GEORGE FOX UNIVERSITY

Digital Commons @ George Fox University

Faculty Publications - School of Nursing | School of Nursing

Winter 2001

Context-Dependent Memory under Stressful Conditions: The Case of Skydiving

Laura A. Thompson
New Mexico State University

Keith L. Williams
University of Michigan-Ann Arbor

Paul R. L'Esperance
George Fox University, plesperance@georgefox.edu

Jerffrey Cornelius

Follow this and additional works at: https://digitalcommons.georgefox.edu/sn_fac

 Part of the Medicine and Health Sciences Commons, and the Other Psychology Commons

Recommended Citation

Thompson, Laura A.; Williams, Keith L.; L'Esperance, Paul R.; and Cornelius, Jerffrey, "Context-Dependent Memory under Stressful Conditions: The Case of Skydiving" (2001). *Faculty Publications - School of Nursing*. 11.
https://digitalcommons.georgefox.edu/sn_fac/11

This Article is brought to you for free and open access by the School of Nursing at Digital Commons @ George Fox University. It has been accepted for inclusion in Faculty Publications - School of Nursing by an authorized administrator of Digital Commons @ George Fox University. For more information, please contact arolfe@georgefox.edu.

Context-Dependent Memory under Stressful Conditions: The Case of Skydiving

Laura A. Thompson, New Mexico State University, Las Cruces, New Mexico, **Keith L. Williams,** University of Michigan, Ann Arbor, Michigan, **Paul R. L'Esperance,** Namaste Child and Family Development Center, Albequerque, New Mexico, and **Jeffrey Cornelius,** Autonomy, Inc., San Francisco, California

Two experiments examined the effect of differing levels of emotional arousal on learning and memory for words in matching and mismatching contexts. In Experiment 1, experienced skydivers learned words either in the air or on the ground and recalled them in the same context or in the other context. Experiment 2 replicated the stimuli and design of the first experiment except that participants were shown a skydiving video in lieu of skydiving. Recall was poor in air-learning conditions with actual skydiving, but when lists were learned on land, recall was higher in the matching context than in the mismatching context. In the skydiving video experiment, recall was higher in matching learn-recall contexts regardless of the situation in which learning occurred. We propose that under extremely emotionally arousing circumstances, environmental and/or mood cues are unlikely to become encoded or linked to newly acquired information and thus cannot serve as cues to retrieval. Results can be applied to understanding variations in context-dependent memory in occupations (e.g., police, military special operations, and Special Weapons and Tactics teams) in which the worker experiences considerable emotional stress while learning or recalling new information.

INTRODUCTION

The present study originated with an observation: The instructors for our (L. T. and J. C.) beginning skydiving course made us rehearse short skydiving procedures repeatedly during most of a 4-h training session. These procedures were for letting go of the plane, arching in the air, checking our chutes, deploying the reserve chute (only in an emergency), and landing. When we asked why we repeated the procedures so many times, one of the instructors replied, "Because no matter how smart you are on the ground, you get stupid the first time you fall out of a plane." He was right. Two of our classmates made mistakes that day that could have cost them their lives. One student "cut away" her main parachute even though it was operating perfectly. She panicked, but she was in radio contact with a staffer at the landing site who calmly told her again how to pull the rip cord to deploy her reserve parachute, which she accomplished at an alarmingly low altitude. Another student, also in radio contact with skydiving personnel on the ground while preparing for landing, pulled hard on his right steering cord when he was told to pull on his left cord. This mistake forced him to crash land on the skydiving center rooftop, spraining his ankle.

The purpose of the present study was to investigate how learning and remembering are affected by high levels of emotional arousal and to compare performance under naturally stressful conditions (Experiment 1 – actual skydiving) with performance under conditions that only mimic the source of arousal and produce milder forms of stress (Experiment 2 – skydiving video procedure). Our results are applicable to situations in which a person must learn and remember new information while performing well-learned tasks under highly stressful circumstances. One example might

Address correspondence to Laura A. Thompson, Psychology Department, 3452, Box 30001, New Mexico State University, Las Cruces, NM 88003; thompson@crl.nmsu.edu. **HUMAN FACTORS,** Vol. 43, No. 4, Winter 2001, pp. 611–619. Copyright © 2001, Human Factors and Ergonomics Society. All rights reserved.

occur in police work, where the police officer is performing a routine but stressful procedure, such as arresting someone, and simultaneously he or she must attempt to encode information about the surrounding scene or event that might prove important during later interrogation.

We modeled our study after Godden and Baddeley's (1975) study of context-dependent memory in scuba divers. Scuba divers learned lists of words, either on land or at the bottom of a lake, and recalled them either in the same environmental context or in the other one. Based on their results, Godden and Baddeley (1975) found that memory was better when people were tested in the same context as the original learning occurred, compared with when learning and test occurred in different contexts. Their findings are widely cited as support for the notion that environmental cues encoded during word learning aid in recalling the words. However, as Eich (1985, 1995) argued, differing environments can evoke differing moods, and mood states are known mediators of memory performance. Thus the source of the context-dependent effects in Godden and Baddeley's (1975) study could be the result of mood cues, environmental context cues, or both. The same argument could be made for any combination of two environmental contexts, such as the land-air contexts employed in the present study.

In support, a number of reports on mood-state dependence reveal a mediating influence of mood on memory. Mood-state dependence is shown when people recall more information when the mood they are in during recall is affectively congruent with the mood they were in when they encoded the material (e.g., Weingartner, Miller & Murphy, 1977). For example, Bower, Monteiro, and Gilligan (1978) used hypnosis to induce either a happy or a sad mood. Participants then learned a 16-item word list and, after a short interval, recalled the words in either the same or the opposite mood. They obtained the same type of interaction as in Godden and Baddeley's (1975) study with scuba divers, a cross-over interaction, showing that recall depended on the match between learning mood and recall mood.

A growing literature reveals that people's ability to learn and recall information is negatively affected by stress. E. L. Loftus (1980) reported a study in which she asked people with a fear of snakes to watch a filmed event that they would be tested on later. Participants who watched the film in a room near a stuffed cobra remembered far fewer details of the film than did people who watched the film with a teddy bear nearby. Researchers exposed participants to a slide of an autopsy embedded within slides of travel scenes (Kramer, Buckhout, Fox, Widman, & Tusche, 1991). The autopsy slide was labeled either "NYPD" (New York Police Department) or "MGM Studios." Participants' recall in the NYPD-labeled condition showed amnesia for slides following the traumatic slide. Retrograde amnesia occurred for material learned while viewing traumatic slides, but it did not occur for material learned immediately after adrenalin injection (Christianson, Nilsson, Mjorndal, Perris, & Tjellden, 1986). E. L. Loftus and Burns (1982) also found a retrograde amnesia effect in an experiment in which a shocking crime occurred immediately prior to recall.

Additional research in naturally occurring stressful environments supports the notion that negative emotions adversely affect cognitive performance. Baddeley (1972) had army personnel recall emergency instructions relevant to a crash landing in one of two conditions – in one, they were deceived into thinking that such an emergency had arisen; in the other, a control condition, the participants had no reason to think that a dangerous situation had arisen. Performance was far better in the control group than in the stressed group. Ashcraft and Faust (1994) investigated college students' ability to solve arithmetic problems. Participants were rated on a math anxiety scale, and those low in math anxiety solved the problems more quickly than those with a medium level of math anxiety. Students with high math anxiety were often just as fast as low-anxiety students; however, the former made far more errors.

We chose skydiving as our means of investigating how context dependence in memory performance might be affected by extreme stress, for several reasons. Ethical considerations prevent studying memory under extreme stress using laboratory induction techniques. Additionally, psychophysiological data already exist that attest to the extremely stressful nature of skydiving (Deinzer, Kirschbaum, Gresele, &

Hellhammer, 1997), in comparison with other common stressors (Bohnen, Houx, Nicolson, & Jolles, 1990; Kirschbaum et al., 1995; Wittersheim, Brandenberg, & Follenius, 1985), including public speaking (Bassett, Marchall, & Spillane, 1987). Physiological data show that skydiving induces very high cortisol responses – a psychological stress indicator – even after repeated parachute jumps (Deinzer et al., 1997), and recent research has demonstrated a negative relationship between cortisol levels and memory task performance (Kirschbaum, Wolf, May, Wippich, & Hellhammer, 1996). Furthermore, psychophysiological data show that both experienced (Fenz & Epstein, 1967) and inexperienced (Deinzer et al., 1997) skydivers show higher stress reactivity during a skydiving event compared with baseline control samples.

Many years ago, two psychologists measured the autonomic system arousal levels of novice and experienced sport parachutists (Fenz & Epstein, 1967) at several points in the sequence of events leading up to and following a jump. Skin conductance and heart rate curves showed patterns of generally increasing autonomic responses between the day before the jump and up to the point when final altitude had been reached before jumping. The high autonomic measures reflect common defensive responses to unpleasant or traumatic stimulation (Christianson, 1987). We relied on Fenz and Epstein's autonomic response data to support our assumption that even in experienced skydivers, emotional arousal while parachuting is greater than arousal on the ground. Because during the skydiving video procedure participants did not make the treacherous plunge from a plane, we assumed that emotional arousal would be greater for experienced skydivers on a skydiving day than for participants in the skydiving video experiment.

Because we were interested in investigating how memory is influenced by emotional arousal in matching and mismatching learning and recall contexts, many of the methodological details of Godden and Baddeley's (1975) study were retained in the proposed study. For example, participants were exposed to the same list of words two times during each learning period, and word lists were presented by cassette recorder through headphones in both contexts. In Experiment 1, skydivers learned lists of 20 unrelated words in each of four conditions: learn and test on land; learn and test in the air; learn on land, test in air; and learn in air, test on land. Because we would have placed novice skydivers at grave risk by asking them to learn or recall material unrelated to skydiving procedures, we tested only experienced skydivers, who averaged 175 previous jumps. Another reason for using highly experienced skydivers as participants was to control for the effects of increased cognitive workload while skydiving. For skilled skydivers, who often boast of being able to skydive "in their sleep," the cognitive workload of navigating themselves under an open parachute that has been "checked" to ensure safe operation should be minimal and, hence, less likely to contribute variance in the air learning and recall conditions, compared with using less-experienced skydivers.

In Experiment 2, college students who had never skydived were given some instruction in skydiving and participated in learning and recall of word lists either while watching or not watching a skydiving video. This procedure served as the less emotionally arousing situation in which to observe context dependence in memory.

Our hypotheses were the following: (a) The extreme level of stress experienced during actual skydiving would disrupt the encoding of words learned in the air; hence recall would be poor in both land and air contexts. However, when skydivers learned words on land, they should exhibit a higher level of recall in the matching context than in the mismatching context. (b) The milder level of stress in the skydiving video experiment should allow participants to encode environmental and/or mood context cues, along with the words, to assist in their recall. Hence, a cross-over interaction should be obtained whereby recall is higher for matching than for mismatching contexts. (c) If extreme stress impairs memory performance, the overall level of recall should be lower in the actual skydiving context than in the skydiving video context.

EXPERIMENT 1

Method

Participants. Participants included 14 men and 2 women, ranging between 18 and 37 years of age (mean age = 26 years), who were

experienced skydivers. The number of previous skydives each person reported ranged between 39 and 350 (M = 175). All were in good health and were free of any known hearing impairments. Participants were recruited from three skydiving locations in Arizona and New Mexico. Each participant received $45, which paid for the cost of the three air drops they were required to make for the experiment.

Stimuli and apparatus. Five 20-item word lists were created and audiotaped, each containing different two- and three-syllable concrete nouns (e.g., *sandwich, bedroom,* and *spider*). One of the word lists was consistently used for practice. The words were unrelated to the context of the study (we did not use *airplane, parachute,* or *building*). The words were spoken loudly, with clear articulation, by a young man and were read in sets of three (except for the final two words) with 4-s intervals between sets. The entire word list was recorded two times onto audiotape, with a 10-s pause between lists. An 8-min interval of loud static noise was recorded onto the tape for participants in the air-air, land-land, and air-land conditions in order to simulate the distracting noises of the plane experienced in the interval between learning and recall in the land-air condition, thus making the conditions more equivalent.

The audiotaped stimuli were played back on a portable Sony cassette recorder (Model TCM-111). The cassette recorder was tightly strapped to the chest of each participant. The participants wore earphones with cotton wadding in order to block out all extraneous noises, and this was effective. The same cassette recorder with internal microphone was used for audiotaping the participants' responses at recall. Participants used either their own parachuting gear or that loaned to them by the skydiving centers. All parachutes were of the easily maneuverable, rectangular-shaped variety that allow for soft landings.

Design. A 2 × 2 factorial design was used, with learning context (land, air) and recall context (land, air) as within-subject variables. There were four learning-recall conditions: land-land (LL), land-air (LA), air-air (AA), and air-land (AL), representing learning and recall contexts, respectively. The pairings of each of the four test lists with the four temporal orderings of conditions was presented according to a Graeco-Latin square design. Each participant received all four word lists, one in each learning-recall condition. Each list appeared in each of the four learning-recall conditions an equal number of times.

Procedure. Participants were tested individually. All instructions were given by the experimenter at private, quiet locations outside the skydiving centers, near the "drop zones" (landing places). Prior to the four testing conditions, participants practiced the procedure with one test list. The specific instructions for each learning-recall context were given immediately prior to the learning phase of the condition. For the LL condition, participants stood in a quiet place, alone, approximately 20 feet (6 m) outside the drop zone. Participants listened to the two repetitions of a word list, waited during the 8-min interval of static noise, and then recalled the words they could remember by speaking into the cassette recorder. For the LA condition, participants listened to the word list and then immediately entered the plane. The plane taxied off and flew up to an altitude of 5000 feet. The participant jumped out, opened the parachute, made sure there were no tangles in the parachute lines, positioned himself or herself, and performed the recall task. The final altitude for the LA context was chosen so that there would be enough time for the skydivers to safely parachute, yet still have plenty of time to recall as many words as they could in the air, before readying for landing.

In the AL condition, participants jumped out of the plane at an altitude of 5000 feet and performed the learning task. After landing, they gathered up their chutes and walked off the landing zone. If any of the 8-min static noise phase was remaining, they waited until that phase was over before recording their responses. For the AA condition, the plane flew to an altitude of 10 000 feet. Parachutes were opened immediately so that there would be enough time for the learning phase, the 8-min static noise interval, and the recall phase before readying for landing.

Results

Participants' audiotaped responses were transcribed onto paper. All words that matched

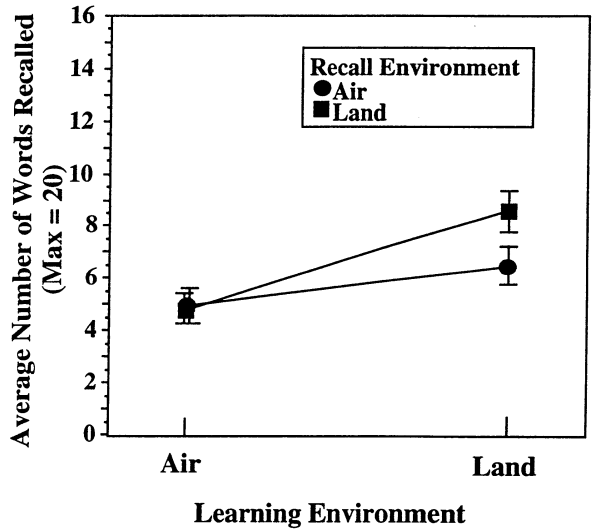

Figure 1. Average number of words recalled by skydivers in each learning-recall condition in Experiment 1. Error bars indicate 1 standard error from the mean.

those presented were scored as correct. Figure 1 presents the average number of words recalled for each of the four conditions in the experiment.

A 2 (learning context) × 2 (recall context) analysis of variance (ANOVA) revealed a significant main effect for learning context, $F(1, 15) = 18.85$, $p < .001$. Recall was higher when words were learned on the ground compared with when they were learned in the air. A significant interaction was also found between learning context and recall context, $F(1, 15) = 4.23$, $p = .05$. Planned *t*-test comparisons revealed no difference in recall for the AA ($M = 4.94$; $SD = 2.43$) and AL ($M = 4.81$; $SD = 2.23$) conditions ($p > .05$). However, recall was significantly higher in the LL ($M = 8.56$; $SD = 2.90$) condition than in the LA ($M = 6.44$; $SD = 2.94$) condition, $t(15) = 2.33$, $p < .05$.

A final post hoc *t*-test comparison indicated significantly higher recall in the LA condition than in the AL condition, $t(15) = 2.66$, $p < .025$. This difference shows that the negative effect of the air context was greater during the encoding phase than it was during word retrieval. To summarize, both predictions for this experiment were supported. Recall was low in the conditions where words were learned in the air and did not differ between AA and AL conditions. Second, words encoded on land were better recalled on land than in the air. Moreover, retrieval was less affected by the air context than was original encoding.

EXPERIMENT 2

Method

Participants. Sixteen young adults (6 men, 10 women) between the ages of 18 and 22 years participated in the study. The majority of the participants were recruited from the introductory psychology participant pool at New Mexico State University and received course credit.

Stimuli and apparatus. The same word lists used in Experiment 1 were used in Experiment 2, although they were re-recorded using the same procedure as before. One 15-min videotape was created for participants to watch while participating in each learning or recall condition. The video recording included several repetitions of a skydiving scene from the movie *Point Break.* In the scene, skydivers are shown jumping out of a plane, falling several thousand feet, and opening their parachutes. Loud static noise was dubbed over the sound track. The scene was filmed from the vantage point of a fellow skydiver.

The same cassette recorder and earphones employed in Experiment 1 were used in the

present experiment. A Hitachi videocassette recorder (Model VT-F330A) and a 19-inch (48-cm) RCA XL-100 television presented the video.

Procedure and design. Participants were run individually in 1-h sessions. At the beginning of the session, the experimenter taught each participant basic skydiving techniques. Each was told how a skydiver stands on a platform of a plane, holding onto the strut of the wing. The experimenter further explained aspects of skydiving that would be true for novices. For example, beginning skydivers do not open their own parachutes; the parachute is attached by a cord (the static line) to the body of the plane, causing the chute to open automatically when the skydiver reaches a given distance from the plane.

The participants then listened to a tape containing the practice word list. After an 8-min lag, participants spoke their responses into the cassette recorder. Following this, participants viewed the skydiving videotape. They were given a backpack filled with clothing and books and were told that the backpack feels somewhat like wearing a parachute. Participants stood in front of the TV while viewing the tape and asked any questions they might have about skydiving. They were then given instructions regarding the testing procedures for the four conditions of the experiment.

For each learning and recall condition, participants wore the "skydiving" backpack and sat in a chair. The only difference between "air" and land learning and recall conditions was the direction that the chair was facing; the chair faced toward the TV for air conditions and away from it for land conditions. Facing away from the TV, participants could see only a sheet-covered bookshelf and the walls of the room. All other aspects of the design were identical to those in Experiment 1.

Results

Participants' audiotaped responses were transcribed onto paper. The cell means for each of the four conditions are presented in Figure 2.

The number of correctly recalled words was submitted to a 2 × 2 (Learning Context × Recall Context) ANOVA. Recall was significantly greater when words were learned in the land context than in the air context, $F(1,15) = 9.64$, $p < .01$. There was no significant main effect for recall environment ($p > .05$). Recall environment also interacted with learning environment, $F(1, 15) = 27.71$, $p < .001$. Planned t-test comparisons revealed significantly greater recall in the AA condition ($M = 9.00$; $SD = 1.67$) compared with the AL condition ($M = 6.75$; $SD = 1.06$), $t(15) = 4.20$, $p < .001$. Recall was also significantly higher in the LL

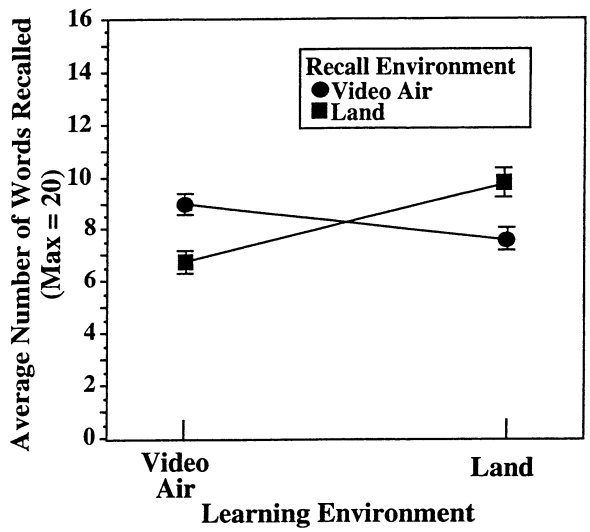

Figure 2. Average number of words recalled in each learning-recall condition in Experiment 2, the skydiving video experiment. Error bars indicate 1 standard error from the mean.

condition (M = 9.69; SD = 1.62) than in the LA condition (M = 7.56; SD = 1.41), $t(15)$ = 3.64, $p < .005$. Finally, a t test for independent groups was performed that compared overall recall performance across experiments. Results showed significantly greater recall, across all conditions, in Experiment 2 compared with Experiment 1, $t(30) = 4.20$, $p < .0001$.

GENERAL DISCUSSION

This study examined how the context-dependence effect in memory performance is mediated by stress by testing participants' ability to learn and remember words under extremely stressful conditions (real skydiving) and less-stressful conditions (skydiving video condition). Recall was greater when retrieval occurred in the same context in which the words were originally encoded for three of the four opportunities we created for observing a context-dependence effect. In each of these cases, extreme arousal did not characterize the conditions of encoding. When extreme arousal was present during encoding, context-dependent retrieval was not obtained. Instead, extreme arousal significantly weakened participants' ability to learn and remember new material. There is now a large body of literature concerning the effects of stress on recall (for a review, see Christianson, 1992). To put the present study in perspective, it seems necessary to review some theoretical claims made by previous investigators in order to interpret how learning and memory processes might be affected by emotional arousal.

Broadbent (1971) argued persuasively that different arousal-activation systems may be operating at different phases of the Yerkes-Dodson curve (Yerkes & Dodson, 1908). At medium levels of arousal, for example, the reticular activating system (RAS) is at maximum potential. The RAS receives sensory information and receives and transmits cortical information. At the medium to high phases of the curve, limbic structures may be activated and could be responsible for reduced levels of performance at high stress levels. However, although many studies do support the inverted U-shaped curve, there is now much evidence to refute the assumption that high levels of stress necessarily produce memory performance decrements (Christianson, 1992).

Another theoretical context for our findings can be found in Easterbrook's (1959) cue-utilization hypothesis, which predicts that increasing levels of emotional arousal results in a restriction of the range of cues that are attended to. The cues that are attended to are considered to be the most salient at the time. The hypothesis receives support within the field of eyewitness memory research (Christianson, 1992; Christianson & E. F. Loftus, 1987; E. L. Loftus, 1980). For example, studies have shown that crime victims show good memory for the perpetrator's weapon and poor memory for more peripheral details of the person and the event (e.g., Kramer, Buckhout, & Eugenio, 1990; E. F. Loftus, G. R. Loftus, & Messo, 1987).

However, it would seem that previous research used an inherent circularity in defining salient information under traumatic circumstances – namely, that what one remembers are the salient cues, and salience is determined on the basis of cues recalled. One could also argue that what should be considered to be salient information (including a perpetrator's face, for the purpose of later identification) is not actually attended to in traumatic circumstances; without defining *salience* before the event, however, one cannot avoid the circularity. In our study, one could argue that the newly acquired words were salient pieces of information because we instructed our participants to learn them for a later recall test. Interpreting our results within the context of the cue-utilization hypothesis, the overall low recall performance in air-learning conditions indicates that the words were not receiving large amounts of conscious processing.

It is more within the logical bounds of argumentation to focus our interpretation on this issue: To what degree are contextual cues effective in facilitating retrieval in stressful circumstances, bearing in mind that in our study the learning material itself was a list of words unassociated with the act of skydiving? This focus shifts attention away from the question of how arousal affects memory in a general sense and toward the question of what types of retrieval cues are unlikely to be processed under stressful conditions. Looked at this way, the results are fairly straightforward to interpret. Under

extremely stressful conditions, compared with learning situations that create milder forms of stress, contextual cues are less likely to become associated with the material to be learned.

The phenomena we observed in our experiments could be plausibly tied both to Craik and Lockhart's (1972) levels-of-processing view of memory and to Schacter's implicit/explicit memory distinction (Schacter, 1995). Regarding the latter, *explicit memories* are those that participants are consciously attempting to retrieve from memory, such as the list of words. *Implicit memories* are unconsciously processed memories that influence recollection, such as the mood or environmental context cues present in each learning condition. Extreme emotional arousal during encoding could disrupt the process of creating links between the information explicitly attended to (the words) and the information that is part of the context (the person's mood or environmental context cues). In this scenario, implicit information is encoded, but pathways between implicitly and explicitly processed information are not created. Thus, when the implicitly encoded contextual cues are recreated at retrieval, they do not assist in recalling the explicitly processed information because no pathways were originally formed between explicitly and implicitly stored information.

Alternatively, implicitly processed contextual information is not encoded in the first place. If not encoded, those same-context cues presented at recall would likewise not facilitate retrieval of explicitly processed information. In this second scenario, information that is attended to would receive priority and would be encoded, but other cues would be encoded only if there were spare attentional resources to process the material. Interpreting the results within the levels-of-processing framework (Craik & Lockhart, 1972), words and contextual cues may receive less depth of encoding when people are experiencing extreme stress, compared with when they are not.

On the basis of the present study's data alone, we cannot discriminate among these, or other, plausible explanations for how extreme arousal could affect the encoding of new information. Additional research employing paradigms to test various causal explanations will be required to address this issue. One final caveat is worth considering. Although we used highly experienced skydivers as participants to help control for the effects of increased cognitive workload while under a "checked" parachute, it is possible that the spatial navigation procedures were not completely routinized in this group and contributed more variance than we suspected.

There are wide individual differences in cortisol reactions to stress (Deinzer et al., 1997), and cortisol levels are negatively related to memory performance (Kirschbaum et al., 1996). This would imply that managers should devise procedures for selecting individuals who experience low levels of emotional arousal for the jobs that require "memory under fire," such as police, Special Weapons and Tactics (SWAT) teams, and U.S. Navy sea, air, land (SEAL) work.

ACKNOWLEDGMENTS

The research was supported by funds through the McNair Program at New Mexico State University. We wish to thank Sue Brown and David Trafimow for their support and constructive feedback. We are also grateful for the cooperation of the operators and skydivers at the Marana Skydiving Center in Tucson, Arizona, and at the Coronado Skydiving Center in Belen, New Mexico.

REFERENCES

Ashcraft, M. H., & Faust, M. W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. *Cognition and Emotion, 8,* 97–125.

Baddeley, A. D. (1972). Selective attention and performance in dangerous environments. *British Journal of Psychology, 63,* 537–546.

Bassett, J. R., Marchall, P. M., & Spillane, R. (1987). The physiological measurement of acute stress (public speaking) in bank employees. *International Journal of Psychophysiology, 5,* 265–273.

Bohnen, N., Houx, N., Nicolson, N., & Jolles, J. (1990). Cortisol reactivity and cognitive performance in a continuous mental task paradigm. *Biological Psychology, 31,* 107–116.

Bower, G. H., Monteiro, K. P., & Gilligan, S. G. (1978). Emotional mood as a context for learning and recall. *Journal of Verbal Learning and Verbal Behavior, 17,* 573–578.

Broadbent, D. E. (1971). *Decision and stress.* San Diego, CA: Academic.

Christianson, S.-A. (1987). Emotional and autonomic responses to visual traumatic stimuli. *Scandanavian Journal of Psychology, 28,* 83–87.

Christianson, S.-A. (1992). Emotional stress and eyewitness memory: A critical review. *Psychological Bulletin, 112,* 284–309.

Christianson, S.-A., & Loftus, E. F. (1987). Memory for traumatic events. *Applied Cognitive Psychology, 1,* 225–239.

Christianson, S.-A., Nilsson, L.-G., Mjorndal, T., Perris, C., & Tjellden, G. (1986). Psychological versus physiological determinants of emotional arousal and its relationship to laboratory amnesia. *Scandinavian Journal of Psychology, 27,* 302–312.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11,* 671–684.

Deinzer, R., Kirschbaum, C., Gresele, C., & Hellhammer, D. H. (1997). Adrenocortical responses to repeated parachute jumping and subsequent h-CRH challenge in inexperienced healthy subjects. *Physiology and Behavior, 61,* 507–511.

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review, 66,* 183–201.

Eich, E. (1985). Context, memory, and integrated item/context imagery. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 764–770.

Eich, E. (1995). Mood as a mediator of place dependent memory. *Journal of Experimental Psychology: General, 124,* 293–308.

Fenz, W. D., & Epstein, S. (1967). Gradients of physiological arousal in parachutists as a function of an approaching jump. *Psychosomatic Medicine, 29,* 33–51.

Godden, D. R., & Baddeley, A. D. (1975). Context-dependent memory in two natural environments: On land and underwater. *British Journal of Psychology, 66,* 325–331.

Kirschbaum, C., Prussner, J. C., Stone, A. A., Federenko, I., Gaab, J., Lintz, D., Schommer, N., & Hellhammer, D. H. (1995). Persistent high cortisol responses to repeated stress in a subpopulation of healthy men. *Psychosomatic Medicine, 57,* 468–474.

Kirschbaum, C., Wolf, O. T., May, M., Wippich, W., & Hellhammer, D. H. (1996). Stress- and treatment-induced elevations of cortisol levels associated with impaired declarative memory in healthy adults. *Life Sciences, 58,* 1475–1483.

Kramer, T. H., Buckhout, R., & Eugenio, P. (1990). Weapon focus, arousal, and eyewitness memory. *Law and Human Behavior, 14,* 167–184.

Kramer, T. H., Buckhout, R., Fox, P., Widman, E., & Tusche, B. (1991). Effects of stress on recall. *Applied Cognitive Psychology, 5,* 483–488.

Loftus, E. L. (1980). *Memory: Surprising new insights into how we remember and why we forget.* Reading, MA: Addison-Wesley.

Loftus, E. L., & Burns, T. E. (1982). Mental shock can produce retrograde amnesia. *Memory and Cognition, 10,* 318–323.

Loftus, E. F., Loftus, G. R., & Messo, J. (1987). Some facts about "weapon focus." *Law and Human Behavior, 11,* 55–62.

Schacter, D. L. (1995). Implicit memory. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 815–824). Cambridge, MA: MIT Press.

Weingartner, H., Miller, H., & Murphy, D. L. (1977). Mood-state-dependent retrieval of verbal associations. *Journal of Abnormal Psychology, 86,* 276–284.

Wittersheim, G., Brandenberg, G., & Follenius, M. (1985). Mental task-induced strain and its after-effect assessed through variations in plasma cortisol levels. *Biological Psychology, 21,* 123–132.

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology, 18,* 459–482.

Laura A. Thompson received her Ph.D. in psychology in 1987 at the University of California, Santa Cruz. She is an associate professor of psychology at New Mexico State University.

Keith L. Williams received his Ph.D. in psychology in 1999 at the University of Michigan, where he is a postdoctoral researcher.

Paul R. L'Esperance received his M.A. in counseling in 2000 at the University of New Mexico. He is a children's mental health therapist and outpatient admission director at the Namaste Child and Family Development Center, Albuquerque, New Mexico.

Jeffrey Cornelius received his M.A. in psychology in 1991 at New Mexico State University. He is district sales manager at Autonomy, Inc., San Francisco, California.

Date received: October 12, 2000
Date accepted: April 21, 2001