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Accuracy of eyewitness memory for persons encountered during exposure to highly intense stress

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1. Introduction

Over the past 20 years there have been over 2000 scientific investigations on the reliability of eyewitness identification (Cutler & Penrod, 1995). The majority of studies have been conducted in the laboratory using videotapes or live simulations of crime events; only a handful have been field studies involving victims and eyewitnesses of real crimes. Laboratory studies are limited because crime simulations do not entail the degree of personal "threat" or "alarm" that an individual may experience during actual life-threatening events (Penrod et al., 1995). A major limitation of extant field studies is the inability to control for specific factors (such as severity and intensity of traumatic events) that may significantly affect human memory. Limitations notwithstanding, the relevant literature supports the general view that memory formation is better in response to events that are perceived to be as stressful, personally relevant, and that elicit adequate physiological arousal or alarm (Gold, 1992; Canli et al., 2000). At apparent odds with this general consensus are the findings from recent studies suggesting that the eyewitness memories reported by combat veterans who have been exposed to life-threatening events during combat may be inconsistent and subject to substantial error (Southwick et al., 1997; Roemer et al., 1998). In order to explain this phenomenon, some have proposed that during exposure to potentially

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traumatic events, peritraumatic symptoms of dissociation may disrupt the encoding of memory and contribute errors in memory for the traumatic events (Koopman et al., 1994).

The current limitations in eyewitness studies and the difficulties in applying such data to studies of memories in people exposed to traumatic stress could be effectively overcome by evaluating human memory at a venue where subjects are exposed to valid, reliable, and controlled conditions of realistic stress. Recent evidence suggests that military survival school training may provide such a venue. A series of psychobiological investigations conducted by our laboratory at the U.S. Army survival school training program have shown that survival school represents a valid and reliable model for the study of realistic, threat-to-life stress in humans (Morgan, 2000; Morgan, Wang, Mason et al., 2000; Morgan, Wang, Southwick et al., 2000; Morgan, Hazlett, Wang et al., 2001; Morgan, Wang, Hazlett, Rasmusson et al., 2001). Unlike mock crime or field studies, survival school investigations can apply severe stress in a uniform manner that controls for intensity and duration across subjects. The extreme stress experienced by participants is pronounced and results in significant alterations of neurobiological processes and psychological experiences (such as peritraumatic dissociation) that are on a par with those noted in individuals experiencing real-world, threat-to-life events such as landing on an aircraft carrier at night for the first time, skydiving for the first time, open-heart surgery, and actual combat (Morgan, Wang, Mason et al., 2000; Morgan, Wang, Hazlett et al., 2001). As such, the survival school is an ideal "laboratory" for prospective, objective evaluation assessing the accuracy of eyewitness memory for events experienced during exposure to realistic stress.

Survival school training is divided into two general phases. The first phase is didactic; the second phase is experiential. In the didactic phase, participants undergo one week of classroom instruction to prepare them for the experiential phase. In the experiential phase, participants are confined in a mock prisoner of war camp (POWC). This phase is designed to offer one of the most challenging training experiences that active duty participants will ever experience while in the military. In the POWC, each participant is placed in isolation and then subjected to various types of interrogation. These interrogations are designed to test the limits and abilities of the participants to withstand "exploitation by the enemy" and to demonstrate problem-solving skills while experiencing extreme stress. As documented in our previous investigations, all school participants are exposed to both high- and low-intensity types of interrogation stress.

As we have previously reported, the stress experienced during the confinement phase is intense and provides a valid environment for the study of uncontrollable stress in human subjects. Psychological symptoms of peritraumatic dissociation, and stress hormones (such as cortisol, norepinephrine, and epinephrine), are significantly elevated and comparable to alterations documented in real-world, threat-to-life events, whereas gonadal steroids, such as testosterone, are reduced below fertility levels in response to TL stress (Morgan, Wang, Mason et al., 2000; Morgan, Hazlett, Wang et al., 2001; Morgan, Wang, Hazlett et al., 2001). These two types of interrogations experienced by participants differ in the degree to which the participant is confronted with the threat of physical violence during the interrogation. Thus, survival school offers a model wherein there is (1) exposure to realistic, personally relevant acute stress; (2) uniform application of stressors (high and low) across subjects; (3) objective data about the "perpetrator" (interrogator) against which eyewitness reports provided by subjects can be compared; and finally, (4) a uniform time frame for the poststress assessment of memory for perceived events.

In the present study, accuracy of suspect recognition after high-stress and low-stress interrogation was assessed. Although some investigators have evaluated eyewitness memory in subjects who have personal, compared to vicarious, exposure to stress (Lindberg et al., 2001; Yuille et al., 1994), there do not appear to be any empirical studies that have critically evaluated the relationship between realistic high-intensity stress and the accuracy of eyewitness recognition. In a study comparing the eyewitness testimonies of children who directly versus indirectly experienced a painful medical inoculation, Lindberg, Jones, McComas Collard, and Thomas (2001) reported that those with direct and personal experience exhibited increased production of flashbulb-like memories (Lindberg et al., 2001). Similarly, Yuille et al. (1994) reported that adult police trainees who directly participated in stressful role plays exhibited increased accuracy of eyewitness memory and resistance to decay over time compared to fellow trainees who simply observed the role plays (Yuille et al., 1994). Although the data from these investigations support the idea that eyewitness memory is better if the stress has personal relevance, the intensity of the stress experienced by subjects was not of a magnitude such as that experienced by victims of trauma. As such, the data from these studies may not be applicable to understanding the nature of memory for traumatic events. Because preclinical (Haycock et al., 1977) and human neurobiological experiments (O'Carrol et al., 1999) have shown that increased levels of arousal and adrenalin may enhance memory, we hypothesized that eyewitness accuracy rates would be higher for the high-stress interrogation compared to low-stress interrogation.

We also compared accuracy of eyewitness recognition using three established law-enforcement methods for identifying crime suspects: the live lineup, the photo-spread technique, and the sequential photo method. Based on previous literature and the Department of Justice (DOJ) guidelines (The Guide, US DOJ, 2003), we hypothesized that accuracy rates of suspect recognition would be higher when using the sequential, compared to the live lineup and photo-spread techniques. Finally, we assessed differences in accuracy in eyewitness identification for cued and uncued photographs of suspects presented during the sequential photo method. Because studies in humans have shown that memory may be facilitated by contextual cues, we hypothesized that accuracy of suspect recognition would be better for cued, compared to uncued, photographs.

2. Methods

2.1. Subjects

Five hundred and nine of 530 consecutively recruited, active-duty military personnel enrolled in military survival school training were the subjects of this investigation. The mean age of subjects was 25 (S.D. = 5). The average number of years in the service was 4.2 (S.D. = 4). As designated by their military branch, 255 (50%) were navy air wing personnel, and 163 (32%) were marine pilots. Ninety-two (18%) subjects were sailors.

The assignment of subjects to a survival school cohort was determined administratively according to social security numbers. As in previous studies, the subjects in each cohort of training that formed part of this investigation did not differ significantly in age, rank, number of years in the service, or in military occupational specialty. The number of subjects per study were as follows: Study 1 (live lineup identification), $N = 228$ ($n = 188$, confronted by two instructors; $n = 40$, confronted by one instructor); Study 2 (photo-spread identification), $N = 114$; Study 3 (sequential photo identification for high-stress condition), $N = 167$ (cued photographs); $N = 51$ (uncued photographs); Study 4 (sequential photo identification for low-stress condition), $N=56$ (cued photographs); $N=60$ (uncued photographs). Assignment to study group was based on order of enrollment to the survival school program, which itself selects potential trainees from multiple sites and assigns them randomly (via social security numbers or alphabet) to any given training session.

Each participant completed induction into the survival training course prior to enrollment in the study. Recruitment of subjects was conducted by the principal investigator (CAM). All subjects gave written informed consent and understood that participation (or lack of participation) in the study would not influence their status in the survival school course in any manner. Per survival training course requirements, all subjects provided documentation of physical examination and medical and psychiatric clearance prior to enrollment. All subjects were free of illicit substances.

The phases of survival school training have been described in detail elsewhere. (Morgan, Wang, Mason et al., 2000; Morgan, Wang, Southwick et al., 2000; Morgan, Hazlett, Wang et al., 2001). Briefly, after the didactic phase of the course, participants are given, in as highly realistic manner as possible, an experience of wilderness evasion, followed by a mock captivity in a POWC. Because of the classified nature of the course a complete description is not possible. The types of stressors experienced by participants are modeled from the experiences of actual military personnel who have been prisoners of war. During the POWC the application of stress is uniform across participants. Approximately 12 h after being placed in the POWC, participants experience interrogation stress. All participants experienced both high- and low-stress interrogations conducted by different instructors. The interrogations were separated by approximately 4 h, involved different interrogators, and were of equal duration in length (approximately 40 min). In order to control for the possibility of an order effect, subjects were randomized so that one half experienced their high-stress interrogation prior to their low-stress interrogation and vice versa.

In Studies 1 and 2 of this project, subjects experienced interrogation stress while standing alone in a room with two survival school instructors, neither of whom was known to the subjects. During the interrogation, the room was illuminated and the subjects were able to see and hear the two instructors. The two instructors had distinct roles and were identified to subjects as "the guard" and "the interrogator." One instructor (the interrogator) would ask questions of the subject, whereas the task of the second instructor (the guard) was to physically confront the student if he or she did not appear to be complying with the interrogator's requests. Interrogation stress was approximately 40 min in duration. (Due to lack of instructors, a subsample of subjects in Study 1 [40 individuals] experienced their high-stress interrogation with only one instructor and not two. This instructor performed the role of both guard and interrogator. Thus, the high-stress interrogation data from this subset of subjects permitted an examination as to whether or not the accuracy of eyewitness ID was significantly affected by the number of instructors in the room.) In Studies 3 and 4 of this project, participants were confronted by only one instructor in the room who both asked questions and physically confronted them.

As noted above, all participants experienced two types of interrogation: a high-stress interrogation (with real physical confrontation) and a low-stress interrogation (without physical confrontation, but wherein the subject was presented with the challenge of being "tricked" by the interrogator into giving away information). Unlike subjects in Studies 1 and 2, subjects who participated in Studies 3 and 4 provided eyewitness data for either the high-stress or the low-stress condition and not both. Thus, while within subject comparisons were possible (between the high- and low-stress conditions) for Subjects in Studies 1 and 2, such comparisons were not possible for Studies 3 and 4.

All participants were exposed to the stress of uniform sleep and food deprivation for approximately 48 h prior to being subjected to interrogation stress. Upon release from the POWC, all subjects were given access to food and rest.

2.2. Assessment of eyewitness identification

2.2.1. Live line-up method

Twenty-four hours after release from the POWC, subjects met in the classroom of the survival school training facility. After being instructed to remain silent and to avoid communicating with peers, each was given a sheet of paper containing several statements. For Studies 1 and 2, the statements printed on the sheet of paper were: "Please identify the individual who was 'the guard' (the one manhandling you) during your high-stress interrogation"; "Please identify the individual who was the 'interrogator' (the one asking you questions) during your high-stress interrogation"; "Please identify the individual who was your low-stress interrogator;" "Please indicate on a scale of 1–10 (where 1 = totally guessing and 10 = not a doubt in your mind) your level of confidence in the accuracy of your responses.

At this point (in Study 1) 15 survival school instructors entered the room and stood side by side in a "lineup" in front of the class. Each held a card on which was printed a letter of the alphabet.

Next, subjects were given the following instructions: "Please look carefully at each of the individuals in the lineup. We want you to know that not all of the instructors who participated in your interrogations while you were in the POWC are present in this lineup. We have included people in this lineup that were not present during your interrogation experience. When you view the lineup, if you are unsure about your answer, please write "I do not know" on your form. If you are sure that the individual you are looking for is NOT in this lineup, please state "not in lineup" on your form, next to the appropriate category/question. Finally, please indicate next to your responses your level of confidence in how accurate you believe your responses are. Please take your time."

In Study 1, subjects were then invited to come up and walk down the lineup and to look at each of the instructors closely. During this process, instructors remained silent and looked straight ahead. No instructor had altered his or her facial appearance for the lineup compared to their facial appearance in the POWC. Each appeared as he or she did during the interrogation stress with one exception—the color of their military uniform. Whereas during the interrogations instructors wore the same "foreign" uniforms, at the assessment time point each wore identical green U.S. military battle dress uniforms (BDUs). After a 10-min period, the instructors left the room and the responses of subjects were collected. This procedure was repeated for assessment of the low-stress eyewitness memory.

2.2.2. Photo spread method

In Study 2, there was no "live" lineup. Instead, subjects were each given two 8 1/2 × 11 sheets on each of which eight color digital photographs of the survival school instructors were printed. Each of the color photographs was uniform in size (2 × 2.5 in.). Each depicted the subject wearing BDUs against a white background from the same distance such that the face, neck, and tops of both shoulders were visible. This method is identical to that used by the police departments of many states. Subjects were given the above noted instructions but were instructed to use the photos as a reference point for indicating their choices and confidence levels. Responses were collected by the research team at the conclusion of the 10-min period.

2.3. Assessment of eyewitness identification (sequential photo assessment method)

In Studies 3 and 4, a sequential method of photo presentation was utilized to assess eyewitness memory. The difference in the procedure for Study 3 and Study 4 was whether or not the photos of the interrogators that were presented to subjects were from the high-stress (Study 3) *or* the low-stress (Study 4) interrogations (but not both). In Studies 3 and 4, there were two subsamples of subjects. One subgroup of subjects in each study was shown "cued" photos (photographs of the interrogator in the exact uniform that he or she had worn while actually conducting the interrogation of the subject). The second subgroup of subjects was presented "uncued" photos (photographs of the interrogators wearing their regular green BDUs.). The inclusion of cued and uncued photographs from both high- and low-stress conditions permitted an examination as to whether or not eyewitness memory would be enhanced by the presence of additional visual cues that were actually present at the time of stress exposure.

Once the subjects were assembled in the classroom, a large projection screen was lowered in the front of the room, on which a sequence of 16 photos were sequentially presented using a projection system. The projection system rendered a 6×8-ft image of high color quality. Prior to the presentation of the photos, subjects were given the following instructions: "You have each been given a sheet of paper on which there are spaces for up to 16 responses. Next to each of the numbers on the page you will see the words "yes" and "no." To the right of these words you will see a row of numbers ranging from 1 to 10. You will be asked, when viewing a photo projected on the screen, whether or not the face on the screen is the individual who conducted your high-stress interrogation. You may select "yes" or "no." Once you have selected a response, please circle the number to the right of your answer that best corresponds to your level of confidence in the accuracy of your answer. A response of 10 indicates you have no doubt in your mind; a response of 1 indicates that you are guessing. Once you have selected an individual as your interrogator, your participation in the test is complete. Please hand your paper to a member of the research team and place your head down on your desk. You will not be permitted to review the photographs. It is possible that none of the photographs in this test include the face of the person who interrogated you."

At this point, the slide presentation began. Subjects were given 1 min to view each slide, provide their response and either quit or continue the test. Response sheets were passed to the research staff, and the subjects who had finished the test remained seated in the room.

2.4. Assessment of psychological symptoms of dissociation

In order to assess whether or not peritraumatic symptoms of dissociation experienced by subjects would be significantly related to eyewitness accuracy, subjects were administered a self-report instrument designed to assess such symptoms. As in our previous studies, subjects were administered Clinician Administered Dissociative Symptom Scale (CADSS) after completing the POWC phase of training. The CADSS is a reliable, valid, self-report instrument designed to assess state symptoms of dissociation in response to a specified stressor (Bremner et al., 1998). The self-report version of the CADSS is composed of 19 self-report items (e.g., "During the experience colors and sounds seemed changed in their intensity," "During the experience things appeared to be moving in slow motion," "During the experience I felt separated from my body as if watching things from above the scene"). Subjects were instructed to respond to the items on the CADSS using their POWC experience as a reference point. Each of the items is scored on a Likert scale of 0 (none) to 4 (extreme). A total score of 76 is possible.

2.5. Method of analysis

In each of the studies, only 80% of the instructors who actually conducted high-stress or low-stress interrogations were present in the live lineups, photo spreads, or sequential photos that were used for subject viewing. Thus, for 20% of subjects, none of the individuals presented during testing represented target suspects. The data from these subjects provided information about the percentage of true negative and false negative responses. Apart from the target suspects, the lineup, the photo spreads, and the sequential photo presentations each contained instructors who had never been seen by any of the subjects.

For each study, the number of true positive, true negative, false positive and false negative identification were calculated. Responses were considered true positive when a subject correctly identified their interrogator in the lineup, on the photo spread or in the sequential photo presentation of photos. Responses were considered true negative when a subject correctly identified that their interrogator was not present in the lineup, photo spread or sequential presentation of photos. Responses were considered false positive when the subjects did not pick their true interrogator, but instead selected another individual in the lineup, photo spread, or sequential presentation of photos. Finally, responses were coded as false negative when a subject erroneously indicated that their interrogator was not present in the lineup, photo spread, or sequential presentation of photos. The definitions of true positive, false positive, true negative, and false negative responses resulted in the fact that the denominator in the calculations of percent correct responses was not the same for each category. For example, in Study 1 ($N=188$) instructors for 38 (20%) of the 188 subjects in Study 1, were not present in the lineup. Thus, the denominator for calculating true positive and false negative responses was 150, whereas the denominators for true negative responses and false positive responses were 38 and 188, respectively.

2.6. Assessment of confidence and psychological symptoms of dissociation

Dissociation scores and confidence scores were the total scores on the CADSS and on the confidence scales, respectively. Cross tab nominal by interval (eta) were calculated to evaluate relationships between the variables "correct ID" and symptoms of dissociation and between "correct ID" and level of confidence.

2.7. Comparison of responses across methods of assessment

Because subjects in Study 1 and Study 2 provided eyewitness responses for *both* the high-stress and low-stress conditions, nonparametric sign tests were employed to detect whether accuracy differed between the two conditions. However, because subjects in Studies 3 and 4 were independent groups, chi-square analyses were utilized when comparing eyewitness accuracy rates for the high- and low-stress conditions.

Because the cohorts of subjects enrolled in survival school did not differ significantly from one another on any of the independent variables (age, years in the service, military operational specialty), comparisons across the studies (within stress condition) were considered as a "between-group" design from a statistical perspective. Chi-square analyses (SPSS 10.1) (SPSS, 2003) were used to examine whether the accuracy of suspect identification differed between the methods of assessment utilized (lineup, photo spread, sequential photo presentation) within the high- and low-stress conditions, respectively. Chi-square analyses were also used when comparing accuracy rates between the groups who were presented cued and uncued photographic stimuli.

3. Results

As shown in Table 1, regardless of method of assessment, the accuracy of eyewitness recognition (true positive responses) for the interrogator appeared to be greater for the low-, compared to the high-stress condition. This observation was statistically significant as indicated by nonparametric, within-subject comparisons (sign tests) for the subjects who participated in the live lineup and photo-spread

Table 1
Eyewitness recognition across type of assessment within stress conditions

Technique of assessment	Stress condition	
	High	Low
True positive responses		
Live line-up method	40/150 (30%)	113/182 (62%)[a]
Photo-spread method	33/98 (34%)	70/92 (76%)
Sequential photo method	20/42 (49%)[b]	42/55 (76%)
True negative responses		
Live line-up method	21/38 (55%)	23/46 (50%)
Photo-spread method	12/23 (52%)	9/23 (39%)
Sequential photo method	10/10 (100%)[c]	12/12 (100%)[d]
False positive responses		
Live line-up method	105/188 (56%)	87/228 (38%)
Photo-spread method	77/114 (68%)	14/114 (12%)[e]
Sequential photo method	26/51 (51%)[f]	16/64 (25%)
False negative responses		
Live line-up method	0/150 (0%)	5/182 (3%)
Photo-spread method	0/91 (0%)	15/24 (61%)[g]
Sequential photo method	0/41 (0%)	0/56 (0%)

Chi-square analyses were conducted to compare the methods *within* a condition (high stress, low stress) and *not* between the two conditions. For information regarding comparisons between the high and low conditions see the Results section of this paper.

[a] Method elicited significantly fewer true positive responses within the low-stress condition ($\chi^2=7.5$; $df=2$; $P<.02$).

[b] Method elicited significantly more true positive responses within the high-stress condition ($\chi^2=8.3$; $df=2$; $P<.016$).

[c] Method elicited significantly more true negative responses within the high-stress condition ($\chi^2=7.6$; $df=2$; $P<.02$).

[d] Method elicited significantly more true negative responses within the low-stress condition ($\chi^2=12.5$; $df=2$; $P<.002$).

[e] Method elicited significantly fewer false positive responses within the low-stress condition ($\chi^2=25$; $df=2$; $P<.0001$).

[f] Trend for false positive responses to be lower within the high-stress condition ($\chi^2=5.6$; $df=2$; $P<.06$).

[g] Method elicited significantly more false negative responses within the low-stress condition ($\chi^2=86$; $df=2$; $P<.0001$).

methods of testing (Studies 1 and 2) and by chi-square comparisons between the subjects who participated in the serial photo presentations (Studies 3 and 4). Sign tests of eyewitness memory for the high- and low-stress conditions for subjects in the live lineup and photo-spread conditions indicated that 42–45% of subjects performed equally well or poorly across the stress conditions, 42–50% of subjects performed better in the low-stress condition, and that 8–13% of subjects performed better in the high-stress condition [sign test for live lineup ($N=150$): high stress = low stress, $n=68$ (45%), low stress > high stress, $n=63$ (42%); high stress>low stress, $n=19$ (13%); $z=-4.7$; $P<.0001$. Sign test for photo spread ($N=92$); high stress = low stress, $n=39$ (42%), low stress>high stress, $n=46$ (50%); high stress>low stress, $n=7$ (8%); $z=-.5$; $P<.001$]. Examination of the eyewitness performance scores where high stress = low stress indicated that of the 68 subjects in the live lineup condition only 21 (11%) were accurate in their eyewitness identification; of the 39 subjects in the photo spread condition whose eyewitness accuracy scores were the same for both stress conditions, only 15 (16%) were accurate. These data also support the conclusion that overall eyewitness accuracy in subjects was better for the low- compared to the high-stress condition. Similarly, chi-square analyses of eyewitness accuracy rates across the high- and low-stress conditions for subjects in Studies 3 and 4 (independent subject samples) indicated that the observed differences between the two conditions were significant (sequential method, $\chi^2=7.3$; $df=1$; $P<.007$) and that accuracy was greater for the low- compared to the high-stress condition.

As noted in Table 1, comparisons of accuracy in eyewitness responses across types of eyewitness assessment (live lineup, photo spread, serial photo presentation) indicate that the sequential method was the more accurate method overall. Although not shown in Table 1, the eyewitness identification responses from the subgroup of individuals in Study 1 (live lineup) who were interrogated by a single instructor did not differ from the responses of subjects in Study 1 who were interrogated in the presence of two instructors. Similarly, the eyewitness responses regarding the identification of the "guard" (Studies 1 and 2), did not differ from the responses for the interrogator. These data suggest that eyewitness accuracy was not significantly affected by the presence of two instructors during stress exposure and that subjects were no more likely to be able to identify the guard compared to the interrogator.

As shown in Table 2, when subjects were presented with cued photographs (photographs of the interrogator that were taken at the time of the stress exposure) accuracy of eyewitness identification of the interrogator was increased compared to the responses of subjects shown uncued photographs (instructors wearing regular military uniforms). Although improvement in suspect recognition in response to a cued photograph was observed for both stress conditions, the effect was not significant for the low-stress condition.

Table 2
Percentage of true positive responses regarding facial recognition of interrogator using cued and uncued sequential photo presentation methods

	High-stress condition	Low-stress condition
Uncued photo presentation	20/41 (49%)	39/52 (75%)
Cued photo presentation	61/93 (66%)[a]	48/56 (86%)

[a] True positive responses were significantly higher for cued, compared to uncued presentation within the high-stress condition [$\chi^2=3.7$; exact significance (one-sided) $P<.05$]. True positive responses for cued compared to cued photographs did not differ significantly between one another within the low-stress condition [$\chi^2=1.9$; exact significance (one-sided) $P<.12$].

3.1. Confidence ratings

The mean confidence scores for the high-stress interrogation guard and interrogator were 4.5 (S.D. = 3.8) and 4.9 (S.D. = 4.1), respectively. Nominal by interval analyses (eta) failed to reveal any significant relationships between confidence and the group of accurate versus inaccurate subjects.

The relationship between stress-induced symptoms of dissociation (as measured by the CADSS) and facial recognition was examined, using dissociation as a continuous variable and ID as a dichotomous variable. Nominal by interval (eta) analyses failed to reveal any significant relationships between stress-induced symptoms of dissociation and facial recognition accuracy. The percentage of subjects who were able to correctly identify *either* the guard or the interrogator from the high-stress interrogation was 59%.

In each of the studies, subjects rated their confidence in the accuracy of their reports. Confidence scores regarding eyewitness identification did not differ between the studies. Mean confidence scores for the high-stress guard and interrogator were 6.2 (S.D.=.24) and 6.4 (S.D.=.26), respectively. The mean confidence score for the low-stress interrogator selection was 7.9 (S.D.=.36). Separate nominal by interval (eta) analyses (for each of the studies separately) as well as nominal by interval (eta) analyses for the combined (across studies) confidence data did not reveal any significant relationships between confidence and accuracy.

The mean CADSS dissociation scores did not differ between the study groups, and for the group as a whole was 23 (S.D. = 14). Nominal by interval analyses did not reveal any significant relationships between stress-induced symptoms of dissociation and accuracy of facial recognition.

3.2. Eyewitness assessment methodologies

With regard to the high-stress condition, the sequential method of eyewitness identification elicited more true positive and true negative responses and resulted in significantly fewer false positive responses compared to the other methods of assessment (Table 1). With regard to the low-stress condition, this method resulted in a significantly greater number of true negative and significantly fewer false positive responses (Table 1).

4. Discussion

Contrary to the popular conception that most people would never forget the face of a clearly seen individual who had physically confronted them and threatened them for more than 30 min, a large number of subjects in this study were unable to correctly identify their perpetrator. These data provide robust evidence that eyewitness memory for persons encountered during events that are personally relevant, highly stressful, and realistic in nature may be subject to substantial error.

Within-subject comparisons across the stress conditions indicate that for more than one half of the subjects eyewitness performance was significantly better in the low- compared to the high-stress conditions. For many individuals, eyewitness performance was the same across conditions (equally good or equally poor), and for a minority of subjects eyewitness memory was better for the high-, compared to the low-stress condition. Because demographic or subjective confidence and dissociation measures were not significantly different between these groups of subjects, the present data also strongly support the view that factors such as age, rank, years in the service, as well as subjective confidence or stress-induced symptoms of dissociation are not reliable indicators of accuracy of suspect recognition.

With regard to the high-stress condition, suspect recognition was better if the subjects were shown photos of the "suspect/perpetrator" wearing the clothing worn at the time of the stress event. The design of the "mug shot" photographs used in this study was such that the difference between uncued and cued photos differed only in the color and style of the collar and shoulders of the uniform worn by the individual. This limited but salient information (the color of the uniform worn by the instructor) appears to have facilitated the ability of subjects to recognize the instructor. Future studies might be designed to critically evaluate the degree to which specific stimuli (visual and/or aural) might enhance memory for stressful events (Gibling & Davies, 1998).

As suggested by the DOJ Guide (The Guide, US DOJ, 2003), the sequential method appeared to be overall the best method for assessing suspect recognition. This method resulted in significantly more true positive and true negative responses compared to the photo-spread or live lineup methods. The reasons for this are not clear. It is possible that the presentation methodology (using a large screen projector) to show the photographs facilitated recognition. Unlike the reports of previous studies employing the sequential technique, false positive responses in this study were not lower using the sequential method compared to other methods (Wells et al., 2000; Fisher et al., 1987).

No significant differences were observed in the rates of false positive responses elicited by the various assessment methods. Although false positive identification error has been historically noted in eyewitness memory studies involving civilians, the prevalence of such responses in this population of special-operations military subjects is noteworthy. The present subjects are successful graduates of military selection programs that are designed to screen for individuals who have superior abilities for retaining information and tasking ability while experiencing potentially life-threatening situations. The rates of false positive responses may be indicative of their complex and persistent nature. The different types of false positive responses evidenced in this study (such as picking someone when the target suspect was not present; picking someone else in spite of the target suspect's presence), raise the possibility of multiple etiologies for false positive responses.

Twenty percent of the instructors were not presented during the testing of facial recognition. This permitted an evaluation about the degree to which subjects were able to correctly identify that their instructor was not present. Approximately 50% of the relevant subjects were able to identify that their instructor was not present. Because these subjects did not differ significantly from other subjects on any other variables, the reasons for their ability to be more accurate compared to other subjects awaits future elucidation. Similarly, many subjects provided false negative reports in the live lineup or photo-spread methods, but not those assessed with the sequential presentation method. At present, the reasons for this are not known.

For many individuals eyewitness memory (true positive suspect recognition) for the high-stress condition was consistently poorer than eyewitness memory for the low-stress condition regardless of the method of assessment. Previous investigations at survival school have demonstrated that the high- and low-stress conditions (interrogations) differ significantly in the degree to which they elicit physiological and neurobiological states of alarm (Morgan, Wang, Mason et al., 2000; Morgan, Wang, Southwick et al., 2000; Morgan, Hazlett, Wang et al., 2001; Morgan, Wang, Hazlett et al., 2001). Thus, differences in plasma levels of catecholamine and/or cortisol elicited by exposure to the two types of stress may explain why the accuracy of eyewitness memory was better for the low- compared to high-stress interrogation. Numerous animal studies have provided evidence that there is an inverted-U-shaped relationship between arousal and memory. At moderate levels of arousal, stress hormones such as catecholamines and glucocorticoids may enhance memory, whereas at higher levels, they may disrupt memory (Liang, Bennett & McGaugh, 1985; Liang, Chen & Huang, 1995; Sternberg et al., 1986; Oitzi et al., 1998; Gold & McCarty, 1995). Indeed, (Kirchbaum et al., 1996) evaluated this hypothesis in humans and have reported that stress-induced elevations of cortisol significantly impaired performance on a declarative memory task. Based on our previous hormone research at survival school (Morgan, Wang, Mason et al., 2000; Morgan, Wang, Southwick et al., 2000; Morgan, Hazlett, Wang et al., 2001; Morgan, Wang, Hazlett et al., 2001) it seems reasonable to speculate that the increased level of glucocorticoid and catecholamine release in response to the high-stress interrogation may have contributed to a significant disruption of the encoding of eyewitness memory, whereas the previously documented moderate level of arousal elicited by the low-stress interrogation may have facilitated eyewitness memory. Clearly, this explanation does not explain the performance of all subjects since for many subjects eyewitness memory either did not differ across the stress conditions or it was superior for the high-stress condition.

The present data underscore the need for future studies designed to assess memory and neuro-hormones concurrently in survival school subjects. Such studies would clarify whether nor not the arousal hypothesis adequately explains the current data. Future studies might also be designed to assess whether differences are primarily due to the influences of arousal on the processes of encoding and recall of memory as well as on the influence of factors such as neuropeptide-Y release on memory formation during stress (Gold & McCarty, 1995). Such studies might test whether individuals who are correct in facial recognition differ significantly in specific neuropeptide or catecholamine hormones during stress compared to those who are incorrect in facial recognition. Inaccurate facial recognition might be due to an effect of stress on the unique neural structures involved in facial recognition, the encoding-recall mechanisms for stressful events, or perhaps due a negative effect on the capacity to modulate stress at the time of the stressful event. The role of stress modulation during and after exposure to stressful events in the facilitation or disruption of memory is an area for future investigation. Future studies may also include a standardized assessment of the ability to perform facial recognition tasks in subjects before and after survival school training. This might clarify whether the present noted problems in facial recognition for high-stress events are also detectable at nonstressed time points. This type of information would also be extremely relevant to contemporary issues in the field of posttraumatic stress disorder related to the characteristics of memory (i.e., reliability and accuracy) for traumatic events.

In addition to the impact of neurohormones released during stress, the observed differences between eyewitness memory may be a function of the amount of time elapsed between stress exposure and the assessment of memory. Preclinical data have shown that the consolidation of memory may occur over a number of days after stress exposure (Labar & Phelps, 1998; McGaugh & Hertz, 1972; Gold & van Buskirk, 1975). Indeed, REM sleep has been thought to play a role in this process (Maquet et al., 1996; Adolphs, Denburg & Tranel, 2001; Stickgold, 1999). It is possible that memory for the low-stress condition consolidated more rapidly that that for the high-stress condition and that an assessment at a later time point may have reduced the observed differences in memory between the two conditions. Future studies designed to assess the impact of sleep quantity on facial recognition for highly stressful events may enhance current understanding about when eyewitnesses are optimally accurate.

The present data have a number of implications for law enforcement personnel, mental health professionals, physicians, attorneys, and judges (Goldstein, Chance & Schneller, 1989; Lindsay & Wells, 1985). The current data offer a more realistic view about the accuracy of suspect recognition for events of a highly personal and stressful nature. All professionals would do well to remember that a large number of healthy individuals may not be able to correctly identify suspects associated with highly stressful, compared to moderately stressful, events. Furthermore, these data raise the possibility that other types of stress-induced memory deficits (such as narrative memory) may also exist in healthy individuals. This issue awaits future investigation. The present data underscore the idea that the sequential method will most likely result in more true positive and true negative responses compared to other methods of eyewitness assessment. One should also be extremely wary of using subjective confidence and/or the degree of stress symptoms reported by victims or eyewitnesses in making judgements about the accuracy of the witness. In the present study neither factor contributed to accuracy of suspect recognition.

There are several limitations to the present study. First, the present subjects represent military subjects who have participated in rigorous selection programs; therefore, the actual rates of suspect recognition reported in this study may be higher than those found within the general population. Nevertheless, the present results may have applicability to certain populations of civilians who engage in highly stressful work (such as law enforcement and firefighting). A second limitation is that the present study did not assess narrative memory. Because memory is not a homogeneous construct the present findings pertain only to suspect recognition. It is possible that stress differentially affects the ability to recognize a suspect and the ability to describe events that occurred during stress (39) (Gibling & Davies, 1998). However, given the role of eyewitness identification in contemporary law enforcement and jurisprudence, the present data provide a much-needed foundation of empirical evidence regarding eyewitness accuracy for highly realistic, personally meaningful, highly stressful events.

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