for affectively toned material to be cued in the absence of arousal. As already discussed, positive experiences share many attributes in addition to changes in arousal with one another. Thus it should be possible for a positive experience in the present to cue positive experiences from the past in the absence of enhanced arousal. We only wish to argue that the elevated arousal which accompanies

positive experiences may make recall of positive experiences from the past *more* probable because it serves as one cue for positive memories.

Before turning to a general discussion, the lack of a significant positive correlation between blood pressure or pulse increases and the favorability of judgments in the two success conditions should be addressed. There are a number of explanations for these correlations not being significant. First, while people can detect arousal and probably can detect *substantial differences* in arousal such as those between our high and low arousal conditions, they may not be particularly adept at detecting very small differences in arousal such as those which were reflected *within* our conditions. Second, even if they could, random error in our crude arousal measures and individual differences between subjects both in their abilities to discriminate levels of arousal and in their typical experiences of changes in arousal would obscure such a correlation. Third, and finally, autonomic arousal involves *many* physiological changes *in addition to* changes in blood pressure and pulse and these changes are not always well correlated (Hassett, 1978). Thus, there is no reason to expect, within conditions, that blood pressure or pulse in particular should be positively correlated with evaluations. The person with the smallest increase in pulse, for instance, may have shown the largest increase in arousal if some *other* measure of arousal had been taken. Indeed, since blood pressure is widely considered to be "symptomless," blood pressure would be especially unlikely to be positively correlated with changes in judgment. Thus we do not interpret the absence of a significant positive correlation between these measures in the success conditions as evidence *against* our hypotheses.

General Discussion

In this article we have presented evidence that arousal may be stored in memory along with other material and that arousal experienced later may later prime that material. Furthermore, we have presented evidence that arousal priming arousal-related material is one mechanism underlying positive moods cuing positive material from memory. At this point, an alternative interpretation for the results of the three studies in this paper should be raised. The explanation goes as follows: perhaps information about arousal is not directly stored in memory linked to other mood-related material. Instead, at the time it occurs, arousal may intensify the experience of existing feelings perhaps in a way such as that suggested by Schachter and Singer (1962). *Then* the resultant *feelings* rather than information about arousal per se may be stored in memory. Later arousal may produce similar intensification of feelings and those feelings may cue similar feelings stored earlier as well as material linked to it. If one assumes that individual subjects in our first two studies tended to feel good or bad and that the nature of these feelings did not change during the course of the study (i.e., from time of learning to time of recall), this can provide a plausible alternative explanation for the results of those studies. One might also argue that it explains the results of the third study as well. In that study arousal may have intensified positive feelings of the subjects receiving success feedback producing the increased favorability of judgments observed. Furthermore, one might reason that it may have intensified the existing feelings of people in the No Feedback condition but that since some of them felt good and some bad, the average judgments *across* people did not become more favorable. *However,* if that were the case the variability of judgments in the No Feedback-High Arousal condition should have been higher than in the other three conditions and that was clearly *not* the case.

The interpretation advocated throughout the paper, however, *can* account for the results of all three studies as well as for the lack of increased variability in that cell. If one assumes that most people in the No Feedback condition were not experiencing any particular emotion our interpretation

suggests that arousal will prime both positive and negative thoughts in connection with the object to be judged. These thoughts may then cancel one another out *within each subject before* judgments are made. This would account for the lack of increased variability in the No Feedback–High Arousal condition. While in defense of the alternative explanation one might reply that if people were not feeling anything in particular in that condition, there would be no feelings to be exaggerated, it is implausible to assume that people in Studies 1 and 2 *did* have preexisting tendencies to feel good or bad (in order to make the alternative explanation work for those studies) but that people in Study 3 did *not* have such tendencies (to make the explanation work there). Finally let us briefly address just three remaining issues.

Is Enhanced Arousal Necessary for Positive Moods to Cue Positive Material from Memory?

We think the answer to the above question is "no" for two reasons. First, as already noted, positive experiences have many attributes in common. Arousal is just one. Positive facial expressions and global evaluations of how fortunate one is are others. Thus, pleasant experiences may well cue pleasant material from the past even if a person is not experiencing enhanced arousal in the present.

Second, some moods may be associated with *decreases* in arousal. Russell (1980) has provided some evidence that affective states vary in terms of whether they are associated with high or with low arousal. While the manipulations of positive states that psychologists have typically used, including that used in our third study, produce feelings we would call "happiness" and involve *increases* in arousal, *other* positive states that have not yet received research attention may involve decreases in arousal. Examples are feelings of serenity or calmness. We suspect that such states may be due in part to *low* arousal, along with positive facial expressions and evaluations, cuing material stored with *low* arousal and with similar expressions and evaluations in memory. In support of these ideas, three recent studies have shown that after relaxing in a lounge chair subjects tend to interpret positive facial expressions and phrases as indicating serenity whereas after exercising subjects are significantly more likely to interpret the same positive expressions and phrases as indicative of joy (Clark, 1982b).

Implications of the Present Findings for Negative Feeling States

While our third study involved positive moods, manipulations that produce such negative states as fear, anger, and frustration have *also* been shown to elicit enhanced arousal (Averill, 1969; Ax, 1953; Levi, 1972; Lundberg, 1976; Patkai, 1971). Thus, we believe that arousal acting as a retrieval cue for arousal related material in memory may *also* account, in part, for *negative* states cuing material stored with negative feelings in memory. As with positive states, though, we should note that not *all* negative states are associated with enhanced arousal. Some, such as sadness, may be associated with low arousal (Schwartz et al., 1981).

Might Arousal Cuing Arousal-Related Material Account for Other Psychological Phenomena?

Finally, we would like to point out that the phenomenon of arousal cuing material stored in memory with a similar level of arousal has important implications beyond the fact that it seems to underlie mood effects. Specifically, it may be the mechanism underlying other state-dependent learning effects as well as such previously reported social psychological phenomena as "misattribution" of arousal to attraction (e.g., Dutton & Aron, 1974), excitation transfer effects (e.g., Zillmann & Bryant, 1974), the observations that arousal enhances humor (Shurcliff, 1966) and self-focus (Wegner &

Guiliano, 1980), and Hohmann's (1966) finding that paraplegics report a reduction in the intensity of emotion they feel following their injury.

Consider first other state-dependent learning effects. State-dependent effects for both alcohol (Weingartner & Faillace, 1971) and drugs (Eich, Weingartner, Stillman, & Gillin, 1975) have been reported. Since both drugs and alcohol affect arousal, altered levels of arousal may underlie those state-dependent learning effects as well as mood effects. Second, consider "misattribution" of arousal to attraction. In past studies it has been observed that if subjects meet a friendly, attractive person in an arousing situation they like the person more than when the same person is met in a non-arousing situation (Dutton & Aron, 1974). The present research suggests that when we meet attractive, friendly people, that situation may prime positive thoughts and arousal may exaggerate the cuing of positive memories from similar situations in the past, thus exaggerating attraction. Third, consider excitation transfer. Zillmann and his colleagues have shown in many studies that arousal elicited by one source, for example by watching an erotic film, may "transfer" or intensify emotional feelings elicited in a subsequent situation. For example, subjects who watch an erotic film and are then provoked by an irritating confederate will be more aggressive than if they had not previously watched the film (Zillmann, Katcher, & Milarsky, 1972). They have suggested that arousal summates and that subjects *attribute* it all to the irritating confederate and are thus more aggressive. The present results are not in conflict with this proposition but go beyond it to suggest that perhaps this effect may be an unconscious, unintentional one due to arousal plus an irritating person cuing more aggressive thoughts and behavior from memory than would have been cued by the irritating person alone.[5]

Fourth, consider the phenomena that arousal enhances humor (Shurcliff, 1966) and increases self-focus (Wegner & Guiliano, 1980). Arousal cuing material stored in memory with a similar level of arousal may also account for these effects. Arousal plus a humorous situation may be more likely to cue humorous situations from the past, and the behavioral tendency to laugh or smile, than would a humorous situation by itself. In addition, since most emotional memories involve arousal and implicate the self, the present perspective makes it easy to understand why arousal might increase self-focus. Specifically, arousal may prime past emotional memories linked to the self. Finally, consider Hohmann's (1966) finding that paraplegics report a reduction in the intensity of their emotions following their injury. Such injuries reduce the ability to experience arousal, and according to the present analysis should reduce the tendency for emotions to cue similarly toned material from the past thereby accounting for the reduction in intensity of feelings.

Summary

In summary, we have presented clear evidence that arousal serves as a retrieval cue for arousal-related material from memory. We have also presented evidence that this phenomenon may partially underlie recent observations that moods cue similarly toned material from memory. Finally, we have suggested that this phenomenon may underlie many other effects that social psychologists have observed.

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[5] It should be noted that, unlike the "misattribution" of attraction and excitation transfer studies, it is difficult to explain the results of our third study by saying that subjects might have attributed their enhanced arousal to a target. The mundane questionnaire about their university that we gave our subjects seems to be a very unlikely source of arousal. Thus, it is not plausible to assume that our subjects attributed their arousal to the questions they were asked.

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(Received April 23, 1982)