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Our investigations into the effects of stressful military training have shown that individuals exhibiting superior performance differ significantly from individuals exhibiting poor performance in their psychological and biological responses to stress. Specifically, stress-hardy individuals retain mental focus and clarity of memory under stress, commit fewer errors during stress, experience less burnout, demonstrate better navigational skills, and are able to stay physiologically calmer during potentially life threatening events and during uncontrollable stress. To ascertain individual differences in stress responses, we will investigate the effects of stressful military training on physiological, and cognitive functioning of armed forces members. Noninvasive saliva sampling will be used to assess hormonal stress levels. A 6-month no cost extension has been filed. Due to Institutional Review Board delays no human subjects data are available for this annual report. Additionally we developed novel telemetric technology for untethered measurements of heart rate activity. We will compare these physiological measures with training performance, cognitive performance and measures of stress.

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INTRODUCTION

This report is an addendum to the final report for The War Fighter's Stress Response: Telemetric and Noninvasive Assessment. The final report focused primarily of the development of the Wireless Intelligent Sensor (WISE) Heart Rate Variability (HRV) system and provided background information about the project. Our investigations into the effects of stressful military training have shown that individuals exhibiting superior performance differ significantly from individuals exhibiting poor performance in their psychological and biological responses to stress. To ascertain individual differences in stress responses, we investigated the effects of stressful military training on physiological, psychological, and cognitive functioning of armed forces members. This addendum to the final report provides the analyses of biopsychological data collected from students at the Combat Diver Qualification Course (CDQC), Aviation Preflight Indoctrination (API), Navy Aircrew Candidate students, Survival Resistance Evasion and Escape (SERE) training. We have found that some psychological measures and biological measures are correlated with performance through high intensity military training.

Body

Previous investigations into the effects of stressful military training (such as Army and Navy survival schools, Combat Diver Qualification Course, and Special Forces Selection and Assessment) have shown that elite war fighters differ significantly from general war fighters in their psychological and biological responses to stress. Specifically, stress-hardy individuals retain mental focus and clarity of memory under stress, commit fewer errors during stress, experience less burnout, demonstrate better navigational skills, and are able to stay physiologically calmer during potentially life threatening events (such as lack of oxygen) as well as during uncontrollable stress (such as interrogation stress) (Morgan, Wang, Southwick, Rasmusson, Hauger, & Charney, 2000; Morgan, Wang, Hazlett, Rasmusson, Anderson, & Charney, 2001; Helig, McLeod, Brot, Heinrichs, Menzaghi, Koob, & Britton 1993).

To ascertain individual differences in stress responses, we have investigated the effects of stressful military training on the metabolic and hormonal functioning of armed forces members. We developed novel telemetric technology for untethered measurements of heart rate activity, and used noninvasive saliva sampling to assess hormonal stress levels. Responses to stress were studied using ongoing investigations of military members across the services reporting to the Combat Diver Qualification Course (CDQC) at Trumbo NAS, Key West, FL, Aviation Preflight Indoctrination (API) and Navy Aircrew Candidate students reporting to the Naval Operational Medicine Institute (NOMI) located at Naval Air Station (NAS) Pensacola for water survival training, Special Forces members and aircrew reporting to Ft. Bragg for Survival Resistance Evasion and Escape (SERE) training. All of these training sites have been part of ongoing investigations conducted by our research team.

We have found that those individuals who have better stress tolerance exhibit significantly different patterns of heart rate variability, both at baseline (one week prior to stress exposure) and during stress exposure. These baseline differences in heart rate variability are predictive of actual military and cognitive neuropsychological test performance scores assessed during and after stress exposure. Heart rate variability (HRV) indexes both peripheral and central activity of the parasympathetic and sympathetic nervous systems. Recent brain imaging studies have confirmed that at least one component of heart rate variability (high frequency power) reflects activity in areas of the brain critical to the allocation of resources during stress, such as the medial pre-frontal cortex. Thus, assessment of HRV provides a noninvasive means of evaluating the neural systems intimately involved in the capacity to attend to and respond to a threat. These findings linking HRV to actual cognitive performance robustly support the utility of HRV in the assessment of human performance.

SPECIFIC AIMS/SYNOPSIS & HYPOTHESES

This study is designed to extend the findings from our previous neuro-biological studies and characterize: **1)** Baseline psychological and biological profiles that predict superior performance under stress; **2)** Stress-induced psychological and biological responses that are associated with superior performance under stress. This research provides a systematic characterization of psychobiological responses to highly stressful operations provides information that may be extended to the selection and training needs of the DOD. This research provides a detailed characterization of the relationship between physiologic assessment measures and the more traditional measures that have been used in our previous studies (neuro-hormone responses; paper and pencil tests). It is hoped that the data obtained in this project will extend our previous findings, provide additional clues to the factors contributing to excellence in military performance, and finally, provide evidence for a noninvasive, objective assessment of operational performance. It is expected that this type of information will not only lay the groundwork for the development of countermeasures designed to buffer against the negative effects of stress on soldiers, but also provide additional information for selection and assessment programs.

Over the past 4 years our research team has investigated and published a series of papers describing the impact of highly intense stress on the psychological and neuro-biological responses of healthy soldiers who are enrolled in U.S. Army & Navy Survival School training. We have also studied soldiers participating in U.S. Special Forces Assessment and Selection, the Canadian Joint Task Force Selection and in Special Forces Underwater Warfare Operations (Scuba) training. Taken together, the results of these studies have provided evidence that individuals identified by the military as "stress hardy" (or "elite") exhibit a psychological and biological profile that is significantly different from those individuals who are not identified as "stress hardy" and who do not tolerate stress well. For example, we have found that "stress hardy" personnel exhibit significantly greater abilities to remain "cool under pressure" (both biologically and psychologically), retain mental focus, and clarity of memory for events experienced during stress. In addition, they appear to perform fewer operational performance errors during the exposure to stress (i.e., they demonstrate superior performance during interrogation, exhibit better navigational skills (both land navigation and underwater navigation), are able to stay physiologically calm during potentially life threatening events (such as lack of oxygen).

Based on our previous findings, we hypothesize that as they have exhibited significant differences in neuro-hormone responses to stress, individuals exhibiting superior performance during training will also exhibit significant differences in HRV. In brief, certain biological systems in the body and brain that are involved in the response of an animal to threat can be indirectly and noninvasively assessed through specific types of analyses of the timing between beat-to-beat (RR) intervals of the heartbeat. Because there is a relationship between the neuro-hormones and neurobiological systems involved in both threat responding and in the regulation of heart rate, analyses of HRV will provide a noninvasive method for assessing and predicting an individual's ability to perform under stress. Since HRV analyses may be assessed telemetrically the present technology may provide a means of assessing human performance in military training environments and in the theatre of operations.

This is an addendum to the Final Report for this work. For a description of the development of the telemetric monitoring system the Wireless Intelligent Sensor (WISE) Heart Rate Variability (HRV) system, please see the Final Report submitted October, 2002.

SUMMARY OF METHOD AND RESULTS OF DATA FROM DIVE SCHOOL SITE:

Method:

Seventy male active duty personnel who had been accepted to participate in the Special Forces Underwater Warfare Operations Combat Diver Qualification Course were the subjects of this investigation. It was not possible to obtain 130 subjects, as was originally proposed, due to the rapid pace of the training environment. All subjects were recruited by the principal investigator(Morgan for the CDQC study) and each provided written, informed consent. All subjects had received medical and psychiatric clearance to participate in CDQC and all were free of illicit substances as determined by urine toxicology.

The mean age, height and weight of subjects were 27 (SD = 4.3), 70 inches (SD = 2.2), and 177 (SD = 20) respectively. Of the 70 subjects, 28 were Air Force para-rescue and cct personnel, 4 were marines (LURS-D), and 38 were Army Special Forces. 28 subjects were officers and 42 were enlisted.

The present report is part of a larger investigation that was originally designed to assess a number of psychological, biological, psycho-physiological and performance variables at 4 main time points during CDQC: During a non stressful baseline period - one week prior to the commencement of the course; At the end of the first week of the course; At the end of the 3rd week of the course (and after subjects' had experienced their first week-end respite from training); and finally, at recovery - 24 hours after completing and graduating from CDQC. In the larger study we also assessed salivary hormones before and after exposure to the various training exercises.

At baseline, subjects completed several valid reliable self-report instruments designed to assess trauma exposure (Brief Trauma Questionnaire), Burnout (Maslach Burnout Inventory) psychological symptoms of dissociation (CADSS), mood (Profile of Mood States (POMS)). Subjects were re-administered the SAM, CADSS, and the POMS at each assessment time points during the study. The measures of trauma, stress and burnout were administered at baseline only.

At each of the above noted assessment time points, and after completing the self report measures, subjects participated in heart rate variability monitoring (polar vantage NV heart rate monitors) and each donated saliva and plasma samples that were to be later analyzed for the following neuro-hormones (cortisol, DHEA, DHEA(S), Norepinephrine, Epinephrine, Neuropeptide-Y, and Testosterone).

The present manuscript addresses: 1) The relationship between Military Performance and Baseline hormone measures (DHEA, DHEA(S), cortisol), baseline physiological measures (heart rate variability [HRV]), and baseline psychological measures (Dissociation, Subjective Distress) to the subsequently assessed Military Performance as measured by subjects underwater navigation scores; 2) The relationship between Acute Stress Induced alterations in HRV and salivary cortisol and subsequently assessed Military Performance - as measured by underwater navigation scores.

Analysis of the relationship between Military Performance at CDQC and the other hormones, physiological and psychological measures is ongoing and we anticipate that as additional funding becomes available we will be able to complete the assays.

Data analyses:

Plasma samples were spun down in a refrigerated centrifuge, pipetted into micro-tubules and frozen within 40 minutes of veni-puncture. Samples were stored at -70 degrees C from the time of initial collection until analyses were performed. Salivary samples were frozen and shipped with plasma samples to our laboratory within 24 hours of collection.

Cortisol analysis methods:

Plasma was collected as described above. Saliva was collected in Salivette tubes (Sarstedt, Newton NC), centrifuged and pipetted into two 1.5 ml plastic vials. The samples were shipped on dry ice to our laboratory and stored at -70 degrees C until assayed. Plasma and salivary cortisol were analyzed by R.I.A. procedures (Incstar Corp, Stillwater, MN). The inter-assay coefficient of variation in our laboratory is 6.1%.

DHEAS analysis methods:

Frozen plasma samples were used and processed in batch. DHEA and DHEA-S commercial RIA kits were purchased from Diagnostic Systems Laboratories Inc. (Webster, TX) and assays were performed according to manufacturer's recommendations utilizing 10 or 100 nL of plasma for DHEA-S and DHEA, respectively, with intra-assay variability for DHEA-S up to 9% (DHEA-4%) and inter-assay variability of up to 10% (DHEA-9%). Minimum reported sensitivities for these assays is 0.009 ng/mL (DHEA) and 1.7 ng/dL (DHEA-S). Reported cross-reactivity of the DHEA assay with DHEA-S was 0.02%. All assays were performed in duplicate.

Heart Rate Variability (HRV):

Heart rate variability was assessed using Polar Vantage NV monitors which measured RR interval data for 10 minutes at baseline, and for 4 minutes following exposure to the acute stress of the Free Assent exercise. Analysis software (Polar Precision Performance 8.5) provided time dependent, geometric and spectral analysis of data. Due to the recording length of the data, we followed the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996) and used power spectral analyses as the indicators of sympathetic and parasympathetic activity. The parameters set for the frequency bands were: high frequency (HF, 0.15-0.4 Hz); low frequency (LF, 0.04-.15 Hz); very low frequency (VLF, 0.00-0.04 Hz); total power (TP, 0.00-0.4 Hz). Current scientific literature supports the idea the HF best reflects parasympathetic (vagal) activity, whereas, the LF/HF ratio best indexes sympathetic tone ()(). HRV files were rejected if the percent error was greater than 5%.

The Polar Precision Performance software error filtering procedure uses an auto-regressive method for calculating HRV. The software uses a median and moving average based filtering method to check for possible errors and artifacts. After this it computes several better matching candidates to substitute the errors. The criteria adapts to the R-R data to be checked. In the correction phase, very small corrections are prevented and thus the initial detection of errors is sensitive. In the final interpolation the algorithm first checks the series of corrected values (usually 2-4 intervals) in order to follow the same differential coefficient (derivative). Log 10 transformations were used in order to give the HF and LF data a normal distribution prior to performing subsequent analyses.

Psychological measures:

At baseline and immediately following participation in the free ascent exercise, subjects completed the Self-Assessment Manikin (SAM), a valid, nonverbal pictorial assessment technique that measures the degree to which dimensions of pleasure/displeasure, agitation/calm and dominance/inferiority are affected by a wide variety of stimuli (Bradley & Lang, 1999). The three sub-scales may be combined to provide a total score that indicates the overall level of distress. The total possible score on this version of the SAM is 27.

Subjects completed the self-report version of the Clinician Assessed Dissociative Symptoms Scale (CADSS) in order to rate their symptoms of dissociation during the classroom phase. The CADSS is designed to assess the occurrence and intensity of state symptoms of dissociation. The items of the instrument are designed to assess how perceptually "in touch" (or "out of touch") an individual is, vis a vis his or her environment during specific conditions (non-stress; stressed). While some of the items on the scale ask about one's sense of physical self (For example: "Do you feel as if you are looking at things outside of your body?," "Do you feeling as if you are watching the situation as an observer or spectator?"), other items ask about cognitive or perceptual distortions (For example: "Do colors seem to be diminished in intensity?," "Do sounds almost disappear or become much stronger than you would have expected?", "Do you space out or in some way lose track of what is going on?" "Do you see things as if you were in a tunnel, or looking through a wide angle photographic lens?"). The self report scale contains 19 items each of which is rated by subjects on a Likert type scale of 0 (not at all) to 4 (extremely). A total score of 76 is possible.

Underwater navigation scores:

Underwater navigation performance is considered by the CDQC staff as the core skill about which subjects at CDQC must demonstrate competence if they are to successfully pass the course. Underwater navigation skill indexes a soldier's ability to arrive accurately and one time at his target destination without being detected by enemy troops. Thus, this skill is given a priority weight in determining a student's standing in the course. The underwater navigation performance scores represent 90% of the final grade at CDQC and are computed as the number of meters from the target a participant averages during his 2 weeks of underwater ocean navigation testing during the course. Navigation performance scores were calculated by the CDQC training staff and not the research team.

Results

Of the 70 subjects who initially started CDQC, 40 successfully completed the course. Analyses of the relationship between the baseline and post free ascent variables and Military Performance are based on 40 subjects. All other analyses are based on the original 70 subjects.

The variables Age, Height, Weight and years in the services were not significantly associated with the hormonal, HRV or psychological variables and were subsequently removed from the analyses.

Baseline:

Descriptive statistics of variables at baseline:

At baseline, the mean morning and afternoon levels of salivary cortisol were 0.5 ug/dl (SD = 0.14) and 0.28 ug/dl (SD = .15). The mean afternoon plasma level of cortisol was 9.8

ug/dl (SD = 4.9). Baseline plasma levels of DHEA and DHEA(S) were 6.8 ng/dl (SD = 2.7) and 375 ng/dl (SD = 188), respectively.

At baseline, baseline heart rate variability data were as follows: the mean number of beats per file was 491 (SD = 141), and the mean percent error was 3.1 (SD = 6.3). The RR interval average at baseline was 805 ms (SD = 96). Spectral analyses (and Log 10 transformations) indicated the high and low frequency domains were 2.6 (SD .59) and 3.1 (SD = .36) milliseconds squared.

At baseline, the mean dissociation score as measured by the CADSS was 2 (SD = 4.3). The mean sub-scores and total score on the Self Assessment Manikin were: Happiness/sadness dimension = 3 (SD = 1.5); Peaceful/Agitated dimension = 3.8 (SD = 1.7); Confident/insecure = 4.2 (SD = 1.4); Total Score = 11.1 (SD = 3.4).

Correlation between hormone variables at baseline:

There was a significant and positive relationship between the afternoon salivary and afternoon cortisol measures ($r = 0.7$; $p<0.001$). Similarly a significant, positive relationship was observed between plasma cortisol and plasma DHEA ($r = 0.65$; $p<0.001$).

Correlation between hormone variables and HRV at baseline:

A significant, negative relationship was observed between afternoon salivary cortisol (free cortisol) and the LF component of HRV ($r = -.30$; $p<0.05$).

Correlation between hormone variables and psychological variables at baseline:

A significant, positive relationship was observed between afternoon plasma cortisol at baseline and the SAM sub-score measure of confidence ($r = 0.33$; $p<0.05$) and the SAM total score ($r = 0.35$; $p<0.03$). A significant, negative relationship was observed between baseline CADSS dissociation scores and mean a.m. salivary cortisol ($r = -.34$;$p<0.04$).

Correlation between psychological variables and HRV at baseline:

At baseline a significant, positive relationship was observed between subjective distress as measured by the total score on the Self Assessment Manikin ($r = .33$; $p<0.04$).

Acute Stress Exposure (Free Ascent Exercise):

Descriptive statistics of hormone variables in response to Free Ascent Exercise:

Salivary cortisol values immediately prior to, and immediately following the free ascent exercise were .36 ug/dl (SD = .15) and .50 ug/dl (SD = .24), respectively.

Descriptive statistics of HRV in response to Free Ascent Exercise:

In response to the free ascent exercise, the LF and HF components of HRV were noted to be 2.2 (SD = .48) and 3.1 (SD = .33) milliseconds squared, respectively.

Descriptive statistics of psychological variables in response to Free Ascent Exercise:

Self Assessment Manikin sub scores and total scores immediately prior to the free assent exercise were as follows: Happiness/sadness = 2.5 (SD = 1.5); Peaceful/agitated = 3.5 (SD = 1.5); Confident/insecure = 4.1 (SD = 1.4); Total Score = 10.2 (SD = 3).

Following exposure to the free ascent exercise, Self Assessment Manikin sub scores and total scores were as follows: Happiness/sadness = 3 (SD = 1.4); Peaceful/agitated = 2.5 (SD = 1.4); Confident/insecure = 3.2 (SD = 1.5); Total Score = 8.8 (SD = 3.4).

Following exposure to the free ascent exercise the mean CADSS dissociation score was 3 (SD = 3).

Correlation between hormone variables in the free ascent exercise:

A significant, positive relationship was observed between salivary cortisol immediately prior to the free ascent exercise and salivary cortisol assessed immediately after the exercise ($r = 0.53$; $p<0.008$).

Correlation between hormone variables and HRV in the free ascent exercise:

No significant relationship was observed between HRV and salivary cortisol prior to, or following the free ascent exercise.

Correlation between psychological variables and hormone variables in the free ascent exercise:

Significant, positive relationships were observed between the Pre-free ascent exercise total SAM score and the post free ascent exercise salivary cortisol values (Total Score, $r = 0.51$; $p<0.01$).

Correlation between psychological variables and HRV in the free ascent exercise:

A significant, positive relationship was observed between the Pre-free ascent SAM sub-score of Peacefulness/agitation and the post exercise LF component of HRV ($r = 0.49$; $p<0.001$).

Relationship of Baseline and Acute Stress Related Variables and Military Training at CDQC:

Correlation analyses:

Analysis of baseline variables and military performance revealed a significant positive relationship between baseline plasma levels of both DHEA & DHEA(S) and Military Performance ($r = .56$; $p<0.004$; $r = .53$; $p<0.004$, respectively). Spearman correlation analyses indicated there was a significant, negative relationship between the post free ascent LF component of HRV and Military Performance (underwater navigation scores) ($r = -.62$; $p<0.001$).

SUMMARY OF METHOD AND RESULTS OF DATA FROM NAVY ADVANCED PREFLIGHT INDOCTRINATION AND NAVY AIRCREW CANDIDATE SCHOOL

Method

This section of the present report is part of 2 larger investigations designed to assess a number of psychological, biological, and psychohhysiological variables and performance through Aviation Water Survival Training (AWST). Navy student pilots, student flight officers and aircrew candidates are required to attend aviation water survival training (AWST). AWST part of the curriculum of Aviation Preflight Indoctrination (ground school) and Navy Aircrew Candidate

School. Students are subjected to basic water survival training, which consists of basic water survival skills training such as activating floatation devices and riding in a parachute hoist. Advanced water survival training includes Multi-Place Under Water Egress Trainer (METs) training. The METs is a reasonably realistic representation of a helicopter conducting an emergency landing, turning upside down and sinking. Exposure to the METs is a mandatory training evolution during the Naval Aviation Survival Training Program at Advanced Preflight Indoctrination and Naval Aircrew Candidate School. Each student receives the same instructions and training prior to the experience; therefore, the experience was uniform across participants. Six students are seated in the METs, and strapped in with seatbelt restraints. The students then receive instructions about the proper methods of egress. The METs is then hoisted about 4 feet. After a short pause, the METs is plunged into the surface of the water, then it rolls over and sinks. On the first ride, students must unbuckle themselves and egress out any hatch or the main cabin door (there are 4 window hatches and 1 main cabin door). The students must egress through the main cabin door for their second ride. The third ride is the most difficult and requires students to don light filtering goggles to simulate a nighttime over water mishap, and the students must egress through the main cabin door. If a student is unsuccessful for any portion of this training, the student is provided up to 3 remediation rides to perform the procedures correctly. If the student is unsuccessful following the 3 remediation rides, the student is rolled back into a later class so that he or she can have additional training and return for METS training, or he or she is dropped from the program.

Measurements were obtained during 2 non-stressful baseline assessments (morning and afternoon), prior to, during, and following METS training, and recovery. Originally, only student pilots and flight officers were to be investigated, but the analysis was expanded to include and enlisted aircrew.

At baseline, participants completed several valid and reliable self-report instruments designed to assess trauma exposure (Brief Trauma Questionnaire, psychological symptoms of dissociation (CADSS), and subjective distress (SAM). Participants were re-administered the SAM throughout METs training, and the CADDS upon the completion of training. Additionally measures of cognitive performance following the stressful training were assessed through the Rey-Osterrieth Complex Figure (ROCF) task, which is a valid and reliable measure of visuospatial and organizational skills that was administered 5 minutes following the students' final METS ride, and a declarative task which required students to learn a list of nouns containing 5 inherent categories in 5 minutes. Participants were then distracted for 5 minutes and then instructed to write all of the words from the list. Originally it was proposed to have the students only write the words in one of the categories, but preliminary testing within the API population indicated little variance in performance with this task so the participants were asked to write all the words they recalled from the list.

At each of the above noted assessment time points, participants also provide heart rate variability samples using the Polar NV system as discussed earlier. Samples were collected for 10 minutes. Due to the rapid training environment, only salivary samples were taken during the same sample times. Additionally participants completed the SAM at each sample period.

The section of the manuscript addresses: 1) the relationship between METS training performance and baseline hormone measures, baseline physiological measures (HRV), and baseline psychological measures (dissociation and subjective stress) to the subsequently assessed military performance through the METS at AWST and the influence of the training on the psychological and cognitive variables as assessed by the ROCF and the declarative memory task; 2) The relationship between Acute Stress Induced alterations in HRV and salivary cortisol and assessed military performance as measured by METS scores

One hundred thirty six student naval aviators and flight officers, and 145 (mean age = 20.32, SD 3.29) male (160) naval aircrew candidate students were the subjects of this investigation. All subjects were recruited by the civilian principle investigator, and each provided written, informed consent. All students had been medically cleared by a flight physical prior to the initiation of their training.

Data analyses:

Physiological measures

Cortisol analysis and HRV samples were analyzed as described in the CDQC section. Samples were collected during 2 non-stressful baseline assessments prior to training (morning, 0700; and afternoon, 1500), prior to, during, and following METS training (METs training occurs between 0800 and 1200), and recovery (morning, 0700; and afternoon, 1500). After the initiation of this investigation, the laboratory conducting the salivary analysis reported that testosterone and DHEA were not reliably assessed via saliva, thus only cortisol was analyzed. HRV was collected throughout METS training, however the electromagnetic noise produced by the METS interfered with the signals, thus prohibiting reliable analysis. Analysis software (Polar Precision Performance 8.0) provided time dependent, geometric and spectral analysis of data. Due to the recording length of the data, we followed the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996) and used power spectral analyses as the indicators of sympathetic and parasympathetic activity. The parameters set for the frequency bands were: high frequency (HF, 0.15-0.4 Hz); low frequency (LF, 0.04-.15 Hz); very low frequency (VLF, 0.00-0.04 Hz); total power (TP, 0.00-0.4 Hz). Current scientific literature supports the idea the HF best reflects parasympathetic (vagal) activity. Note that cortisol samples were analyzed for the student pilots and flight officers, and HRV were analyzed for the aircrew.

Psychological measures:

The SAM and CADSS were administered and scored as described in the previous section. Subjects completed the BTQ and the CADDS during the classroom phase of their training (6 weeks prior to METS training for student pilots and flight officers and 2 weeks prior to METS training for the aircrew candidates). All students were administered the CADDS again roughly 2 hours following METS training. Additionally the SAM was administered each time physiological samples were collected.

Cognitive measures:

Five minutes following METS training students were administered the ROCF. They were instructed to copy the complex figure. Students were then distracted for 10 minutes with the declarative memory task. Following the 10-minute distraction period, students were asked to draw the complex figure from memory. Figures were scored with a method similar to Hamby, Wilkins, Barry (1993), with the highest possible score being 36. For the Declarative memory task, students were given 5 minutes to memorize a list of 20 nouns containing 5 inherent categories. Following the five-minute memorization period, students were asked to write all the words they recalled from the list. The lists were scored for the number of correct nouns listed, with 20 representing a perfect score.

Military Performance:

Each student participated in mandatory METS training. It is mandatory that students complete 3 successful rides. Performance was calculated as a dichotomous variable: pass or remediation; and as a continuous variable 3 rides (success), 4 rides (1 remediation ride), 5 rides (2 remediation rides), and 6 rides (3 or more remediation rides required).

Results

Of the 136 pilot and flight officer students included in this study 85 successfully completed METS training and 51 required remediation. Of the 160 navy aircrew candidate students 104 successfully completed METS training and 56 required remediation.

Descriptive statistics of physiological variables:

Table 1 provides the mean salivary cortisol levels for API students

Table 1

Salivary Cortisol at Baseliner and Throughout Training

Data collection phase	Ug/dl (SD)
Baseline Morning	0.55 (0.25)
Baseline Afternoon	0.12 (0.17)
METS Morning	0.62 (0.28)
Before 1st Dunk	0.48 (0.26)
After 1st Dunk	0.55 (0.30)
After 3rd Dunk	0.71 (0.32)
After Remediation Dunks	0.86 (0.42)
METS Afternoon	0.17 (0.22)
Recovery Morning	0.53 (0.24)

Table 2 provides the baseline descriptive statistics for the heart rate variability data for Aircrew students. The Polar Precision Performance software error filtering procedure uses an auto-regressive method for calculating HRV. The software uses a median and moving average based filtering method to check for possible errors and artifacts. After this it computes several better matching candidates to substitute the errors. The criteria adapts to the R-R data to be checked. In the correction phase, very small corrections are prevented and thus the initial detection of errors is made sensitive enough. In the final interpolation the algorhythm first checks the series of corrected values (usually 2-4 intervals) in order to follow the same differential coefficient (derivative). Log 10 transformations were used to normalize the HRV data (SPSS 11.5).

Table 2

HRV at Baseline and throughout training

	Beats per file (SD)	% error (SD)	RR average (SD)	LF (SD)	HF (SD)
Baseline Morning	726.62 (150.39)	2.89 (1.22)	768.76 (99.76)	2.99 (.36)	2.49 (.60)
Baseline Afternoon	697.5 (154.08)	3.41 (1.53)	789.45 (789.45)	3.19 (.33)	3.41 (1.54)
Pre METS	757.43 (180.31)	3.07 (1.3)	794.08 (127.63)	3.01 (.33)	2.49 (.48)
Post METS	799.42 (200.35)	3.16 (1.35)	782.65 (93.04)	3.05 (.32)	2.61 (.47)
Recovery Morning	687.99 (159.65)	3.22 (1.56)	811.25 (112.62)	3.09 (.37)	2.60 (.47)
Recovery Afternoon	703.32 (159.89)	3.27 (1.41)	803.79 (130.58)	3.11 (.33)	2.58 (0.47)

At baseline, the mean dissociation score as measured by the CADDS was 2.51 (SD=2.65) for the pilot and flight officer sample and 3.43 (SD=3.98) for the aircrew sample. Following METS training, when asked specifically if subjects experienced any symptoms listed on the CADDS while participating in METS training the mean number of items endorsed for the student pilot and flight officer, and aircrew samples were 1.9 (SD=2.56) and 2.56 (SD=3.67). At baseline, 76% of flight students indicated that they had been exposed to a traumatic event sometime during their lives and 23.5% reported that they had feared for their lives during that event.

The SAM was administered along with the physiological sampling, please see table 3 for the descriptive statistics. An analysis of variance demonstrated that there were many significant differences between the student pilot and flight officer and aircrew candidates' scores. The asterisks indicate significant differences with $p<.05$. The higher the score the more the distress for each subscale. Note that due to the training schedule at API, we were unable to obtain recovery afternoon date from student pilots and flight officers.

Table 3

SAM scores for Officers and Enlisted at Baseline and Throughout Training

	Valence (SD)		Arousal (SD)		Dominance (SD)		Total (SD)	
	Officer	Enlisted	Officer	Enlisted	Officer	Enlisted	Officer	Enlisted
Baseline Morning	3.71(1.56)	3.68(1.60)	2.48(3.63)	3.25(1.87)*	3.99(1.54)	3.66(1.60)	10.05(3.39)	10.47(4.06)
Baseline Afternoon	3.23(1.56)	3.36(1.54)	2.47(1.69)	2.71(1.69)	3.83(1.58)*	3.48(1.63)	9.29(3.52)	9.40(3.69)
METS Morning	3.32(1.50)	3.21(1.68)	3.14(1.67)	3.27(2.00)	3.82(1.32)*	3.39(1.66)	10.17(3.54)	9.79(4.43)
Pre METS	3.46(1.68)*	2.95(1.84)	4.08(1.85)*	3.33(2.00)	3.82(1.44)*	2.23(1.78)	11.36(4.05)*	9.51(4.57)
After 1st ride	3.09(1.82)*	2.57(1.82)	3.72(1.98)*	3.32(2.23)	3.46(1.70)*	2.84(1.87)	10.27(4.50)*	8.74(4.99)
After 3rd ride	2.84(2.23)*	2.73(2.19)	3.00(2.04)	3.01(2.15)	3.02(2.00)	2.83(1.96)	8.87(5.44)	8.57(5.26)
After remediation ride	2.74(2.28)	2.67(1.92)	3.11(2.23)	2.64(1.92)	3.07(1.91)	2.65(1.74)	8.93(5.56)	7.96(4.71)
METS Afternoon	3.16(1.91)*	2.29(1.68)	2.03(6.65)	1.82(1.43)	3.36(1.62)*	2.57(1.77)	8.55(4.23)*	6.67(3.89)
Recovery Morning	3.41(1.63)	2.46(1.60)	1.99(1.59)	2.13(1.64)	3.63(1.77)*	2.77(1.62)	9.04(3.69)*	7.37(3.81)
Recovery afternoon		2.25(1.65)		2.13(1.75)		2.58(1.61)		6.96(4.11)

Note. Asterisks indicate a significant difference between the officer and enlisted population.

Note that the officer sample indicated more subjective distress than the enlisted sample except for arousal during the baseline morning collection phase.

Descriptive Statistics of cognitive variables:

Student pilots and flight officers recalled an average of 13.51 (SD 3.64) items correctly on the declarative memory task. Additionally, student pilots and flight officers scored 34.15 (SD=2.45) on the copy task of the ROCF and 22.02 SD=7.58) on the recall portion of the ROCF.

Correlation between hormone variables and psychological and cognitive variables:

There were no significant correlations between baseline levels of cortisol and psychological and cognitive variables. However, a significant, positive relationship was observed between salivary cortisol prior to the first METS ride and the SAM sub score of valence (r=.209; p,.05) and the overall SAM (r=.239, p<.01), and between arousal following the 3^{rd} METS ride (r=.211, p.<.05). There no significant relationships between cortisol and pre or post METS CADDS scores. There were no significant relationships between cortisol and the cognitive measures.

Correlation between HRV and psychological measures:

No significant relationships were observed between HRV and dissociation at baseline or following METS training. There was a positive correlation between valence and recovery afternoon HF HRV r=0.245; p<0.05.

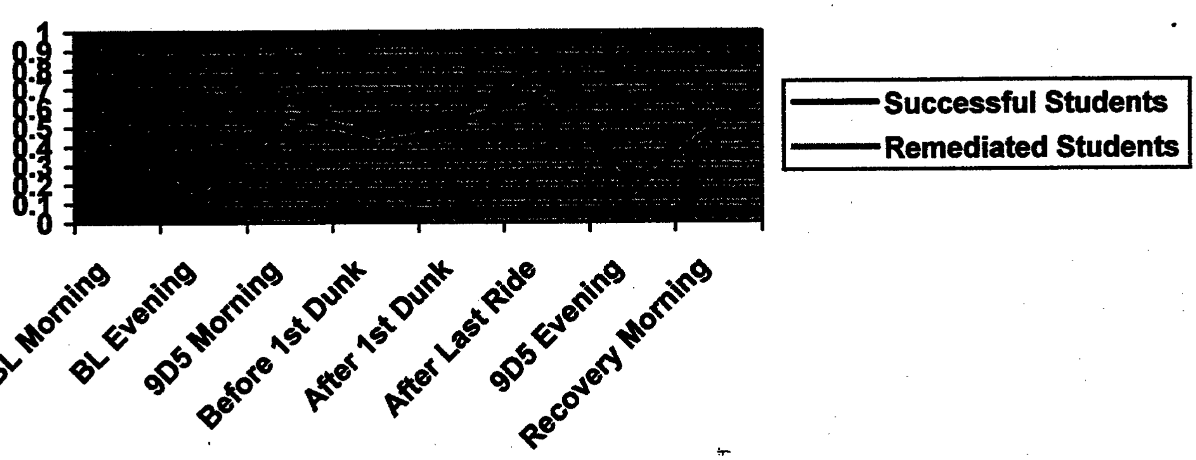
Acute Stress Exposure (METS training):

The previous tables depict the descriptive statistic of these measures throughout training.

Physiological measures and performance in the METS:

Unsuccessful students' cortisol levels were significantly different at morning baseline $F(1, 123)=7.035$, $p<0.01$ and after their last dunker ride $F(1, 123)=11.89$, $p<0.01$. Unsuccessful students had a tendency to have higher levels of cortisol throughout training, see Figure 1. additionally, students who required remediation had significantly greater LF HRV in the morning prior to METS training (1,89) f=4.219. p=.043.

Figure 1. Salivary Cortisol



Psychological and cognitive variables and performance in the METS:

Students who were successful through METS training reported having more experiences that caused them to fear for their lives (baseline BTQ) $F(1, 144) = 4.52$ $p = 0.035$. A significant correlation was found between the number of traumatic events as measured by the BTQ and the number of items endorsed on the CADDS, $r(179) = 0.471$, $p < 0.01$, and between the intensity of items on the CADDS, $r(179) = 0.520$, $p < 0.01$.

There were no differences between the CADDS administered at baseline and subsequent performance in the METS, however a one-way analysis of variance demonstrated that that Student pilots and flight officers who required remediation endorsed significantly more items (1,144) f=7.035 p=.009 and rated those items as more intense (1,144) f=9.17, p=.003 than their successful counterparts. Successful students endorsed 1.57 items with an intensity of 2.9 while students who required remediation endorsed 2.56 items with an intensity of 5.35. There were no differences on pre or post dissociation for the aircrew students. There was no correlation between the number of METS rides and the number of words recalled for the declarative task. Additionally there was no correlation between the performance on the ROCF copy of recall task and the number of METS rides.

SUMMARY OF METHOD AND RESULTS OF DATA COLLECTED AT SURVIVAL EVASION RESISTANCE AND ESCAPE TRAINING

Methods

Forty of 50 consecutively recruited active duty males (mean age 25, SD = 3.5), were the subjects of this study. It was not possible to obtain 130 subjects, as was originally proposed, due to the rapid pace of the training environment. All subjects were recruited by the principal investigator (Morgan for the SERE study) and each provided written, informed consent. As per survival training course requirements, all subjects provided documentation of physical examination and medical clearance prior to enrollment. All subjects were free of illicit substances.

The methodology employed in this study has been reported in extensive detail elsewhere (Morgan et al., 2000a; Morgan et al., 2000b; Morgan et al., 2001). However a brief description will be given to facilitate an understanding of the data. Military survival training is designed to provide individuals with specific skills that may enhance their chances of surviving behind enemy lines. It is rigorous, realistic and modeled after the experiences of American POWs from WWII, and the Korean, Vietnam and Gulf Wars. The course is divided into a didactic and an experiential phase. Baseline psychological and biological measures were collected one week prior to stress exposure, during the didactic phase of survival school training. Saliva samples were collected at 07:00 and at 16:30; plasma samples and psychological measures were collected at 16:30, following the saliva collection. Stress assessment occurred during the confinement phase of the course and immediately after the conclusion of exposure to a stressful interrogation. At this time point, psychological ratings as well as saliva and plasma were collected. emotional state with minimal disruption of their survival school training experience. Recovery samples were collected 24 hours after subjects exposure to stress had terminated. This assessment occurred at 07:00 on the recovery day.

Sample processing method:

Saliva and plasma samples were spun down in a refrigerated centrifuge, pipetted into microtubules and frozen at -70 degrees C within 40 minutes of venipuncture. Analysis methods for cortisol, catecholamines and testosterone are as previously detailed in our previous investigations (Morgan et al., 2000a; Morgan et al., 2000b; Morgan et al., 2001).

Data Analysis

Salivary and Plasma data:

Saliva and plasma from subjects were compared using one-way repeated measures ANOVA to detect whether significant changes in salivary cortisol and plasma hormones (cortisol, NE, EPI, and NPY) occurred during survival training. Time points included: baseline, interrogation stress and recovery. Post-hoc t-tests, with Bonferroni corrections, were employed to determine how the various time points differed from one another.

Heart Rate Variability methods:

HRV was assessed using Polar Vantage NV monitors which measured RR interval data over 10 minutes at baseline, and over 25 minutes during stress. Analysis software (Polar Precision Performance 8.0) provided time dependent, geometric and spectral analysis of data. Due to the recording length of the data, we followed the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996) and used power spectral analyses as the indicators of sympathetic and parasympathetic activity. The parameters set for the frequency bands were: high frequency (HF, 0.15-0.4 Hz); low frequency (LF, 0.04-.15 Hz); very low frequency (VLF, 0.00-0.04 Hz); total power (TP, 0.00-0.4 Hz). Current scientific literature supports the idea the HF best reflects parasympathetic (vagal) activity, whereas, the LF/HF ratio indexes sympathetic tone.

The mean number of beats per file at baseline was 748 (SD = 121). The mean number of beats per file for the stress time point was 3859 (SD = 280). The mean percent error in files at baseline was 2.3 %. The mean percent error during stress was 3.2 %. The number of files rejected (percent error greater than 5 %) at baseline and during stress was 2 and 3, respectively. The Polar Precision Performance software error filtering procedure uses an auto-regressive method for calculating HRV. The software uses a median and moving average based filtering method to check for possible errors and artifacts. After this it computes several better matching candidates to substitute the errors. The criteria adapts to the R-R data to be checked. In the correction phase, very small corrections are prevented and thus the initial detection of errors is made sensitive enough. In the final interpolation the algorhythm first checks the series of corrected values (usually 2-4 intervals) in order to follow the same differential coefficient (derivative). Log 10 transformations were used to normalize the HRV data (SPSS 11.5).

Psychological data:

A general linear model ANOVA was used to compare subjective stress ratings (SUDS) prior to, and 24 hours after exposure to acute stress. Pearson correlation analyses were performed to detect relationships between SUDS ratings and the hormones assessed at the baseline, stress and recovery time points. Pearson correlation analyses were also performed to evaluate the relationship between SUDS, age, and number of years in the service. Finally, Pearson correlation coefficients were performed between the SAM total score and the hormone indices during stress, as well as between SAM scores during stress and the CADSS scores during stress rated retrospectively at the recovery time point.

Results

Impact of Acute Stress of Survival School on hormones:

Exposure to the stress of survival school resulted in significant increases from baseline values of cortisol (baseline = 8.6 ug/dl (SD = 3.8); stress = 31.1 ug/dl (SD = 5.8)), Norepinephrine (baseline = 152 pg/ml (SD = 53); stress = 760 pg/ml (SD = 297)), and Epinephrine (baseline = 29 ng/ml (SD = 15); stress = 149 ng/ml (SD = 76). Exposure to stress resulted in significant decreases from baseline in plasma testosterone (baseline = 597 (SD = 153); stress = 273 (SD = 140).

Impact of Acute Stress of Survival School on HRV:

Compared to baseline, HRV was decreased by exposure to acute stress (Log10 HF baseline = 2.7 ms^2 (SD = .7); Log10 HF stress = 0.9 ms^2 (SD = .5)[$p<0.001$];(Log10 LF baseline =2.9 ms^2 (SD = .4); Log10 LF stress = 1.6 ms^2 (SD = .4)[$p<0.001$].

Impact of Acute Stress of Survival School on psychological symptoms:

Exposure to survival school stress resulted in a significant increase in symptoms of dissociation (CADDS baseline = 1.3 (SD = 3); CADDS stress = 13.5 (SD = 14). No significant relationships were observed between the variables of age, years in the service, SAM with dissociation at baseline or during stress exposure.

Relationship between HRV and Military Performance:

A significant negative relationship was observed between the Log10 HF and log10 LF components of HRV <u>at baseline</u> and Military Performance <u>assessed one week later</u> and during exposure to the acute stress of the mock POW camp (Spearman's rho = -.53; $p<0.01$; r = -.68; $p<0.001$, respectively).

Relationship between Hormones and Military Performance:

No significant relationship was observed between military performance and the hormone variables cortisol, NE, EPI or testosterone (at baseline or during stress).

Discussion

One of the principal findings of the CDQC phase of the study is that individuals with a higher levels of DHEA and

DHEA(S) where those who exhibited superior military performance (underwater navigation). Because underwater navigational ability presumably index central processes involved in spatial memory and orientation, and because stress has been shown to disrupt spatial relationships/ memory in animals, the current data provide support for the idea that DHEA(S) may help buffer against the negative centrally mediated, effects of stress on task requiring spatial relations memory in soldiers.

Pre clinical investigations have shown that glucocorticoids can be neurotoxic and that DHEA(S) is a potent anti-glucocorticoid agent both peripherally and centrally (Kimonides et al., 1998). For example, prolonged exposure to high levels of circulating corticosterone in rats increases the age related rate at which hippocampal pyramidal neurons are lost (Hortnagl et al., 1993). Glucocorticoids have also been shown to potentiate neuro-degeneration induced by both anoxia and glutamate analogues. The neurotoxic effects of glucocorticoids can be attenuated or blocked by in vivo and in vitro administration of DHEA(S) (Kimonides et al., 1998;1999). These pre-clinical data indicate that the neuroprotective effect was not limited to DHEA, but that DHEA(S) - independent of its conversion to DHEA - exhibits neuroprotective properties as well.

Although the precise mechanism by which DHEA(S) extends its neuroprotective effect is not yet evident from pre-clinical investigations, the literature does suggest several possibilities that assist in an interpretation of the present data in humans. One possible mechanism for the neuroprotective effect is that DHEA(S) functions as a glucocorticoid receptor antagonist (Fleshner et al., 1997). A second possibility is that the attenuating effect of DHEA(S) on the neurotoxic action of NMDA (Kimonides et al. 1999) is due to reduced entry of Ca2+ into cells, or altered free Ca2+ intracellular homeostasis - processes both known to be involved in excitotoxic cell death (37). Third, in vitro studies have shown that DHEA(S) serves as a modulator of the GABA-benzodiazepine receptor complex (GABA-RC) (Demirgoren et al., 1991; Majewska et al., 1987; Majewska et al., 1990). Although future investigations are needed to clarify this issue, these potential mechanisms are not superfluous to the present findings. For example, human studies have implicated NMDA receptor antagonists in dissociative phenomenon as assessed by the CADSS (Anand et al., 2000). In addition, there is evidence of altered benzodiazepine receptor modulation and sensitivity in stress related disorders that are characterized by symptoms of dissociation, such as post traumatic stress disorder (PTSD)(Gavish et al., 1996; Yehuda et al., 1991). Thus, it is reasonable to speculate that the reduced levels of dissociation in subjects with an increased DHEA(S)/salivary cortisol ratio during stress may be due, in part, to the action of DHEA(S) at NMDA receptors and/or at the GABA-RC - perhaps at the level of the hippocampus.

In this study, we did not observe a relationship between symptoms of dissociation and DHEA(S). One of the primary reasons for this may be that the design of our study did not permit us to detect such a relationship. When subjects completed the CADSS, they were instructed to fill out the questionnaire in relationship to how they remembered feeling over the week. They did not specifically provide a report of dissociation for each of the separate swimming events from which the navigation scores were derived. Had we assessed symptoms of dissociation after each of the swim events, it is possible that we might have detected a relationship between stress induced symptoms of dissociation and navigational ability.

A significant and important finding of the METS training portion of this work was that students who required remediation had significantly higher levels of baseline morning levels of cortisol and greater LF HRV prior to METS training. Additionally it should be noted that successful students had lower levels of cortisol throughout training.

Vickers, Hervig, Poth and Hackney (1995) found that personality traits predicted salivary cortisol secretion under low to moderately stressful situations in Navy Basic Training; They found that "agreeableness" was reliably related to higher cortisol secretion in the middle of training, and "conscientiousness" was reliably related to lower cortisol secretion at the end of training (Vickers et al 1995, p. 21). Using a typological analysis, they reported that stress-reactive individuals produced more salivary cortisol at the end of basic training than did non stress-reactive individuals. Although Vickers et al. (1995) clearly demonstrated a relationship between neuroendocrine responses and personality, performance data were not collected or analyzed. In contrast, we examined the relationship between neuroendocrine responses and some psychological constructs including dissociation and found that successful students produce lower amounts of cortisol and experience fewer symptoms of disassociation.

These findings are similar to the previous work of some of the members of this investigatory team. For example, Morgan et al. (2000b) reported that special mission unit war fighters had less overall hypothalmic-pituitary-adrenocortical (HPA) axis activation during SERE training as measured by cortisol when compared to general warfighters. In addition, increased cortisol with low diurnal variation was associated with increased psychological symptoms of dissociation and decreased military performance during SERE training. Thus, it appears that too much HPA axis activation during a stressful event may result in performance decrements and/or psychological distress.

The generalizibility of many studies of stress responses has been limited by the nature of the stress-inducing stimulus used. Historically, relatively simple stimuli have been used to assess pilots' emotional reactivity. For example, a pistol shot or a cold wet rag slapped upon the back of the neck have been frequently used to assess the reactivity of pilots to unexpected events (Driskell & Olmstead, 1989; Koonce, 1984). Operationally, Vlasak (1969) noted that startle stimuli could adversely affect pilot responses during flight situations that demanded rapid decision-making and measured reactions. Recently, however, stressors that more accurately approximate real-world situations have been utilized. Iyer et al. (1994) reported that successful and unsuccessful student pilots reacted differently during training sorties as measured by urinary norepinephrine/ epinephrine ratios. Successful students exhibited sympathoadrenal stimulation during flight training, while unsuccessful students either had little response or an over-stimulation prior to flight. Also, experienced pilots rapidly adapted to flying stress. These results suggested to Iyer et al. (1994) that a moderate amount of sympathoadrenal stimulation may be necessary for successful completion of flight training.

The finding of a significant relationship between baseline HRV and subsequent military performance at SERE training is noteworthy and suggests that individuals who are more vulnerable to cognitive difficulties during stress may be identified prior to stress exposure. Although in this study we did not assess NPY, our previous investigations have demonstrated a relationship between capacity for NPY release and stress tolerance. NPY may significantly affect HRV through cells in the Nucleus Ambiguous and our present finding of increased variability at baseline may identify individuals who have a decreased capacity for NPY release during stress. Future studies may examine this.

The fact that we did not find a relationship between cortisol, NE, EPI and testosterone is consistent with our earlier investigations. Future investigations will have to include analyses of more specific neurotransmitter agents (such as NPY, DHEA, Leptin and Galanin).

The results of these studies have extended the findings from our previous neuro-biological studies and further defined the psychological and biological profiles that predict superior performance under stress and stress-induced psychological and biological responses that are associated with superior performance under stress. We anticipate several lines of investigation in the future. First, we expect that the link between NPY, HRV and performance will warrant further investigation into the biology of a specific "stress resilient" profile. It is possible that this profile is the product of selection programs or, alternatively, the product of specific training environments. Clarifying the etiology of this profile may offer the possibility of increasing its percentage in the active duty population. Additionally, should we receive further funding the WISE HRV system will be tested during high intensity military training and possibly in the theater of operations.

KEY RESEARCH ACCOMPLISHEMNTS

- Provided evidence for the development and refinement of baseline psychological and biological profiles that predicts superior performance under highly stressful training situations at Combat Dive School, Aviation Water Survival Training and at SERE School
- Identified certain biopsychological variables to further develop and refine models that characterize stress induced psychological and biological responses that are associated with superior performance under highly stressful training situations.
- Developed the WISE HRV system, which can be used for telemetric measurement of Heart Rate Variability in dynamic training environments. For a complete description of the HRV system, please see the Final Report (October 2002)
- Provided evidence for a noninvasive, objective assessment methodology of monitoring operational performance under highly stressful training situations.

REPORTABLE OUTCOMES

Jovanov, E., Lords, A., Raskovic, D., Cox, P., Adhami, R., Andrasik, F. (2003). "Stress Monitoring Using a Distributed Wireless Intelligent Sensor System," *IEEE Engineering in Medicine and Biology Magazine*, May/June .

Jovanov, E., O'Donnell Lords, A., Morgan, A. Priddy, B. Hormigo, R. (2002) "Prolonged telemetric monitoring of heart rate variability using wireless intelligent sensors and a mobile gateway," 2nd Joint EMBS-BMES, Houston, Texas, October 2002, pp. 1875-1876.

Jovanov, E., Raskovic, D., Lords, A.O., Cox, P., Adhami, R., Andrasik, F. (2003) "Synchronized physiological monitoring using a distributed wireless intelligent sensor system." 25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Cancun, Mexico, September 2003, pp. 1368-1371.

Lords, A. O'Donnell, Andrasik, F, Prevost, M.C. (2003). Biopsychological Assessment of High Intensity Training: Telemetric and Noninvasive Assessment. *The Association for Applied Psychophysiology and Biofeedback*, Annual Meeting, Jacksonville, FL.

Lords, A. O'Donnell, Andrasik, F., Prevost, M.C., Morgan, C.A. (2003). "Tolerance to stress among student naval aviators: Biopsychological assessment of high stress training." The International Society for Traumatic Stress Studies, Annual Meeting, Chicago, IL.

CONCLUSIONS

The technology that was developed as an aspect of this project (The WISE HRV, please see Final Report) can be utilized in future studies to provide a systematic characterization of psycho-biological responses to highly stressful operations and will provide information that may be extended to the selection and training needs of the DOD. The data obtained in this project has extended our previous findings, and provided additional clues to the factors contributing to excellence in military performance and, finally, provided evidence for a noninvasive, objective assessment of operational performance. Because HRV analyses may be assessed telemetrically, the present technology may provide a means of assessing human performance in both military training environments and in the theatre of operations, should we receive further funding.

Data from our investigations show that intense psychological and physical stress affect neuro-hormones in a manner comparable to psycho-biological responses to real world threat to life situations. Further, these studies demonstrate a significant relationship between psychological and biological responses to stress and objectively assessed operational performance. The current work extended our previous data by focusing directly on whether HRV reflects and predicts superior tolerance to stress. In addition, and because a great deal is known about the neuroanatomy involved in HRV and in threat response systems, the data has enhanced our understanding of the neurobiology that is linked to performance.

Should we receive further funding to conduct this line of research we will continue to develop objective methods for the assessment of human performance during stress and thereby provide aids for military commanders and medical personnel concerning the psychological and physiological status of soldiers during ongoing operations and identify measures and procedures applicable to selection and assessment, prevention, early diagnosis. Additionally, the findings about the relationship between physiological variables, performance and dissociation could be applied to high intensity training curriculums as a counter measures to maladaptive stress reactions. Finally we intend to pursue investigations using the WISE HRV system

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APPENDIX

Presentations and Publications

Jovanov, E., Lords, A., Raskovic, D., Cox, P., Adhami, R., Andrasik, F. (2003). "Stress Monitoring Using a Distributed Wireless Intelligent Sensor System," *IEEE Engineering in Medicine and Biology Magazine*, May/June .

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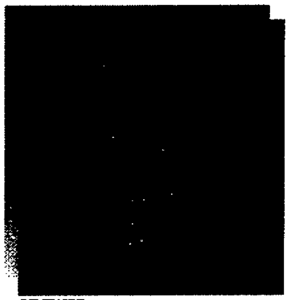

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Stress Monitoring Using a Distributed Wireless Intelligent Sensor System

Quantifying Stress Levels Based on Measures of Heart-Rate Variability (HRV) Using Reliable, High-Precision Instrumentation and Synchronized Measurements

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Because stress is a leading cause of illness and disease and is so pervasive, there is an inherent need to be able to monitor stress in real time over extended periods. A real-time personal stress monitor would benefit individuals by providing continuous feedback about their stress levels and by helping their physicians to objectively evaluate stress exposure between visits.

We are developing personal health monitors based on a wireless body area network (BAN) of intelligent sensors [1]. Individual monitors will be integrated into a distributed wireless system for synchronized monitoring of a group of subjects. This system could be used during the selection process and as part of a psychophysiological evaluation of military members undergoing intense training. We use measures of heart-rate variability (HRV) to quantify stress level prior to and during training as well as to predict stress resistance. This task requires reliable, high-precision instrumentation and synchronized measurements from a group of individuals over prolonged periods (days of training).

Our preliminary results indicate that individuals who have better stress tolerance also exhibit significantly different patterns of HRV, both before and during stress exposure. These baseline differences in HRV are predictive of actual military and cognitive neuropsychological test performance scores assessed during and after stress exposure [1], [2]. During our preliminary investigations, we used a stressful component of aviation water survival training, the 9D5 Multi-place Underwater Egress Trainer, as our event for the whole group. The 9D5 is a reasonably realistic representation of a helicopter conducting an emergency landing, turning upside down, and sinking. Trainees report the 9D5 session as the most stressful training event during water survival training.

Wireless Personal Monitors

Traditionally, personal medical monitors have been used only to perform data acquisition. Typical examples are holter monitors that are routinely used for ECG and EEG monitoring. Recent developments of wireless and mobile technology [3] have laid a foundation for the new generation of wireless intelligent sensors [4], [5]. This same technology has made the implementation of intelligent medical monitors that can provide real-time feedback to the patient feasible, either as a warning of impending medical emergency or as a monitoring aid during exercise. Intelligent medical monitors can significantly decrease the number of hospitalizations and nursing visits [6] by acting as a personal "guardian angel" that can warn the user of a medical emergency or contact a specialized medical response service.

Historically, the development of patient monitors has been progressing toward larger patient mobility and physiological sensor independence. The first step involved connecting monitoring equipment to the hospital information system (HIS) to support data acquisition and archiving. With wider acceptance of the Internet, the HIS was connected to the Internet, paving the way for telemedical health applications. This step allowed remote access to the personal medical record (PMR) stored on a remote telemedical server. Patient mobility within the hospital became possible with the introduction of wireless local area network (LAN) connectivity between patient monitors and static gateways to the HIS. However, in this type of system, individual sensors are still wired to the personal monitor using a BAN. A wearable health-monitoring device using a personal area network (PAN) or BAN can be integrated into a user's clothing [7], [8]. This system organization, however, is unsuitable for lengthy, continuous monitoring, particularly during normal activity, such as intensive training or computer-assisted rehabilitation [9]. On a larger scale, wireless wide area network (WAN) connectivity allows patient monitoring outside the hospital using satellite and cell phone links.

The most recent step in patient mobility and unobstructed use came with the introduction of intelligent and implanted sensors. Wired sensor connections are a huge obstacle to the wide acceptance of these systems for prolonged monitoring. Technological advances in low power microprocessors/microcontrollers, application-specific integrated circuits (ASICs), battery capacity, and wireless technology made possible the increased intelligence of personal health monitors. As a result, wireless connectivity of individual intelligent sensors has emerged as the main research trend. This type of system features extremely low power consumption at the expense of lower communication range and bandwidth. Ultimate examples include implanted sensors and drug pumps, where battery recharging or replacement is very limited or impossible.

We are developing a distributed wireless system to evaluate stress resistance during stressful training using synchronized measurements of HRV within the monitored group.

Therefore, it is necessary to enable multiyear functionality or power the sensors externally.

There is a number of active research and commercial projects in the field of portable monitoring. A typical research project is *Warfighter Physiological Status Monitoring (WPSM)*, led by the U.S. Army Research Institute of Environmental Medicine (USARIEM) and the U.S. Army Medical Research and Materiel Command (USAMMRC) [10]. This experimental prototype consists of sensors for heart rate, metabolic energy cost of walking, core and skin temperatures, GPS location, and activity/inactivity. One of the goals of the project is to provide medics with valuable information about wounded soldiers, but the final system is expected to be able to predict the critical aspects of performance under extreme conditions. Scientists at the d'Arbeloff Laboratory for Information Systems and Technology at MIT have developed a "ring sensor" that continuously monitors heartbeat rate using a photoplethysmograph (PPG) signal and sends data wirelessly to a host computer [11]. Researchers at Kansas State University are developing a wearable Bluetooth-enabled portable monitoring health system [12]. The overall goal of this initiative is to provide affordable systems by utilizing plug-and-play sensor units that comply with the common industry standard. Commercial systems include *Digital Angel*, which is designed to provide phone and e-mail alerts whenever a person changes condition or position, and the *Symphony Diabetes Management System*, from Sontra Medical Corporation, which performs continuous noninvasive sensing of glucose and other analyses.

Implantable sensors could solve many problems in the monitoring of chronically ill patients, such as diabetic patients [13]. Design of intelligent implanted sensors must take into account a number of different considerations, such as size, power consumption, and power-efficient wireless communication. The choice of a communication frequency will dictate the size of the antenna and hence the overall size of the sensor system. In addition, reliable transfer of data from the implanted sensors is one of the most important tasks researchers are facing.

Other ongoing projects/systems include a miniature implantable microcomputer developed by researchers from the University of Washington, Caltech, and Case Western Reserve University [14]. This sensor is capable of recording nerve and muscle signals from animals during their normal activity. Researchers at the Center for Wireless Integrated Microsystems at the University of Michigan developed the BioMOS wireless stimulator chip [15] that will be used in conjunction with micromachined passive stimulating microprobes. Given Imaging offers a commercially available endoscopy system, the *Given Diagnostic System*, which uses a disposable imaging capsule (M2A, 11×26 mm) that passes through the gastrointestinal tract and wirelessly streams video images to the receiver that is worn on a belt. The signal is received through an array of antennas, which are also used to determine the exact location of the capsule.

Researchers at the Biomechanics-Laboratory of the Orthopaedic Hospital of the Free University of Berlin developed an inductively powered implantable device that measures hip joint forces and temperatures for the hip joint prosthesis [16].

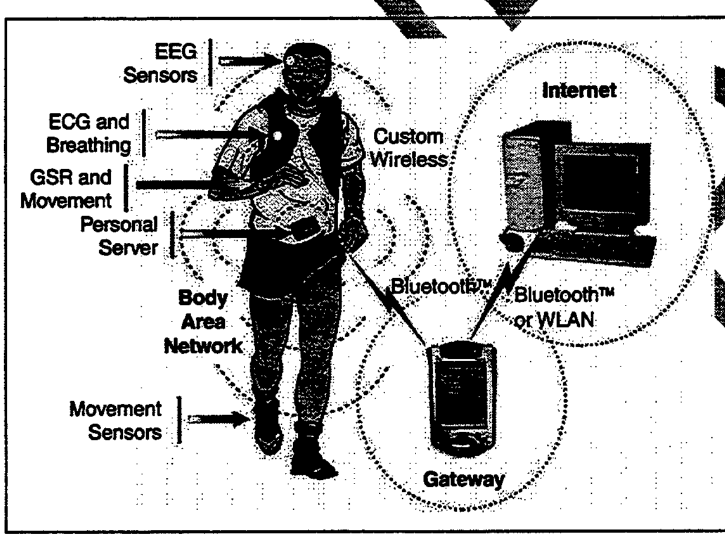

Fig. 1. Wireless body area network of intelligent sensors in the telemedical environment.

Wireless BAN of Intelligent Sensors (WISE)

We have integrated a BAN of wireless intelligent sensors (WISE) as a development environment for research in the field of mobile health monitoring applications [17]-[19], represented in Figure 1. WISE are microcontroller-based, intelligent physiological sensors that are responsible for data acquisition and low-level real-time signal processing tasks. Our BAN is organized as a client-server network with a single personal server (PS) and multiple WISE clients. It is a part of a telemedical system for

Wireless intelligent sensors have made possible a new generation of noninvasive, unobtrusive personal medical monitors applicable during normal activity.

hierarchical signal processing [20]. Individual WISE sensors are controlled by, and communicate with, the PS using a custom wireless protocol [21]. In addition to its responsibilities as a communication server, the PS also provides synergy of information through data aggregation and higher-level signal processing. For example, accelerometer-based movement sensors [17], [22] could provide the information of user activity in the case of increased heart-beat rate or changes in ST segment morphology for monitors of silent myocardical ischemia [23].

We are introducing the concept of a mobile gateway (MOGUL) to reduce power consumption of the wireless transceiver on the PS and to avoid the need to interrupt normal user activities when uploading data [1], [2]. MOGUL is a PDA-based device that can establish wireless communication with a personal server and download collected data. Because the new generation of PDA devices has significant processing capabilities, they could also be used for high-level processing. Connection between the PS and MOGUL is naturally implemented using a standard wireless PAN technology, such as Bluetooth. However, we still use standard 9[illegible]-MHz RF modules because the available Bluetooth technology requires three to five times greater power consumption. In addition, we reduce power consumption by using a custom, power-efficient communication protocol [21].

Finally, the highest level of hierarchy in our architecture is the telemedical workstation on the Internet. Connection between the MOGUL gateway and the Internet is implemented using Bluetooth, IEEE 802.11, IR, or a USB via cradle. The telemedical workstation is responsible for long-term analysis of physiological signals, data presentation, and archiving.

The core of our wireless intelligent sensor (WISE) consists of a low-power Texas Instruments microcontroller (MPS430F149). The controller features a 16-bit architecture, ultra-low power consumption (less than 1 mA in active mode and ~1 μA in standby mode), 60-KB on-chip flash memory, 2-KB RAM, 12-bit A/D converter, and dual UART. Internal microcontroller analog channels monitor battery voltage and temperature. Therefore, WISE is capable of reporting the battery status and temperature to the upper level in the system hierarchy.

We developed WISE sensors for ECG/EEG monitoring [1], [2], [17], [18], portable computer-assisted physical rehabilitation [24], prolonged monitoring of breathing [19], and future generation human-computer interfaces [25] with possible applications to affective computing [26]. Our experience with system development indicates that the largest obstacle to wide acceptance and convenience of its use is the physical implementation of physiological sensors. For example, initially we used standard wet electrodes for the ECG sensor. The result was excellent signal quality and relative immunity to noise and movement artifacts. However, this approach is not applicable for intensive training, particularly during prolonged monitoring. Fortunately, a new generation of recreational heart-monitoring devices, such as Polar [27], offers a wireless link between the HRV sensor in the chest belt and a watch-type data acquisition unit. This type of device is very convenient for heart monitoring during normal activity, exercise, and training. Therefore, we decided to use the Polar sensor for our HRV monitoring device. Because the Polar data acquisition device supports only an IR interface and has limited storage, we developed a custom data acquisition device that could be integrated into a wireless PAN of intelligent sensors.

We had to slightly change the architecture of our BAN network for this particular project. Because we are using an off-the-shelf heart-monitoring sensor (Polar chest belt), we had to separate sensing from processing. Thus, we created a WHRM monitoring device that serves as a PS and wirelessly communicates with the HRV sensor (Figure 2). The wireless heart monitor device has been developed in collaboration with RP Technologies (Huntsville, Alabama).

To keep the system power consumption low and to increase security, we are purposely designing our system to use short-range communication. Increased device intelligence allows data compression and transmission of results only, avoiding continuous signal transmission that is the characteristic of most telemetric systems. This is particularly important in the case of sensor networks. Without the sensor intelligence, the system must have multiple communication chan-

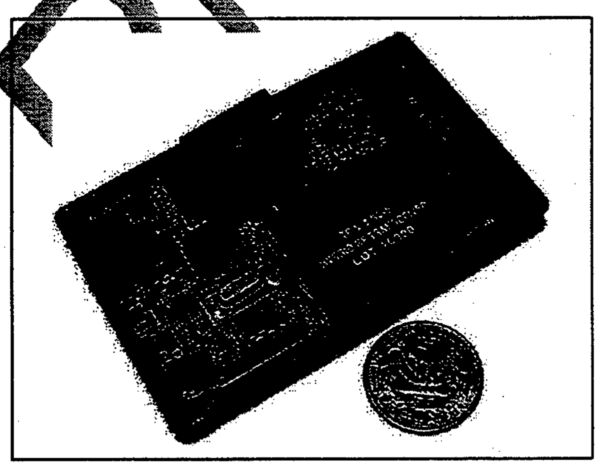

Fig. 2. Wireless heart rate monitor (WHRM).

nels, or employ complex transmission protocols with collision control mechanisms. Another important design issue is the protection from eavesdropping [28]. Our sensors are able to support strong encryption due to the sensor's intelligence, preventing disclosure of a user's health condition [29].

Distributed Wireless System for Stress Monitoring

Most monitoring applications are patient-centered, requiring synchronization among sensors on the same subject only. In some setups it is necessary to evaluate individual performance of subjects within the group during specific events. That requires synchronization of measurements of individual monitors within the sampling interval of the monitored physiological parameter. Monitored subjects can include patients, soldiers, firefighters, police officers, athletes, meeting participants, etc. We are developing a distributed wireless system to evaluate stress resistance during stressful training using synchronized measurements of HRV within the monitored group. This feature is not, to the best of our knowledge, available in the present generation of intelligent monitors.

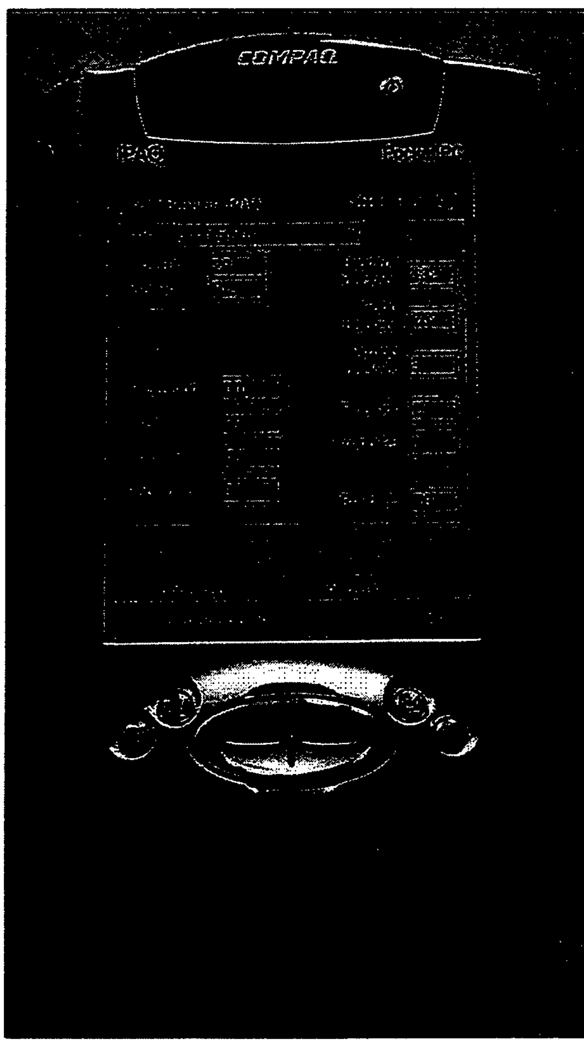

Fig. 3. Monitoring application running on mobile gateway (MOGUL).

Our preliminary results indicate a very good correlation between the HRV and stress level/resistance. In our preliminary investigations, we are validating the applicability of HRV measurements by correlating the various HRV parameters and psychological evaluations and hormone tests. Depending on the type of subjects being evaluated, we expect to assess both stress level and stress resistance.

System Description

The Wireless Distributed Data Acquisition System uses the Polar chest belt as a HRV physiological sensor, WHRM as the personal server, and an iPAQ PDA as the mobile gateway (MOGUL) as represented in Figure 1. Our prototype system features custom wireless interfaces for both sensor to WHRM and WHRM to MOGUL connections.

Data acquisition systems that are currently in use at NAMRL require inconvenient data uploading using an infrared link to a PC. Due to limited memory storage, acquired data should be uploaded to the server for offline analysis every two to three hours. It is necessary to interrupt regular activity (or even to wake up the soldier), connect the wearable unit to the computer, and upload stored information.

The WHRM can store up to 60 hours of HRV data in nonvolatile onboard memory. An operator carrying a MOGUL periodically visits the group under the test and downloads data wirelessly without interrupting the subject's normal activity. After upload, WHRM will free its local memory for new measurements.

We use an iPAQ PDA with a custom wireless interface as a mobile gateway. The choice of a data acquisition platform is critical for device acceptance and ease of use. Although a laptop PC represents the best platform for software development and application environment, it would be difficult to collect data from soldiers undergoing intense training because of size and weight limitations. The main features of the iPAQ PDA computing platform include significant processing power (200-400 MHz RISC processors), excellent screen resolution and brightness, a standard program development environment, and system support for data synchronization. Generated files can be automatically transferred to a PC as soon as the PDA is returned to its cradle for recharging.

The system is organized in a master-slave configuration with the MOGUL acting as a master. Periodic visits to the training facility with the handheld MOGUL device allow uploading of collected data from individual WISE sensors. A person holding the MOGUL will move through the training area in order to establish wireless contact with all of the WISE devices in the system. Whenever the MOGUL is able to talk to the WISE devices it downloads and catalogs the data collected since the last visit.

Because the gateway is synchronized with all the other sensors, the user can conveniently (via voice recording and GUI) enter the exact start time of the training exercise, time and a description of other events, unexpected changes in the plan and schedule, etc. Some of the existing systems support *event switches*. However, this interferes with training, and very often users (particularly in stressful situations) forget to press the switch.

The system features 1-ms resolution HRV measurements, very low power consumption, and reliable data transmission based on error detection and retransmissions. Very low power consumption is achieved through short-range transmissions thanks to gateway mobility. In addition, device intelligence significantly reduces the amount of data and length of wireless transmission (more than 100 times compared to wireless telemetry systems in the case of HRV monitoring). Power consumption is further reduced due to the fact that the WHRM is idle most of the time and scans for MOGUL presence only periodically.

The system supports multiple gateways. In each contact with the individual monitoring device, the gateway creates a separate communication session file containing data downloaded from the device. A custom-made wireless interface device is connected to the iPAQ serial port and controlled by a dedicated PDA application. The same application is responsible for communication protocol implementation, data collection, file creation, data consistency checking, automatic repeat requests, and graphical user interface. A screen shot of a development version of the application is given in Figure 3. In addition to data collection, this application also monitors characteristics and the quality of the wireless channel (number of retransmissions, bit error rate, number of loss packets, etc.). We want to use that data to further improve the wireless communication protocol and to decrease power consumption of the personal monitors. All communication session files from multiple gateways are aggregated into a training session file on a central workstation that has established partnerships with all gateway PDAs. A screen shot of a program used for data aggregation, processing, and archiving is given in Figure 4.

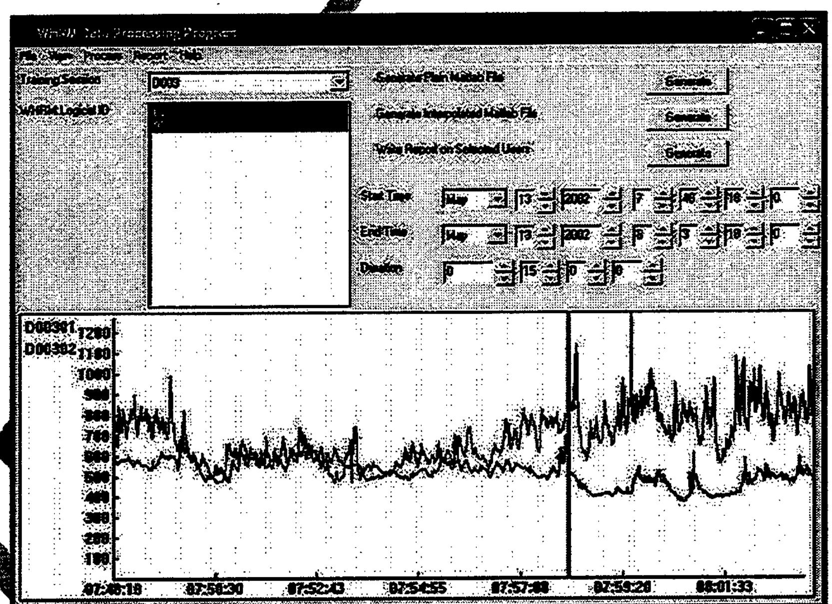

Fig. 4. HRV processing application.

Methods and Preliminary Results

We collected HRV data from the military personnel during several days of training to determine baseline HRV parameters, as well as HRV changes immediately before, during, and after stress exposure. Prolonged monitoring also facilitates assessment of stress recovery.

The 9D5 Multi-place Underwater Egress Trainer was selected as the stressor stimulus for our investigations; the 9D5 is a reasonably realistic representation of a helicopter conducting an emergency landing, turning upside, down, and sinking (Figure 5). Exposure of the trainees to the 9D5 is a mandatory training evolution during the Naval Aviation Survival Training Program at aviation preflight indoctrination. Each student receives the same instructions and training prior to the experience. Each student is subjected to the device at least three times, with each egress increasing in complexity. For example, students must wear light-filtering goggles for the third egress to simulate nighttime conditions. Students often report that this is the most stressful API training event (LCDR Lords, Head, Aviation Water Survival Training Department, NOMI Detachment Central, personal communication).

Salivary hormone responses and cognitive and psychological functioning are additionally assessed prior to, during, and after stress exposure. Circulating levels of hormones that are involved in the human response to threat have been shown to predict military performance [30]. These measures will be used to further validate the usefulness of HRV parameters as a prediction tool for military performance.

An example from our preliminary work is displayed in Figure 4, with the red line representing the beginning of the stress event. Two students simultaneously encountering 9D5 training were seen to exhibit visibly differing HRV patterns. There were differences between these two students on psychological cognitive measures as well. Student 1 reported more trait anxiety on a standardized anxiety questionnaire [31] than student 2. During training, Student 1 preformed poorly and had to be remediated. Immediately following 9D5 training, both students were administered a standardized measure of visuospatial and organizational skills requiring delayed recall [32]. Student 1 exhibited much poorer performance on the delayed recall task than student 2. Although no definite conclusions can be drawn from preliminary data from so few cases, the differences between these students is

Fig. 5. The 9D5 Multi-Place Underwater Egress Trainer [Courtesy of US Navy].

Our distributed wireless intelligent sensor system is convenient for prolonged stress monitoring during stressful training and normal activity.

striking. Upon completion of the entire study, details of the tasks administered and their relationship to HRV and hormone levels will be analyzed and submitted for publication.

Discussion

Wireless intelligent sensors have made possible a new generation of noninvasive, unobtrusive personal medical monitors applicable during normal activity. Sensor intelligence allows implementation of real-time processing and sophisticated encryption algorithms. On-sensor data processing decreases the amount of energy spent on communication and allows implementation of power-efficient communication protocols. Decreased power consumption will significantly increase battery life and even enable externally powered intelligent sensors. The current technological trend will allow wider use of wireless intelligent sensors, lower power consumption, and smaller sensor sizes. The ultimate goal is to have a single-chip, externally powered, intelligent MEMS sensor, as proposed by NASA's Jet Propulsion Laboratory [33]. This device could be disposable and comparable in size to an ordinary adhesive bandage.

Our preliminary results indicate that HRV may represent an inexpensive methodology for the objective assessment of human reactions under stress. Our distributed wireless intelligent sensor system is convenient for prolonged stress monitoring during stressful training and normal activity. We plan to develop a more compact and efficient system for evaluation of the psychophysiological state of individual subjects as well as the relative state of the subject within the group (soldiers in the battlefield, firefighters, police officers, athletes, meeting participants, etc.).

MOGUL can be wirelessly connected to the Internet, using add-in PDA cards for WAN connectivity, creating a true real-time telemedical system. Increased device intelligence will change a whole paradigm of personal monitoring in m-Health systems [10], [17], [34] and human computer interfaces in ubiquitous computing [25], [26].

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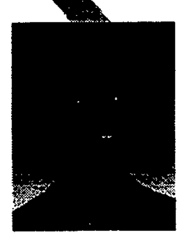

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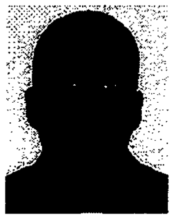

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Prolonged telemetric monitoring of heart rate variability using wireless intelligent sensors and a mobile gateway

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Abstract:
Mobile health monitors allow patients to leave the hospital and engage in normal activity, uploading physiological data only periodically. Most existing system use fixed gateways to upload data to the server. The Wireless Distributed Data Acquisition System presented in this paper is developed for prolonged, synchronized, health/stress monitoring of a selected group of subjects/patients. The system is based on mobile client devices, and mobile gateways. We use personal digital assistant (PDA) as a mobile gateway to collect data from individual monitors, and synchronize collected records with existing records on the telemedical server. Each client device uses flash memory as a temporary storage until the reliable connection with a mobile gateway is established. Individual intelligent sensors are based on a very low-power microcontroller TI MSP430F149, and use standard 900 MHz wireless link, and flash memory. This system is used to evaluate the effects of stressful military training. We have found that patterns of heart rate variability correlate with stress tolerance.

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Synchronized Physiological Monitoring Using a Distributed Wireless Intelligent Sensor System

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Abstract—**Psychophysiological evaluation of a group of subjects requires synchronized monitoring of the individual subjects in the group during collective events. We present a concept of a wireless distributed data acquisition system for prolonged, synchronized health/stress monitoring of a selected group of subjects. The Wireless Distributed Data Acquisition System uses Wireless Intelligent Sensors (WHRM) as individual heart rate variability (HRV) monitors, and a Mobile Wireless Gateway (MOGUL). Each microcontroller sensor is equipped with a low power/low range (up to 100 ft) wireless transceiver, and communicates with the mobile gateway whenever the gateway comes into a range and identifies itself. The system is used for stress level evaluation using HRV monitoring during intense military training, and could be used to evaluate the stress level of individuals within the group in different settings, such as battlefield monitoring or day-trading on the stock market. In this paper we present the implemented distributed system architecture, system design issues, and lessons learned during implementation of the system.**

Keywords—**Wireless Monitoring, Heart Rate variability, Stress, Intelligent Sensors, Physiological Monitoring.**

I. Introduction

Traditional holter monitors, such as ECG and EEG monitors, only collect data for later processing. Recent developments of wireless and mobile technology have laid a foundation for a new generation of wireless intelligent sensors, and allowed patient mobility. Patient mobility within the hospital became possible with the introduction of wireless Local Area Networks (LAN) connectivity between patient monitors and static gateways to the hospital information system. However, in this type of system, individual sensors are still wired to the personal monitor using a Body Area Network (BAN). A wearable health-monitoring device using a Personal Area Network (PAN) or Body Area Network (BAN) can be integrated into a user's clothing. This system organization, however, is unsuitable for lengthy, continuous monitoring, particularly during normal activity, such as intensive training or computer-assisted rehabilitation. Wireless Wide Area Networks (WAN) allow patient monitoring outside the hospital using satellite and cell phone links.

WHRM project has been partially funded by USAMRMC (ERMS#01145005) as a part of "The Warfighter's Stress Response: Telemetric and Noninvasive Assessment" project. The WISE project has been partially supported by the University of Alabama in Huntsville, grant 87716.

Device intelligence also allows real-time feedback to the patient, either as a warning of impending medical emergency or as a monitoring aid during exercise. A real-time personal stress monitor would benefit individuals by providing continuous feedback about their stress levels and by helping their physicians to objectively evaluate stress exposure between visits.

There are a number of active research and commercial projects in the field of portable monitoring. A typical research project is Warfighter Physiological Status Monitoring (WPSM), led by the U.S. Army Research Institute of Environmental Medicine (USARIEM) and the U.S. Army Medical Research and Materiel Command (USAMMRC) [1]. This experimental prototype consists of sensors for heart rate, metabolic energy cost of walking, core and skin temperatures, GPS location, and activity. One of the goals of the project is to provide medics with valuable information about wounded soldiers, but the final system is expected to be able to predict the critical aspects of performance under extreme conditions.

We are developing personal health monitors based on a wireless body area network of intelligent sensors [2,3]. Individual monitors are integrated into a distributed wireless system for synchronized monitoring of a group of subjects. We implemented a distributed wireless system to quantify stress level prior to and during intensive military training, and to estimate stress resistance based on heart rate variability (HRV). This task requires reliable, high precision instrumentation and synchronized measurements from a group of individuals over prolonged periods (days of training). Individual monitors must be synchronized within the dynamics of the monitored signal.

During our preliminary investigations, we used a stressful component of Aviation Water Survival Training, the 9D5 Multi-place Underwater Egress Trainer, as the main stressor for the whole group. Trainees report the 9D5 session as the most stressful training event during water survival training. The system is being developed for aviation selection at the Naval Aerospace Medical Research Laboratory at Pensacola, Florida.

We present the status of our current system and discuss system design issues, as well as possible applications for stress and psycho-physiological state estimation in the workplace and the battlefield.

II. SYSTEM ARCHITECTURE

We are integrating a BAN of Wireless Intelligent Sensors (WISE) for health monitoring applications [4-5], represented in Figure 1. WISE are microcontroller-based, intelligent physiological sensors that are responsible for data acquisition and low-level real-time signal processing tasks. Our BAN is organized as a client-server network with a single server (PS) and multiple WISE clients. It is a part of a telemedical system for hierarchical signal processing [6]. Individual WISE sensors are controlled by, and communicate with the Personal Server (PS) using a custom wireless protocol [7]. In addition to its responsibilities as a communication server, the PS also provides synergy of information through data aggregation and higher-level signal processing. For example, accelerometer-based movement sensors could provide the information of user activity in the case of increased heartbeat rate, or changes in ST segment morphology for monitors of silent myocardical ischemia.

The core of our WISE sensor is a low-power Texas Instruments microcontroller MPS430F149. The controller features a 16-bit architecture, ultra-low power consumption (less than 1 mA in active mode and ~1 μA in standby mode), 60KB on-chip flash memory, 2KB RAM, 12-bit A/D converter, and dual serial communication controller. Internal microcontroller analog channels monitor battery voltage and temperature. Therefore, WISE is capable of reporting the battery status and temperature to the upper level in the system hierarchy.

We are introducing the concept of a Mobile Gateway (MOGUL) to reduce power consumption of the wireless transceiver on the Personal Server, and to avoid the need to interrupt normal user activities when uploading data [2]. MOGUL is a PDA-based device that can establish wireless communication with a personal server, and download collected data. Because the new generation of PDA devices has significant processing capabilities, they could also be used for high-level processing. Connection between the PS and MOGUL is naturally implemented using a standard wireless PAN technology, such as Bluetooth. However, we still use standard 900 MHz RF modules because the available Bluetooth technology requires 3-5 times greater power consumption. In addition, we reduce power consumption by using a custom power-efficient communication protocol [7].

Finally, the highest level of hierarchy in our architecture is the telemedical workstation on the Internet. Connection between the MOGUL gateway and the Internet is implemented using Bluetooth, IEEE 802.11, IR, or via a USB cradle. The telemedical workstation is responsible for long-term analysis of physiological signals, data presentation, and archiving.

III. DISTRIBUTED STRESS MONITORING

We implemented a non-invasive wireless system for synchronized distributed monitoring of heart rate variability.

The Wireless Distributed Data Acquisition System uses Wireless Intelligent Sensors (WHRM) as individual HRV monitors, and a MOGUL Gateway. The Wireless Distributed Data Acquisition System uses the Polar chest

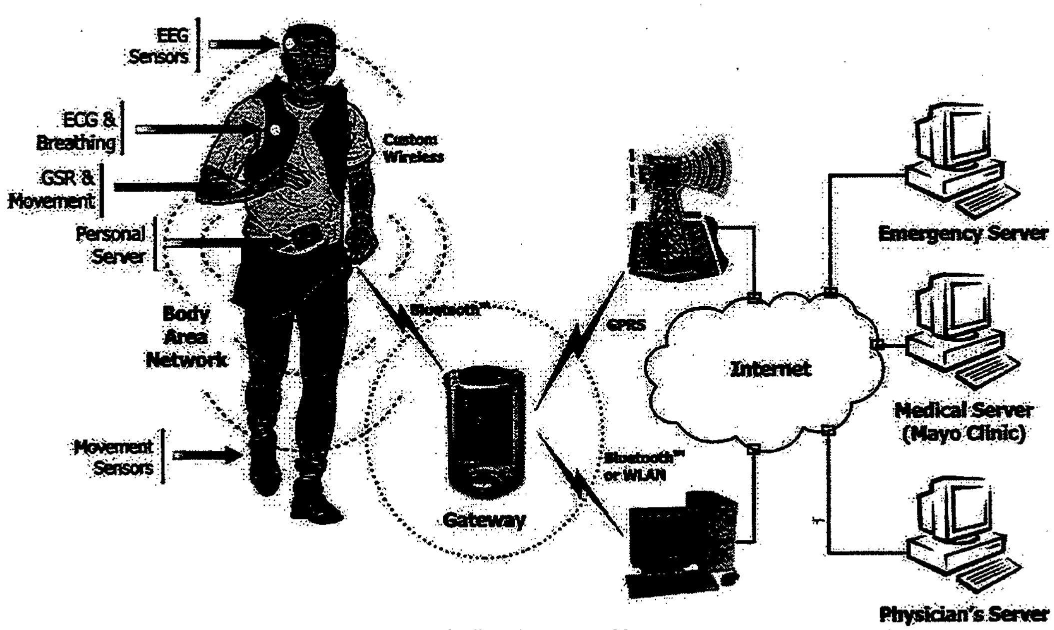

Fig. 1. Distributed system architecture

belt as a HRV physiological sensor, WHRM as the personal server, and an iPAQ PDA as the mobile gateway (MOGUL) as represented in Figure 1. Our prototype system features custom wireless interfaces for both sensor to WHRM, and WHRM to MOGUL connections.

We had to slightly change the architecture of our BAN network for this particular project. Because we are using an off-the-shelf heart-monitoring sensor (Polar chest belt [8]), we created a WHRM monitoring device that serves as a personal server and wirelessly communicates with the HRV sensor. The wireless heart monitor device has been developed in collaboration with *RP Technologies*, Huntsville, Alabama. Individual heart rate monitors are small battery powered data acquisition and processing devices with physiological sensors (1 ms HRV resolution), a wireless transceiver, and a 4 Mb non-volatile flash memory that can store up to 60 hours of HRV data. After upload, the WHRM will free its local memory for new measurements. Each microcontroller sensor is equipped with the low power/low range (up to 100 ft) wireless transceiver, and communicates with the mobile gateway whenever the gateway comes into a range and identifies itself.

The system is organized in Master-Slave configuration with the MOGUL acting as a master. We use a personal digital assistant (PDA) with a custom wireless interface module as a mobile gateway to collect data from individual monitors during periodic visits to the training facility. Reliable data transmission is based on error detection and retransmissions. MOGUL can be wirelessly connected to the Internet, using add-in PDA cards for WAN connectivity, creating a true real-time telemedical system.

Wireless communication is very convenient as it allows data collection without interruption of the subject's activity. Monitored subjects can include patients, soldiers, day traders on the stock market, firefighters, police officers, athletes, meeting participants, etc. Our goal is to quantify stress level within the group in real time, during the event.

A. Experimental Setup

The 9D5 Multi-place Underwater Egress Trainer was selected as the stressor stimulus for our investigations; the 9D5 is a reasonably realistic representation of a helicopter conducting an emergency landing, turning upside down and sinking [2]. Exposure of the trainees to the 9D5 is a mandatory training evolution during the Naval Aviation Survival Training Program at Aviation Preflight Indoctrination. Each student receives the same instructions and training prior to the experience. Each student is subjected to the device at least 3 times, with each egress increasing in complexity. For example, students must wear light filtering goggles for the third egress to simulate nighttime conditions. Students often report that this is the most stressful API training event (LCDR Lords, Head, Aviation Water Survival Training Department, NOMI Detachment Central, personal communication).

Salivary hormone responses and cognitive and psychological functioning are additionally assessed prior to, during, and after stress exposure [10, 11]. Circulating levels of hormones that are involved in the human response to threat have been shown to predict military performance [12]. These measures will be used to further validate the usefulness of HRV parameters as a prediction tool for military performance.

B. Device Synchronization

Group monitoring requires precise synchronization of individual records, particularly in the case of collective events. We use a custom data storage format to allow re-synchronization of individual records, even in the case of permanent loss of parts of the record. All record segments are recombined and merged on the telemedical server.

The precision of individual monitors depends on the stability of the on-board crystal oscillators. Commercially available oscillators have stability in the order of 10-20 ppm. Therefore, an 8MHz crystal can create time desynchronization of up to ±1.7 seconds per 24 hours. Therefore, it is necessary to calibrate individual monitors and re-synchronize monitors just before the critical event. Moreover, it is possible to use an integrated microcontroller temperature measurement to compensate frequency shift based on calibrated measurements of the oscillator.

Some of the existing systems support event switches. However, this interferes with training, and very often users (particularly in stressful situations) forget to press the switch. Because the gateway is synchronized with all the other sensors, we allowed MOGUL to synchronize all monitors within the communication range. The user can use voice recording and GUI to enter the exact catch start time of the training exercise, and enter descriptions of other events, unexpected changes in the plan and schedule, etc.

IV. Discussion

The proposed concept of a distributed wireless monitoring system is very convenient for group monitoring during normal activity. Our preliminary results indicate a very good correlation between the heart rate variability and stress level/resistance. In our preliminary investigations, we are validating the applicability of HRV measurements by correlating the various HRV parameters and psychological evaluations and hormone tests. Depending on the type of subjects being evaluated, we expect to assess both stress level and stress resistance. The main issues in the system design, and lessons learned during implementation of the system are given below.

- Wireless health monitoring requires careful consideration of privacy and security issues. In the case of our system short-range communication enforces privacy because of locality of communication, while the custom communication protocol allows mobile gateway identification as a condition for data transmission. Our sensors are able to support strong encryption due to the sensor's intelligence, preventing disclosure of a user's health condition.

- Increased device intelligence allows data compression and transmission of results only, avoiding continuous signal transmission that is a characteristic of most telemetric systems. Without the sensor intelligence, the system must have multiple communication channels, or employ complex transmission protocols with collision control mechanisms.
- Careful hardware and software system design is necessary to reduce power consumption and extend battery life. Battery capacity is limited by the size and weight of batteries, which represent the main limiting factor in the monitor design. As a result, overall size and weight of the monitor determines acceptance of the whole system. Power consumption is further reduced due to the fact that the WHRM is idle most of the time, and scans for MOGUL presence only periodically. System support for power down modes significantly increases battery life.
- Custom wireless protocols maximize power efficiency and increase channel utilization, although standardization may become an issue if heterogeneous sensors are to be employed.
- Health monitoring in a wireless body area network of intelligent sensors is a very promising and viable approach due to convenience and ease of integration. However, body area networks represent a dynamic environment influenced by sensor movement and the body itself.

V. Conclusion

Wireless intelligent sensors have made possible a new generation of non-invasive, unobtrusive personal medical monitors applicable during normal activity and capable of real-time signal processing. On-sensor data processing decreases the amount of energy spent on communication, and allows implementation of power-efficient communication protocols. Decreased power consumption will significantly increase battery life, and even enable externally powered intelligent sensors. The current technological trend will allow wider use of wireless intelligent sensors, lower power consumption, and smaller sensor sizes.

Our preliminary results indicate that individuals who have better stress tolerance also exhibit significantly different patterns of heart rate variability, both before and during stress exposure. These baseline differences in heart rate variability are predictive of actual military and cognitive neuropsychological test performance scores assessed during and after stress exposure. Our distributed wireless intelligent sensor system is convenient for prolonged stress monitoring during stressful training and normal activity. We plan to develop a more compact and efficient system for evaluation of the psychophysiological state of individual subjects, as well as the relative state of the subject within the group.

Acknowledgment

We would like to thank Andy Morgan, Yale University School of Medicine, Rick Hormigo and Brent Priddy, University of Alabama in Huntsville, for all their help during implementation of this project.

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Lords, A. O'Donnell, Andrasik, F, Prevost, M.C. (2003). Biopsychological Assessment of High Intensity Training: Telemetric and Noninvasive Assessment. *The Association for Applied Psychophysiology and Biofeedback*, Annual Meeting, Jacksonville, FL.

Title of the Symposium

New Psychophysiological Measures and Treatments: Expanding the Boundaries

Statement of the Problem

The major goal of this symposium is to acquaint individuals with a number of developing physiological measures that may be useful in assessment and treatment. The first presentation examines differences in cortical habituation between children who are diagnosed with migraine or with ADHD and children who are healthy and diagnosis-free by use of a relatively unstudied aspect of EEG, contingent negative variation. Work in this area is helping to illuminate pathophysiology and is leading to development of a treatment that is more directly tied to the underlying cause and that is physiologically specific in nature. The second presentation examines the utility of a motoric measure for assessing and evaluating treatment outcome for ADHD. The third presentation describes the initial development and testing of a feedback system that utilizes Doppler ultrasonography for monitoring blood flow. Potential applications are discussed as well. The fourth presentation describes results from an ongoing biopsychological investigation with military personnel undergoing stressful training. The goal of this work is to improve current selection procedures and to gather data that might assist in enhancing training and any needed remediation. The fifth presentation discusses the development of and potential applications for a novel feedback modality based on the sense of touch. The sixth presentation describes the ongoing developmental work on a computing system that provides a real-time cardiac-based measure of arousal. Potential applications are discussed, as well. An expert, known internationally for his innovation and research, will discuss all of the papers.

Biopsychological Assessment of High Intensity Training: Telemetric and Noninvasive Assessment

Individuals exhibit certain biopsychological responses during stressful training. This talk will summarize findings from 3 separate investigations, focusing on Navy Student Pilot Candidates and Navy Aircrew Candidates undergoing water survival training Neuroendocrine (cortisol, testosterone, DHEA, and estriadiol), heart rate variability, personality, and cognitive measures are being examined to see if they can reliably discriminate successful from unsuccessful candidates. Implications for selection, training, and intervention will be discussed.

Questionnaires

Brief Trauma Questionnaire

Clinician Assisted Dissociative States Scale

Rey-Osterreith Complex Figure Task

Declarative Memory Task

BRIEF Trauma Questionnaire
ID #: ___________________

The following questions ask about events that may be extraordinarily stressful or disturbing for almost everyone. Please circle **Yes** or **No** to report if any of these events have happened to you.

If you answer **Yes** for an event, please answer the two additional questions that are listed on the right to report: (1) whether you thought your life was in danger or you might be seriously injured; and (2) whether you were seriously injured. If you answer **No** for an event, go on to the next event.

Has this ever happened to you?		Answer these questions for each event that has happened to you.	
		Did you think your life was in danger or you might be seriously injured?	Were you seriously injured?
1. Have you ever served in a war zone, or have you ever served in a noncombatant job that exposed you to war-related causalities (for example, as a medic or on graves registration duty?)	*Yes No*	**Yes No**	**Yes No**
2. Have you ever been in a serious car accident, or a serious accident at work or somewhere else?	**Yes No**	**Yes No**	**Yes No**
3. Have you ever been in a major natural or technological disaster, such as a fire, tornado, hurricane, flood, earthquake, or chemical spill?	**Yes No**	**Yes No**	**Yes No**
4. Have you ever had a life-threatening illness such as cancer, heart attack, leukemia, AIDS, stroke, etc.?	**Yes No**	**Yes No**	
5. Before age 18, were you physically punished or beaten by a parent, caretaker, or teacher so that: you were very frightened; or you thought you would be injured; or you received bruises, cuts, welts, lumps or other injuries?	**Yes No**	**Yes No**	**Yes No**

6. Not including any punishments or beatings you already reported in question 5, have you ever been attacked, beaten, or mugged at any age by anyone, including friends, family members, or strangers?	**Yes** **No**	**Yes** **No**	**Yes** **No**
7. Has anyone ever made or pressured you into having some type of unwanted sexual contact? Note: By sexual contact we mean any contact between someone else and your private parts or between you and someone else's private parts	**Yes** **No**	**Yes** **No**	**Yes** **No**
8. Have you even been in any other situation in which you were seriously injured, or have you ever been in any other situation in which you feared you might be seriously injured or killed?	**Yes** **No**		**Yes** **No**
9. Has a close family member or friend died violently, for example, in a serious car crash, mugging, or attack?	**Yes** **No**		
10. Have you ever witnessed a situation in which someone was seriously injured or killed, or have you ever witnessed a situation in which you feared someone would be seriously injured or killed? Note. Do not answer Yes for this question for any event you have already reported in questions 1-9.	**Yes** **No**		

Clinician Assisted Dissociative States Scale
ID#: ____________________

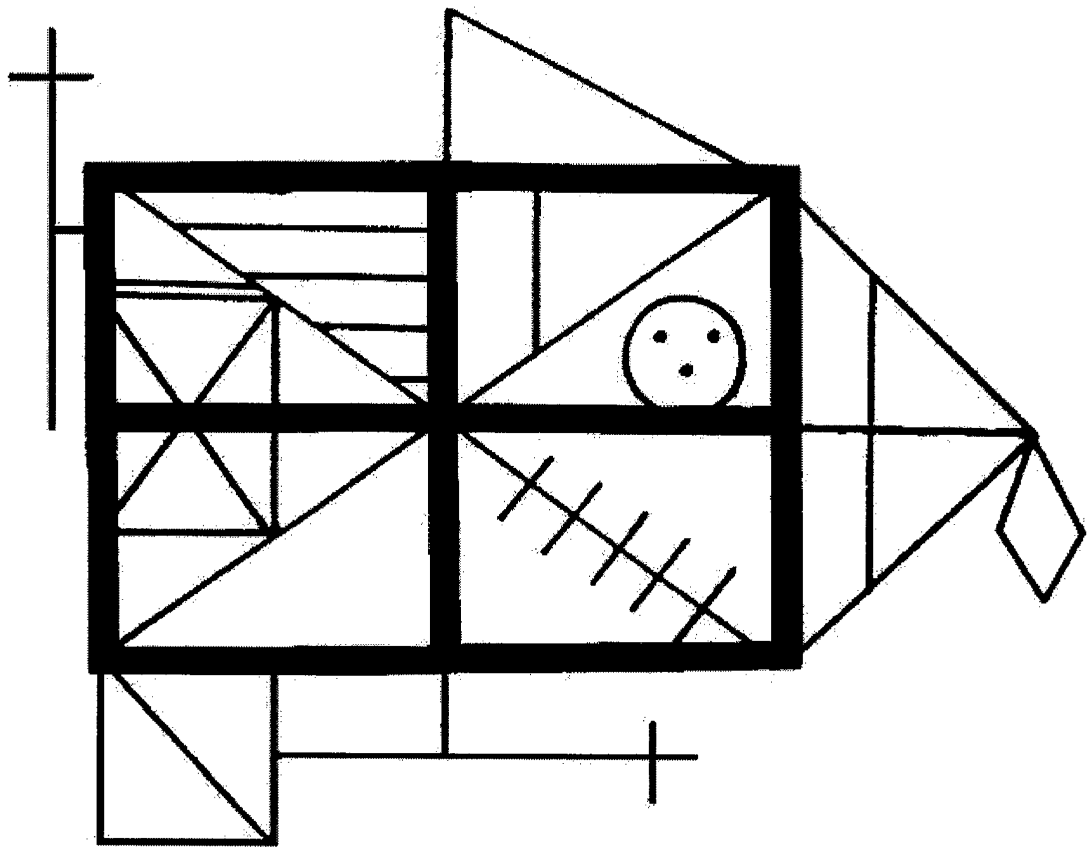
EXPERIENCE SCALE

Please indicate if you have ever had the following experiences during an event or incident by placing in "**X**" in the second column. If you have had any of these experiences, indicate the intensity of the experience in the third column using the following scale:

1=Slightly 2=Moderately 3=Considerably 4=Extremely

Have you ever had the following experience?	If yes, mark "**X**"	Intensity of the experience
1. Did things seem to be moving in slow motion?		
2. Did things seem to be unreal to you, as if you were in a dream?		
3. Did you have some experience that separated you from what was happening; for instance, did you feel as if you were watching a movie or a play, or as if you were an automation?		
4. Did you feel as if you were looking at things from outside of your body?		
5. Did you feel as if you were watching the situation as an observer or a spectator?		
6. Did you feel disconnected from your own body?		
7. Did your sense of your own body feel changed: for instance, did your own body feel unusually large or unusually small?		
8. Did people seem motionless, dead or mechanical?		
9. Did objects look different than you would have expected?		
10. Did colors seem to be diminished in intensity?		
11. Did you see things as if you were in a tunnel, or looking though a wide-angle photographic lense?		
12. Did the experience seem to take much longer than you would have expected?		
13. Did the experience happen very quickly, as if there were a lifetime in a moment?		
14. Were there things that happened during the experience that you later couldn't account for?		
15. Did you space out, or in some other way lose track of what was going on during the experience?		
16. Did sounds almost disappear or become much stronger than you would have expected?		
17. Did things seem too very real, as if there were a special sense of clarity?		
18. Did it seem as though you were looking at the world through a fog, so that people and objects appeared far away or unclear?		
19. Did colors seem much brighter than you would have expected?		

Rey-Osterreith Complex Figure Task



Using the space below, copy the picture as precisely as you can.

Following 5-10 minutes the participant is asked to draw this figure from memory

Memorize all the words in the list highlighted below.

List A	**List B**
Soldier	Principal
Beaver	Pig
Nurse	Lawyer
Peas	Corn
Rat	Fox
Professor	Clerk
Brain	Nose
Carrot	Mushroom
Throat	Heels
Wolf	Seal
Tooth	Mouth
Rice	Apple
Coach	Cook
Lion	Monkey
Chest	Hand
Onion	Spinach
Finger	Eye
Mouse	Bear
Grape	Plum
Judge	Farmer

Please write all the words you recall from the list.

Biographical Sketch

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EDUCATION:

University of West Florida	B.A.	1995	Psychology
University of West Florida	M.A.	1997	Psychology
University of West Florida	Ed.D.	TBA 2004 (spring)	Education

RESEARCH AND PROFESSIONAL EXPERIENCE:

Positions
1998 to Present: Research Psychologist, Naval Aerospace Medical Research Laboratory
Primary responsibilities include serving as team leader (Principal Investigator) on various projects, serving as a full member on several research teams within the division as an Associate Investigator, and as collaborator on joint projects with researchers at outside institutions and universities. As a PI, my responsibilities include identifying, formulating, obtaining funding for, and conducting systematic research, primarily within the field of aviation selection. The various research problems are of considerable scope and complexity. I initiated a series of conceptually related studies investigating the relationships between various selection instruments, cognitive performance, personality, training performance, and various biopsychological measures during stressful training evolutions. These areas of study are of exceptional interest within the psychological and psychiatric fields, military selection and classification communities, and military training communities. The complex approaches that are required to determine these relationships demand sophisticated research techniques that necessitate creative design. The findings are adding knowledge to the fields of general psychology, biological psychology, psychiatry, military selection and classification, and military psychology. Operationally, the techniques and methodology may aid in refining personnel selection and classification practices within the Navy. In order to fulfill these responsibilities, I have made, cultivated, and maintained contacts with researchers at a variety of institutions including other Navy facilities, private and state universities, and federal laboratories in the United States, and with researchers outside the United States. Aside from conducting large-scale research projects, I must interact with a wide variety of individuals include program directors at various funding agencies, commanding officers of training facilities, training coordinators, and research participants. Professional contacts are varied and dependent upon current research activities.

The research methodologies in most of my projects involve creatively applying methods and techniques to attack the specific research problems. Successfully executing my projects requires the application of a high degree of originality and ingenuity in adapting, extending, and synthesizing existing theory, principles, and techniques into original and non-obvious combinations or configurations, and in defining and conducting the specific research studies necessary for the solution of the identified problems.

A major responsibility of this position involves aviation selection, thus I have thorough knowledge of the Aviation Training Jacket, and possess the skills to develop, manage, and query databases concerning aviation training. Although my focus has primarily been aviation selection, I have worked with many different training populations including Landing Craft Air Cushion Crew and Unmanned Aerial Vehicle crew. Consequently, I have the proven ability to synthesize data from disparate sources. I am proficient with Excel, Access, Dbase, SPSS and SAS. Typical statistical analyses that I perform include T-tests, Chi-Square, Analyses of Variance, Multivariate Analyses of Variance, Analyses of Covariance, Multivariate Analyses of Covariance, Correlations, Linear Regressions, Multiple Linear Regressions and Power Analyses. Because of ongoing projects within the division, the incumbent must also possess rudimentary understanding of Bayesian Statistics

Several of my projects require development or refinement of novel tests specifically for selection. I am skilled with test development, modification, administration, and validation of various computer-based performance tasks. Consequently, I remain current with the scientific literature concerning the underlying cognitive principles of performance on various computer-based performance tasks. The performance tasks that I use measure a variety of cognitive and psychomotor skills, including spatial abilities, dichotic listening, 2-dimensional compensatory tracking, mental rotations, and working memory, mathematical skills, comprehension, and mechanical skills.

Principal Investigator:

Validation the Necessity of Basic Water Survival Training: Do Better Swimming Skills Equal Better Helicopter Underwater Egress Skills?

The War Fighter's Stress Response: Telemetric and Noninvasive Assessment Selection of Aviation Personnel with Regard to their Potential Risk of Capture: Psychobiological Assessment of Student Aviator Exposure to a Stressful Training Event

Biopsychological Assessment of Spatial Abilities

Automated Spatial Abilities Test

Aviator and Aircrew Stress Response

Validation of the Armstrong Aviator Preference Survey

1995 – 1998: Research Associate, The Behavioral Medicine Laboratory, University of West Florida
RESPONSIBILITIES INCLUDED: DAY TO DAY MANAGEMENT OF ONGOING RESEARCH PROJECTS WHICH INCLUDED THE FOLLOWING INVESTIGATIONS: PROPHYLACTIC MEDICATION FOR THE CONTROL OF MIGRAINE HEADACHES; SLEEP IMPROVEMENT IN THE GERIATRIC POPULATION; MEMORY IMPROVEMENT IN THE GERIATRIC POPULATION; NON-INVASIVE TREATMENTS FOR MIGRAINE HEADACHE; THE UTILITY OF BIOFEEDBACK FOR A VARIETY OF DISORDERS.

1993-1995: Research Assistant: Laboratory for Studies in Cognitive Psychophysiology

All studies involved either 19 channel or 128 channel EEG/ERP. Primary responsibility was an investigation that attempted to determine the role of the P200 in early encoding. Lab involvement also included providing assistance with all phases of ongoing research projects involving cognitive psychophysiology.

Professional Activities

Member, NAMRL Institutional Review Board

Awards

Civilian of the Year, Naval Aerospace Medical Research, 2002
Civilian of the Year, Naval Aerospace Medical Research, 2001
Student Research Award, Association for Applied Psychophysiology and Biofeedback, 1997
Outstanding Graduate Student of the Year 1996-97
Department of Psychology, University of West Florida

Publications and Presentations ***(note, former name was O'Donnell Albert)***

Albert, A.O'Donnell, Andrasik, F., Grace, M.K., & Miller, C. (1999) *The Effects of Feedback Modality on Thermal Biofeedback: Preliminary Investigation.* The South Eastern Psychology Association, Annual Meeting, Savannah, GA.

Albert, A.O'Donnell, Andrasik, A., Dunn, B.R., & Moore, J. (1998). *Theta/Beta Training for Attention, Concentration and Memory Improvement in the Geriatric Population.* Student Award: The Association for Applied Psychophysiology and Biofeedback, Annual Meeting, Orlando, FL.

Andrasik, F., Otis, J., **Albert, A.O'Donnell.**, Napier, D., Grace, M.K., Miller, C. (1998). *The effects of Three Different Resolution Settings on Peripheral Temperature Training.* The Association for Applied Psychophysiology and Biofeedback, Annual Meeting, Orlando, FL.

Andrasik, F., & **O'Donnell A.S.** (1997). *The Effects of AV Stimulation on Self Reports of Relaxation, Anxiety, and Three Physiological Measures: The Results of an Investigation Conducted at the Behavioral Medicine Laboratory.* Technical report submitted to the Synetics Corporation.

Blower, D.J., Williams, H.P., and **Albert, A.O**'Donnell, *Predicting Primary Flight Grades by Averaging Over Linear Regression Models: Part 1,* NAMRL-1410, Naval Aerospace Medical Research Laboratory, Pensacola, Florida, January 2000. (AD A 375 398)

Blower, D, **O'Donnell, A.**, & Casey, C. (2002). Predicting Probability of Success for Naval Aviation Candidates. *Annual meeting of the Aerospace Medical Association, Montreal, Canada.*

Casey, C., **O'Donnell, A.**, & Blower, D. (2002) Automated spatial abilities test. *Annual meeting of the Aerospace Medical Association, Montreal, Canada.*

Casey, C., **O'Donnell, A.**, Blower, D. (2002). The Automated Pilot Examination System. Annual meeting of the Aerospace Medical Association, Montreal, Canada.

Cahoon, M., **Albert, A.O'Donnell.**, & Dunn, B.R. (1999). Predicting Retrieval from the Brain's Electrical Activity Generated at Encoding. *The South Eastern Psychology Association,* Annual Meeting, Savannah, GA.

Dunn, B.R., & **O'Donnell, A.S.** (1997). *The Relationship Between Two ERP Components and Memory.* Poster Presentation: The Florida Conference on Cognition, Annual Meeting, Pensacola, FL.

Jovanov, E., **Lords, A.**, Raskovic, D., Cox, P., Adhami, R., Andrasik, F. (2003). "Stress Monitoring Using a Distributed Wireless Intelligent Sensor System," *IEEE Engineering in Medicine and Biology Magazine*, May/June .

Jovanov, E., **O'Donnell, A.**, Priddy, B., Hormmigo, R., & Morgan, C.A. (2002). Prolonged Telemetric Monitoring of Heart Rate Variability Using Wireless Intelligent Sensors and a Mobile Gateway. *IEEE Engineering in Medicine and Biology*, Annual Meeting.

Lords, A. O'Donnell, Andrasik, F, Prevost, M.C. (2003). Biopsychological Assessment of High Intesnity Training: Telemetric and Noninvasive Assessment. *The Association for Applied Psychophysiology and Biofeedback*, Annual Meeting, Jacksonville, FL.

Lords, A. O'Donnell, Prevost, M.C, Smith R.E., Graham, P., Throneberry, M. Kauffman, J.K., & Andrasik, F. (2003). "Do better swimming skills equal better helicopter underwater egress skills?" *The International Association for Safety and Survival Training*, Annual Meeting, Lafayette, LA.

Lords, A. O'Donnell, Andrasik, F., Prevost, M.C., Morgan, C.A. (2003). "Tolerance to stress among student naval aviators: Biopsychological assessment of high stress training." The International Society for Traumatic Stress Studies, Annual Meeting, Chicago, IL.

O'Donnell, A. S. (1997). *The Relationship Between the P200 Component of the Event Related Potential and Retrieval.* Thesis submitted to the Department of Psychology, College of Arts and Social Sciences, The University of West Florida.

O'Donnell, A.S., & Dunn, B.R. (1997). The Relationship of the P200 Generated at Encoding and Subsequent Retrieval. *Society for Psychophysiological Research*, Annual Meeting, Cape Cod, MA.

O'Donnell, A., Moore, J., Dolgin, D., Casey, C., & Blower, D. (2002). US Navy Aviation Student Norms on the ALAPS. Annual meeting of the Aerospace Medical Association, Montreal, Canada.

Williams, H.P., **Albert, A.O'Donnell**, and Blower, D.J. (1999). *Selection of officers for U.S. naval aviation training.* Proceedings of the 41st Annual Conference of the International Military Testing Association.

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel.
Photocopy this page or follow this format for each person.

NAME	POSITION TITLE
Charles A. Morgan III, M.D., M.A. (GS-15)	Associate Professor of Psychiatry & Research Affiliate, History of Medicine, Yale University

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training).

INSTITUTION(S) AND LOCATION	DEGREE(S) (if applicable)	YEAR(S)	FIELD(S) OF STUDY
Pacific Union College, Angwin, CA	B.A.	1982	French
Loma Linda University School of Medicine, CA	M.D.	1986	Medicine
Yale University	M.A.	1996	History of Medicine

RESEARCH AND PROFESSIONAL EXPERIENCE:

Positions

Internship (1986 to 1987), Jerry L. Pettis Memorial VA Hospital, Loma Linda, CA.
Psychiatry Resident (1987 to 1989), Dept. of Psychiatry, Loma Linda, University Medical Center, Loma Linda, CA.
Staff Psychiatrist, (1988 to 19 89) David & Margaret Home for Girls, La Verne, CA.
Chief Resident, (1989 to 1990), Neurobiological Studies Unit, National Center for Post Traumatic Stress Disorder, West Haven VA Medical Center, West Haven, CT. Yale University Dept. of Psychiatry.
Assistant Professor of Psychiatry (1990 to 1993), Yale School of Medicine.
Medical Director (1990 to 1991), Dual Diagnosis Unit & Medical Director, Neurobiological Studies Unit, National Center for PTSD.
V.A. Medical Center, West Haven, CT.
Director of Substance Abuse/PTSD Clinic, Medical Director (1991 to 1992), Desert Storm Outreach Clinic, VA Medical Center, West Haven, CT.
Director of Outpatient Psychotherapies (1991 to 1992), PTSD/Anxiety Clinic, National Center for PTSD, VAMC, West Haven, CT.

Assistant Director (1992 to 1993) Outpatient Mental Health Department of Psychiatry, WHVAMC.
Court Clinic Psychiatrist (1993 to), Yale Dept. of Law and Psychiatry.
Assistant Professor of Psychiatry (1993 to 1996), Yale University School of Medicine.
Associate Professor of Psychiatry & Research Affiliate (1996 to), History of Medicine, Yale University Associate Director PTSD Program, National Center for PTSD, VA Connecticut.

Research Grants

Principal Investigator: Assessment of Baseline and Fear Potentiated Acoustic Startle in PTSD, July, 1, 1992. V.A. R.A.G. (completed)
Co-Principal Investigator: Startle Modulation in Combat Veterans with PTSD, 1993-1998, NIMH. (completed).
Principal Investigator: Psychobiological Assessment of High Intensity Military Training. (DoD).
Funding ongoing: $225,000.00 total for fiscal years 1998, 1999, and 2000

Awards

The Stephen Fleck Faculty Award as Exemplary Physician and Clinical Teacher, Yale Department of Psychiatry, 1996-97
Lucia P. Fulton Fellowship Award (History of Medicine, the Nathan Smith Club, Yale University School of Medicine) 1999.

Forensics

Expert Witness, International Tribunal for War Crimes committed in the former Yugoslavia, United Nations Court, The Hague, Netherlands. Case: The Prosecutor vs. Anto Furundzija. 1998

SELECTED PEER REVIEWED PUBLICATIONS

Morgan CA, Grillon C, Southwick SM, Krystal JH, Davis M, Charney D. Yohimbine facilitated acoustic startle in combat veterans with post-traumatic stress disorder. Psychopharmacol, 110:342-346, (1993).

Morgan CA, Grillon C, Southwick S, Nagy LM, Davis M, Krystal, J.H., & Charney D. Yohimbine facilitated acoustic startle in combat veterans with post-traumatic stress disorder. *Psychopharmacol*, 1995, 117:466-471

Morgan C.A., Grillon C., Southwick S.M., Davis M., & Charney D.S. Fear-potentiated startle in posttraumatic stress disorder. *Biol Psychiatry*. 1995, 38:378-385.

Morgan C.A., Grillon C., Southwick S.M., Davis M., & Charney D.S. Fear-potentiated startle in posttraumatic stress disorder. *Biol Psychiatry*. 1995, 38:378-385.

Southwick SM, **Morgan CA**, Nicholau A, Darnell A, Charney DS: Trauma Related Symptomatology in Desert Storm Veterans: Two year follow-up, *Am J of Psychiatry*, 152;8, 1150-1155,(1995).

Morgan CA, Grillon C, Southwick S, Davis M, Krystal, J.H., & Charney D. Exaggerated acoustic startle in Gulf war veterans with PTSD. *Am J Psychiatry*, 1996, 153:64-68.

Grillon C., **Morgan CA**, Southwick S, Davis M, & Charney D. Baseline startle amplitude and PPI in Vietnam veterans with posttraumatic stress disorder. *Psychiatry Res.*, 64, 169-178:1996.

Krystal J.H., Webb E., Grillon C., Cooney N., Casa L., **Morgan C.A, III,** Southwick S.M., Davis M., & Charney D.S. Evidence of acoustic startle hyper-reflexia in recently detoxified alcoholics: Modulation by yohimbine and m-chlorophenylpiperazine (mCPP). *Psychopharmacol*, 131, 207-215: 1997.

Southwick SM, **Morgan III CA**, Nicolaou AL, Charney DS: Consistency of Memory for Combat-Related Traumatic Events in Veterans of Operation Desert Storm. *Am J Psychiatry* (1997) 154:173-177.

Morgan CA, Grillon C, Southwick SM: Startle Abnormalities in Women with Sexual Assault related PTSD. *Am J Psychiatry* (1997) 154:1076-1080.

Grillon C, **Morgan CA**, Davis M, & Southwick SM. Effects of experimental context and explicit threat cues on acoustic startle in Vietnam veterans with posttraumatic stress disorder. *Biol Psychiatry*, Nov 15 1998, 44(10) p1027-36.

Morgan CA, Kingham P, Nicolaou A, Southwick SM: Anniversary Reactions in Desert Storm Veterans: A Naturalistic Inquiry 2 years after the Gulf War. *J of Traumatic Stress* Vol. 11, No. 1, 1998.

Grillon C, **Morgan CA**, Davis M, & Southwick SM. Effects of darkness on acoustic startle in Vietnam veterans with PTSD, *Am J Psychiatry*, 155, 812-817, 1998.

Grillon C & **Morgan CA**: Fear Contextual Startle Conditioning to Explicit and Contextual Cues in Gulf War Veterans with Posttraumatic Stress Disorder. *J Abn Psychology*, (1999) 108: 134-142.

Morgan CA, III & Grillon C. Abnormal mismatch negativity in women with sexual assault related PTSD. *Biol Psychiatry*, (1999) 45: 827-832.

Morgan CA, Hill SR, Fox P, Kingham P, Southwick SM: Anniversary Reactions in Gulf War Veterans: A 6-Year Follow-up Report. *Am J Psychiatry*, (July,1999), 156(7) p1075-9.

Morgan III CA, Wang S, Mason J, Hazlett G, Fox P, Southwick SM, Charney DS, Greenfield G: Hormone Profiles in Humans Experiencing Military Survival Training. *Biol Psychiatry*, 2000; 47: 891-901.

Morgan III CA, Wang S, Southwick SM, Rasmusson A, Hauger R, Charney DS: Plasma Neuropeptide-Y in Humans Exposed to Military Survival Training. *Biol Psychiatry* 2000; 47: 902-909.

Rassmusen A, **Morgan CA**, Hauger S, Bremner DJ, Southwick SM: Plasma NPY in response to Yohimbine Challenge in combat veterans with, and without Post-traumatic Stress Disorder. *Biol Psychiatry*. In press.

Morgan III CA, Wang S, Hazlett G, Rassmusson A, Anderson G, Charney DS: Relationships among Cortisol, Catecholamines, Neuropeptide Y and Human Performance During Uncontrollable Stress. *Psychosomatic Med*. 63: 412-42; 2001

Morgan III CA, Hazlett G, Wang S, Richardson G, Schnurr P, Southwick SM: Symptoms of Dissociation in Humans Experiencing Acute Uncontrollable Stress: A Prospective Investigation. *Am J psychiatry*, 158:8; 1239-1247. 2001.

Morgan III CA, Rassmusson A, Wang S, Hauger R, Hazlett G: Neuropeptide-Y, Cortisol and Subjective Distress in Humans Exposed to Acute Stress: Replication and Extension of a Previous Report. *Biol Psychiatry*. In press.

Non Peer Reviewed Publications

Southwick, SM, Vojvoda D, **Morgan CA**, Lipschitz D: Persian Gulf War, Stress Effects of Encyclopedia of Stress, volume 3, pp 142-148, in press.

Southwick, SM, Paige S, **Morgan CA,** Bremner JD, Krystal JH, Charney DS: Neurotransmitter Alterations in PTSD: Catecholamines and Serotonin. *Seminars in Clinical Neuropsychiatry*; (1999) Vol. 4, (October), pp 242-248.

Morgan CA, and Grillon C: Acoustic Startle in Individuals with PTSD. *Psych Annals*, (1998) Vol. 28 (8); 430-434.

Chapters

Southwick SM, Yehuda R, **Morgan CA**: Clinical Studies of Neurotransmitter Alterations in Post Traumatic Stress Disorder. In: Neurobiological and Clinical Consequences of Stess: From normal adaptation to PTSD, Eds: Friedman MJ, Charney DS, and Deutch AY, Lippencott-Raven Publishers, Philadelphia, (1995) Chapter 18, pp 335-349.

Southwick SM, **Morgan CA**: West Haven VA Medical Center Operation Desert Storm findings. In: Returning Persian Gulf Troops, First Year Findings. Publisher DAV, March 31,1992.

Morgan CA & Southwick SM: Biological alterations in Posttraumatic Stress Disorder: Implications for Research and the U.S. Military. In: Pennington Center Nutrition Series: Countermeasures for Battlefield Stressors. Eds. Friedl, Lieberman, Ryan & Bray. Publisher, Pennington Center, 2000. pp9-25.

Submitted/In Review

Morgan CA, Hazlett GA, Southwick SM, Zimolo Z, Hoyt G, Charney DS: : Plasma DHEA(S), Cortisol, and Symptoms of Dissociation in Humans Exposed to Acute Uncontrollable Stress.

Morgan CA & Southwick: Trauma-Related Symptoms in Veterans of Operation Desert Storm: A Four-Year Follow-up.

Morgan CA, & Southwick SM: Inconsistency of Memory for Traumatic Events: Replication and Clarification Six-Years After the Gulf War.

Morgan CA & Southwick SM : Inconsistency of Memory for Traumatic Events: Replication and Clarification Six-Years After the Gulf War.

Morgan CA: From :Let There Be Light" to "Shades of Grey": The Appropriation of Combat Fatigue 1944-1945. *Bull. Of History of Medicine*. In revision.

Morgan CA: "Don't Worry: It's not you, it's your brain:" The Rhetoric of Biology in Psychotherapy.

In preparation

Morgan CA, Grillon C, Southwick SM: Effect of Clonidine on Acoustic Startle in Combat Veterans with PTSD.

Morgan CA, Wang S, Muncey K, Simpson P, Mason J: Heart Rate, Cortisol and Dissociation in Humans Participating in a Forced Swim Test: Toward a Biology of Selection.

Other Professional Activities

VA Merit Review Subcommittee for Mental Health & Behavioral Science
Reviewer, Am J of Psychiatry
Reviewer, Arch Gen Psychiatry
Reviewer, Biological Psychiatry
Reviewer, Journal of Neuropsychoendocrinology
Book Reviewer, Journal of History of Medicine and the Allied Sciences

Book Reviewer, Nature Medicine
Member, International Society for Traumatic Stress Studies
Member, American Association for the History of Medicine
Member & Secretary/Treasurer, The Beaumont Club of Connecticut for the History of Medicine
Member, Pavlovian Society

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel.
Photocopy this page or follow this format for each person.

NAME	POSITION TITLE
Emil Jovanov, Ph.D.	Associate Professor, UAH

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training).

INSTITUTION(S) AND LOCATION	DEGREE(S) (if applicable)	YEAR(S)	FIELD(S) OF STUDY
School of Electrical Engineering, University of Belgrade	Dip.Ing.	1984	EE/Computer Engineering
School of Electrical Engineering, University of Belgrade	M.Sc.	1989	EE/Computer Engineering
School of Electrical Engineering, University of Belgrade	Ph.D.	1993	EE/Computer Engineering

RESEARCH AND PROFESSIONAL EXPERIENCE:

Positions

Research Assistant (08/84 to 12/96), Institute "Mihajlo Pupin."
Program Director For Image Processing and Multimedia (12/96 to 08/98) Institute "Mihajlo Pupin."
Visiting Assistant Professor (08/98 to 06/99), ECE Dept., The University of Alabama, Huntsville, AL.
Assistant Professor (07/99 to 06/01), ECE Dept., The University of Alabama, Huntsville, AL.
Associate Professor (07/01 to), ECE Dept., The University of Alabama, Huntsville, AL.

Research Grants

The US Army Medical Research and Material Command (USAMRMC) (2002), $430,073. Principal Investigator: Amanda O'Donnell. *The War Fighters Stress Response: Telemetric and Noninvasive Assessment.*
University of Alabama, Huntsville, AL (2001). Principal Investigator: Emil Jovanov. *Distributed Processing in a Wireless Network of Intelligent Sensors*

University of Alabama, Huntsville, AL (2000). Principal Investigator: Emil Jovanov. *Development of Microcontroller-based Testbed Environment for Microcomputer Laboratory* (CPE429, EE 429/509)

Texas Instruments (1999) Principal Investigator: Emil Jovanov. *Real Time Monitoring of Hear Electrical Activity Using Low Power DSP.*

Ministry of Science and Technology of Serbia (MNT) (1996). Principal Investigator: Emil Jovanov. *Automatic quality control prototype.*

Republic Ministry of Science and Technology of Serbia (MNT) (1995). Principal Investigator: Emil Jovanov. *A Prototype Glass Viscosity Measurement System.*

Journals:

E. Jovanov, V. Milutinovic, A. Hurson, "*Acceleration of Non-numeric Operations Using Hardware Support for the Ordered Table Hashing Algorithms*," IEEE Transactions on Computers, Vol. 51, No. 11, 2002.

D.Rakovic, Z.Jovanovic-Ignjatic, D.Radenovic, M.Tomasevic, E.Jovanov, V.Radivojevic, Z.Martinovic, P.Sukovic, M.Car, and L.Skaric, "*An overview of microwave resonance therapy and EEG correlates of microwave resonance relaxation and other consciousness altering techniques*", Electro and Magnetobiology, Vol. 19 (2000), pp. 195-222.

A. Samardzic, E. Jovanov, D. Starcevic, "*Real-time visualization of brain electrical activity*", Real Time Imaging, Vol. 6, No. 1, February 2000, pp. 69-76.

D.Rakovic, M.Tomasevic, E.Jovanov, V.Radivojevic, P.Sukovic, Z.Martinovic, M.Car, D.Radenovic, Z.Jovanovic-Ignjatic, and L.Skaric, "*Electroencephalographic (EEG) correlates of some activities which may alter consciousness: The transcendental meditation technique, musicogenic states, microwave resonance relaxation, healer/healee interaction, and alertness/drowsiness*", Informatica, Vol. 23 (1999), pp. 399-412.

E. Jovanov, K. Wagner, V. Radivojevic, D. Starcevic, M. Quinn, D. Karron, "*Tactical Audio and Acoustic Rendering in Biomedical Applications*", IEEE Transactions on Information Technology in Biomedicine, Vol. 3, No. 2, June 1999, pp. 109-118.

E. Jovanov, D. Starcevic, A. Samardzic, A. Marsh, Z. Obrenovic, "*EEG analysis in a telemedical virtual world*", Future Generation Computer Systems 15, pp. 255-263, 1999.

E. Jovanov, D. Starcevic, A. Marsh, Z. Obrenovic, V. Radivojevic, A. Samardzic, "*Multi Modal Presentation in Virtual Telemedical Environments*", High-Performance Computing and Networking, Proceedings Lecture Notes In Computer Science 1593, pp. 964-972, 1999.

G.C. Ray, A.Y. Kaplan, E. Jovanov, "*Homeostatic Change in the Genesis of ECG During Yogic Breathing*", Journal of the Institution of Engineers (India), Vol. 79, pp. 28-33, March 1999.

E. Jovanov, D. Starcevic, V. Radivojevic, A. Samardzic, V. Simeunovic, "*Perceptualization of biomedical data*", IEEE Engineering in Medicine and Biology Magazine, Vol 18, No. 1, pp. 50-55, 1999.

E. Jovanov, V. Vracar, A. Lazic, R. Dupalo, "*A Prototype Glass Viscosity Measurement System*", Glass Machinery Plants & Accessories, Issue 3, pp. 123-127, 1998.

D. Simic, D. Starcevic, E. Jovanov, "*Guaranteed Single Disk Access for Very Large Database Files*," Yugoslav Journal of Operations Research, Vol. 7, No. 1, pp. 65-78, 1997.

D. Starcevic, E. Jovanov, "*Large File Operations Support Using Order Preserving Perfect Hashing Functions*," Yugoslav Journal of Operations Research, Vol. 3, No. 2, pp. 1-18, 1993.

E. Jovanov, T. Aleksic, Z. Stojkov, D. Starcevic, "*A Sorting Processor for Microcomputers*", Microprocessing and Microprogramming, Vol. 23, No 1-5, pp. 273-278, 1988.

Submitted

Emil Jovanov, Dejan Raskovic, John Price, *"Patient Monitoring Using Personal Area Network of Wireless Intelligent Sensors,"* submitted to IEEE Transactions on Information Technology in Biomedicine, 2001.

C.D. Bagwell, J.S. Jackson, E. Jovanov, *"A Survey of Power Aware Resource Management Support in Existing Operating Systems and Micro Kernels,"* The 8th IEEE Real-Time and Embedded Technology and Applications Symposium, San Jose, California, September 2002.

J.S. Jackson, C.D. Bagwell, E. Jovanov, *"A Survey of System Level Dynamic Power Management Policies for Very Low-Power Mobile Computers,"* The 8th The Eighth Annual International Conference on Mobile Computing and Networking MobiCom 2002, Atlanta, Georgia, September 2002.

P.S. Kerr, M. Oni, E. Jovanov, *"Approximating the Head-Related Transfer Function to Meet Portable Computing Requirements,"* IASTED International Conference on Signal and Image Processing SIP 2002, Kauai, Hawaii, August 2002.

Books, Chapters in Books

E. Jovanov, D. Starcevic, V. Radivojevic, "*Perceptualization of Biomedical Data*", chapter in Akay, M., Marsh, A., Eds, "*Information Technologies in Medicine, Volume I: Medical Simulation and Education*", John Wiley and Sons, 2001.

D. Starcevic, E. Jovanov, V. Radivojevic, Z. Obrenovic, A. Samardzic, "Virtual medical devices for telemedical applications", in P. Spasic, I. Milosavljevic, M. Jancic-Zguricas, Eds., "*Telemedicine*", Academy of Medical Sciences of Serbian Medical Association, Belgrade, Yugoslavi, pp. 218-244, 2000.

E. Jovanov, "On methodology of EEG analysis during altered states of consciousness", in D. Rakovic, D. Koruga, Eds., "*Consciousness: Challenge of the 21st century science and technology*", ECPD, Belgrade, Yugoslavia, 1995., also on
http://www.vxm.com/21R.94.html

E. Jovanov, D. Starcevic, A. Marsh, Z. Obrenovic, V. Radivojevic, A. Samardzic, "*Multi modal presentation in virtual telemedical environments*", High-Performance Computing and Networking, Proceedings Lecture Notes In Computer Science, 1593: 964-972 1999.

Ph.D. Dissertation: E. Jovanov, "*The Architecture of Accelerator for Database Operations*", School of Electrical Engineering, University of Belgrade, Belgrade, Yugoslavia, 1993.

Yugoslav magazines:

A. Samardzic, E. Jovanov, D. Starcevic, "*A System for Visualization of Brain Electrical Activity*", Info Science, 4/97, str. 32-36, 1997.

E. Jovanov, "*Medical Multimedia Systems*", Info Science, 1/97, pp. 27-32, 1997.

A. Samardzic, E. Jovanov, D. Starcevic, "*An Example of Topographic Mapping of EEG Activity*", Info, 5/96, pp. 22-25, 1996.

A. Samardzic, D. Starcevic, E. Jovanov, V. Majstorovic, M. Rakic, B. Buric; "*Realistic head-model development*", Info, 3/96, pp. 19-24, 1996.

A. Samardzic, D. Starcevic, E. Jovanov, "*Digital Video Compression*", Info, 1/96, pp. 29-34, 1996.

Conference Proceedings:

E. Jovanov, A. O'Donnel, A. Morgan, B. Priddy, R. Hormigo, "Prolonged Telemetric Monitoring Of Heart Rate Variability Using Wireless Intelligent Sensors And A Mobile Gateway," 2nd Joint EMBS-BMES, Houston, Texas, October 2002.

D. Starcevic, Z. Obrenovic, E. Jovanov, V. Radivojevic, "Implementation of Virtual Medical Devices in Internet and Wireless Cellular Networks," 1st IFIP Workshop on Internet Technologies, Applications and Societal Impact, Wroclaw, Poland, October 2002.

L. Collier, E. Jovanov, "A Prototype Emotion-Sensing Human-Computer Interface Device for PDA's," 11th World Congress of Psychophysiology, Montreal, Canada, July 2002.

K.G. LeSueur, E. Jovanov, A. Milenkovic, "Lookup Table Based Real-Time Non-Uniformity Correction Of Infrared Scene Projectors," June 2002.

D. Starcevic, Z. Obrenovic, E. Jovanov, V. Radivojevic, "Virtual Medical Devices in Internet and Wireless Cellular Networks," 6th Balkan Conference on Operational Research, Thesaloniki, Greece, May 2002.

A.G. Volkov, E. Jovanov, "Electrical Signaling in Green Plants: Action Potentials," 16th Biennial International EURASIP Conference Biosignal, Brno, Czech Republic, June 2002.

A.G. Volkov, J. Mwesigwa, E. Jovanov, A. Labady, D'J. Thomas, K. Lewis, T. Shvetsova, "Acid Rain Induces Action Potentials in Green Plants," The 4th International Workshop On Biosignal Interpretation, Como, Italy, June 2002.

B. Priddy, E. Jovanov, "Wireless Distributed Data Acquisition System," The 34th Southeastern Symposium on System Theory (SSST2002), Huntsville, Alabama, pp. 463-466, 2002.

M. Milenkovic, E. Jovanov, J. Chapman, D. Raskovic, J. Price, "An Accelerometer-Based Physical Rehabilitation System," The 34th Southeastern Symposium on System Theory (SSST2002), Huntsville, Alabama, pp. 57-60, 2002.

C.D. Bagwell, E. Jovanov, J.H. Kulick, "A Dynamic Power Profiling of Embedded Computer Systems," The 34th Southeastern Symposium on System Theory (SSST2002), Huntsville, Alabama, pp. 15-19, 2002.

D. Corley, E. Jovanov, "A low power intelligent video-processing sensor," The 34th Southeastern Symposium on System Theory (SSST2002), Huntsville, Alabama, pp. 176-178, 2002.

E. Jovanov, "*Distributed Signal Processing in a Wireless Network of Intelligent Sensors*," 2001 Young Faculty Research Proceedings, The University of Alabama in Huntsville, pp. 59-65, 2001.

J. Kim, E. Jovanov, "*Biomedical Applications of Ultra Wide Band Personal Area Networks,*" ISPACS'2001 the 9th International Symposium on Intelligent Signal Processing and Communications Systems, Nashville, Tennessee, November 2001.

D. Raskovic, E. Jovanov, K. Kavi, "*Hierarchical Digital Signal Processing,*" ISPACS'2001 the 9th International Symposium on Intelligent Signal Processing and Communications Systems, Nashville, Tennessee, November 2001.

E. Jovanov, D. Raskovic, J. Price, A. Moore, J. Chapman, A. Krishnamurthy, "*Patient Monitoring Using Personal Area Networks of Wireless Intelligent Sensors,*" Biomedical Sciences Instrumentation Vol. 37, Proc. 38th Annual Rocky Mountain Bioengineering Symposium, April 2001, Copper Mountain, pp. 373-378, 2001.

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel.
Photocopy this page or follow this format for each person.

NAME	POSITION TITLE
Frank Andrasik, Ph.D.	Senior Research Scientist/Professor, Psychology

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training).

INSTITUTION(S) AND LOCATION	DEGREE(S) (if applicable)	YEAR(S)	FIELD(S) OF STUDY
Wright State University, Dayton, OH	B.A.	1971	Psychology
Ohio University, Athens, OH	M.S.	1973	Experimental Psychology
University of Pittsburgh School of Medicine, PA	——	1978-1979	Clinical Psychology Intern
Ohio University, Athens, OH	Ph.D.	1979	Clinical Psychology

RESEARCH AND PROFESSIONAL EXPERIENCE:

Positions

Associate Professor (9/83 to 4/86), Assistant Professor (9/79 to 8/83), Associate Director, Center for Stress and Anxiety Disorders (9/82 to 4/86), Department of Psychology, SUNYA, Albany, NY.

Research Associate Professor (1/84 to 4/86), Department of Neurology, Adjunct Associate Professor (5/83 to 5/88), Department of Family Practice, Albany Medical College, Albany, NY.

Associate Director, Pain Therapy Centers, Greenville Hospital System, Greenville, SC, 4/86 to 6/87.

Senior Research Scientist, Institute for Human and Machine Cognition (10/99 to present), Associate Vice Provost for Graduate Studies (6/98 to 9/99), Professor, Psychology (7/87 to present), Director of

Graduate Studies, Psychology (7/87 to 6/98), Chair, Psychology (8/89 to 5/90), Director, Behavioral
Medicine Laboratory (5/89 to present), University of West Florida, Pensacola, FL.

Research Grants

Principal Investigator, "Assessment and Treatment of Childhood Headache," NINCDS, NS-16891,
$220,852, 3 years, awarded 1/82.

Principal Investigator, Research Career Development Award, "Bio-Psychological Aspects of Headache in Children," NINCDS, NS-00818, $238,542, 5 years, awarded 9/83.

Principal Investigator, "Drug and Non-Drug Treatment for Adult & Pediatric Migraine," NINDS, NS-29855, $796,467, 4 years, awarded 9/92.

Co-Investigator, "Psychological Treatment of Headache," NINCDS, NS-15235, $245,399, 3 years,
awarded 6/79, renewed 3 years, 6/82, $275,585.

Co-Investigator, "Biobehavioral Approaches to the Treatment of Hypertension," NHLBI, NL-27622,
$409,968, 3 years, awarded 8/81.

Co-Investigator, "Biofeedback for Pain: A Multipractitioner Outcome Study." Office of Alternative
Medicine, RR- 09365, $30,000, 1 year, awarded 2/94.

Co-Investigator, "Electro-Therapeutic Pain Blocking Splints & Bandages," NIDA, DA-11845, $750,000,
2 years, awarded, 97.

Grant Reviewing

Member: Risk, Prevention and Health Behavior-3 Study Section, NIH, 1999; Behavioral Medicine Study
Section, NIH, 1997-1999; Life & Biomedical Sciences Review Panel, NASA/AIBS, July, 1994, July,
1995; Special Emphasis Panels, NIH, July, 1993, June, 1994, October, 1994, December, 1995,
November, 1997, August, 1998.

Ad Hoc Reviewer: Psychosocial and Biobehavioral Treatment Subcommittee (TDAA), NIMH, October,
1981; Psychopathology Subcommittee, NIMH, January, 1984; Epidemiology and Disease Control
Study Section, NIH, May, 1984, May, 1985; Psychopharmacological, Biological, and Physical
Treatments Subcommittee (TDAB), NIMH, June, 1985; Collaborative Research Grants Programme,
NATO, April, 1986; Mental Health AIDS and Immunology Review Committee, NIMH, November,
1993; Neurology A Study Section, NIH, December, 1993.

Select Editorial and Professional Appointments and Honors

Editor, Applied Psychophysiology and Biofeedback (formerly Biofeedback and Self-Regulation), 1995-

present.
Editor, Behavior Therapy, 1996-1998.
Associate Editor, Behavior Therapy, 1984-1986, 1995
Associate Editor, Biofeedback and Self-Regulation, 1991 to 1994.
President, Association for Applied Psychophysiology and Biofeedback (AAPB), 1993-1994.
Merit Award for Long-Term Research and/or Clinical Achievements, AAPB, 1992.
Distinguished Scientist Award, AAPB, 2002.
Citation Paper Awards, AAPB, 1984, 1994, 1996, 2000.

Journal Articles, Chapters, and Texts (selected from 160 articles/chapters and 3 texts)

Schwartz, M.J., & **Andrasik, F.** (in press). Biofeedback: A practitioner's guide (3rd ed.) NY: Guilford.

McLeod, M.S., **Andrasik, F.**, Packard, R.C., & Miller, B.D. (in press). Cold room air inhalation to abort cluster headaches: An exploratory study. Journal of Headache and Pain.

Grazzi, L., **Andrasik, F.**, D'Amico, D., Leone, M., Usai, S., Kass, S.J., & Bussone, G. (in press). Behavioral and pharmacological treatment of drug-induced daily headache: Outcome at three years. Headache.

Andrasik, F., & Walch, S.E. (in press). Biobehavioral assessment and treatment of recurrent headaches. In A.M. Nezu, C.M. Nezu, & P.A. Geller (Eds.), Comprehensive handbook of psychology, Volume 9: Health psychology. NY: Wiley.

Andrasik, F., & Flor, H. (in press). Biofeedback. In H. Breivik & C. Eccleston (Eds.), Clinical pain management: Treatment. London: Arnold Publishers.

Larsson, B., **& Andrasik, F.** (2002). Relaxation treatment of recurrent headaches in children and adolescents. In V. Guidetti, G. Russell, M. Sillanpää, & P. Winner (Eds.), Headaches and migraine in childhood and adolescence (pp. 307-316). London: Martin Dunitz.

Andrasik, F., Larsson, B., & Grazzi, L. (2002). Biofeedback treatment of recurrent headaches in children and adolescents. In V. Guidetti, G. Russell, M. Sillanpää, & P. Winner (Eds.), Headaches and migraine in childhood and adolescence (pp. 317-332). London: Martin Dunitz. [To be translated for a text in Russian, edited by M. Shtark & M.S. Schwartz.]

Andrasik, F. (2001). Assessment of patients with headaches. In D.C. Turk & R. Melzack (Eds.), Handbook of pain assessment (2nd ed.; pp. 454-474). NY: Guilford Press.

Grazzi, L., **Andrasik, F.,** D'Amico, D., Leone, M., Moschiano, F., & Bussone, G. (2001). Electromyographic biofeedback-assisted relaxation training in juvenile episodic tension-type headache: Clinical outcome at three-year follow-up. Cephalalgia, 21, 793-803.

Andrasik, F. (2001). Migraine and quality of life: Psychological considerations. Journal of Headache and Pain, 2, S1-S9.

Folen, R.A., James, L.C., Earles, J.E., & **Andrasik, F.** (2001). Biofeedback via telehealth: A new frontier for applied psychophysiology. Applied Psychophysiology and Biofeedback, 26, 195-204.

Andrasik, F. (2000). Biofeedback. In D.I. Mostofsky & D.H. Barlow (Eds.), The management of stress and anxiety in medical disorders (pp. 66-83). Needham Heights, MA: Allyn & Bacon.

Andrasik, F., & Passchier, J. (2000). Psychological mechanisms of tension-type headache. In J. Olesen, P. Tfelt-Hansen, & K.M.A. Welch (Eds.). The headaches (2nd ed.; pp. 599-603). Philadelphia: Lippincott Williams & Wilkins.

McGrady, A.V., **Andrasik, F.**, et al. (1999). Psychophysiologic therapy for chronic headache in primary care. Primary Care Companion for Journal of Clinical Psychiatry, 1, 96-102.

Andrasik, F., Otis, J., Turner, B., & Simon, M.A. (1999). Research methods in health psychology. In M.A. Simon (Ed.), Manual de psicologia de la salud: Fundamentos, metodologia y aplicaciones (pp. 259-306). Madrid, Spain: Biblioteca Nueva.

Bussone, G., Grazzi, L., D'Amico, D., Leone, M., & **Andrasik, F.** (1998). Biofeedback-assisted relaxation training for young adolescents with tension-type headache: A controlled study. Cephalalgia, 18, 463-467.

Billiot, K.M., Budzynski, T.H., & **Andrasik, F.** (1997). EEG patterns and chronic fatigue syndrome. Journal of Neurotherapy, 2, 20-30.

Haddock, C.K., Rowan, A.B., **Andrasik, F.**, Wilson, P.G., Talcott, G.W., & Stein, R.J. (1997). Home-based behavioral treatments for chronic benign headache: A meta-analysis of controlled trials. Cephalalgia, 17, 113-118.

Napier, D., Miller, C., & **Andrasik, F.** (1997). Group treatment for recurrent headache. Advances in Medical Psychotherapy, 9, 21-31.

Andrasik, F. (1996). Behavioral management of migraine. Biomedicine & Pharmacotherapy, 50, 52-57.

Rowan, A.B., & **Andrasik, F.** (1996). Efficacy and cost-effectiveness of minimal therapist contact treatments of chronic headaches: A review. Behavior Therapy, 27, 207-234.

Otis, J.D., Rasey, H.W., Vrochopoulos, S., Wincze, J.P., & **Andrasik, F.** (1995). Temperature acquisition as a function of the computer-based biofeedback system utilized: An exploratory analysis. Biofeedback and Self-Regulation, 20, 183-188.

Andrasik, F. (1995). The role of behavioral techniques in the treatment of migraine. Japanese Journal of Biofeedback Research, 22, 14-18.

Andrasik, F., & Wincze, J.P. (1994). Emotional and psychosocial aspects of mild head injury. Seminars in Neurology, 14, 60-66.

Ham, L.P., **Andrasik, F.**, Packard, R.C., & Bundrick, C.M. (1994). Psychopathology in individuals with post-traumatic headaches and other pain types. Cephalalgia, 14, 118-126.

Andrasik, F. (1994). Twenty-five years of progress: Twenty-five more? (Presidential Address). Biofeedback and Self-Regulation, 19, 311-324.

Andrasik, F., & Gerber, W.D. (1993). Relaxation, biofeedback, and stress-coping therapies. In J. Olesen, P. Tfelt-Hansen, & K.M.A. Welch (Eds.), The headaches (pp. 833-841). NY: Raven.

Passchier, J., & **Andrasik, F.** (1993). Psychological factors. In J. Olesen, P. Tfelt-Hansen, & K.M.A. Welch (Eds.), The headaches (pp. 233-240). NY: Raven.

Andrasik, F., & Passchier, J. (1993). Psychological aspects. In J. Olesen, P. Tfelt-Hansen, & K.M.A. Welch (Eds.), The headaches (pp. 489-492). NY: Raven.

Oyama, O.N., & **Andrasik, F.** (1992). Behavioral strategies in the prevention of disease. In S.M. Turner, K.S. Calhoun, & H.E. Adams (Eds.), Handbook of clinical behavior therapy (2nd ed., pp. 397-413). NY: Wiley.

Gagnon, D.J., Hudnall, L., & **Andrasik, F.** (1992). Biofeedback and related procedures in coping with stress. In A.M. La Greca, L.J. Siegel, J.L. Wallander, & C.E. Walker (Eds.), Stress and coping in child health (pp. 303-326). NY: Guilford.

Andrasik, F. (1992). Assessment of patients with headaches. In D.C. Turk & R. Melzack (Eds.), Handbook of pain assessment (2nd ed., pp. 344-361). NY: Guilford.

Andrasik, F. (1991). Aging and self-regulation: An introduction and overview. Biofeedback and Self-Regulation, 16, 333-336.

Blanchard, E.B., Appelbaum, K.A., Radnitz, C.L., Michultka, D., Morrill, B., Kirsch, C., Hillhouse, J., Evans, D.D., Guarnieri, P., Attanasio, V., **Andrasik, F.**, Jaccard, J., & Dentinger, M.P. (1990). Placebo-controlled evaluation of abbreviated progressive muscle relaxation and of relaxation combined with cognitive therapy in the treatment of tension headache. Journal of Consulting and Clinical Psychology, 58, 210-215.

Appelbaum, K.A., Blanchard, E.B., Nicholson, N.L., Radnitz, C., Kirsch, C. Michultka, D., Attanasio, V., **Andrasik, F.**, & Dentinger, M.P. (1990). Controlled evaluation of the addition of cognitive strategies to a home-based relaxation protocol for tension headache. Behavior Therapy, 21, 293-303.

McCarran, M.S., & **Andrasik, F.** (1990). Behavioral weight-loss for multiply-handicapped adults: Assessing caretaker involvement and measures of behavior change. Addictive Behaviors, 15, 13-20.

Andrasik, F., Oyama, O.N., & Packard, R.C. (1990). Biofeedback therapy for migraine. In S. Diamond (Ed.), Migraine headache prevention and management (pp. 213-238). NY: Marcel Dekker.

Waggoner, C.D., & **Andrasik, F.** (1990). Behavioral assessment and treatment of recurrent headache. In T.W. Miller (Ed.), Chronic pain (Vol. 1, pp. 319-361). Madison, CT: International Universities Press.

Andrasik, F. (1990). Psychological and behavioral aspects of chronic headache. In N.T. Mathew (Ed.), Advances in headache: Neurologic clinics (Vol 8, pp. 961-976). Philadelphia: W.B. Saunders.

Night Imaging and Threat Evaluation Laboratory Instructor: Awarded by Air Force Research Laboratory/Marine Air Weapons and Tactics Squadron One, May 1998.
Hyperbaric Medical Officer: Awarded by the Naval Diving and Salvage Training Center, August 1996.
Aviation Safety Officer: Awarded by the Naval Postgraduate School, February 1999.
Master Training Specialist: Awarded by the Naval Operational Medicine Institute, December 1998.
Contracting Officer Representative: Awarded by the Fleet Industrial Supply Center, San Diego, CA, December 1996.

Publications

Cocaine Alters Myosin Isoform Expression In the Rat Soleus. (1995), **Prevost MC**, Nelson AG, Kelly KP, Han DH, and Conlee RK, *Journal of Applied Physiology*, 79 (2): 514-517.

Creatine Supplementation Enhances Intermittent Work Performance. (1997), **Prevost MC**, Nelson AG, Morris, GS, *Research Quarterly for Exercise and Sport*, 68 (3): 233-240.

Myosin Isoenzyme Distribution in Striated Muscle of Cocaine-Conditioned Rats. (1995), Morris GS, **Prevost MC**, Nelson AG, Kelly KP, Han DH, and Conlee RK, *Research Communications in Alcohol and substances of Abuse*, 16(3): 133-143.

Moderate Diabetes Alters Myosin Isoenzyme Distribution in Cardiac But Not Skeletal Muscle of Male Rats. (1996), Morris GS, **Prevost MC**, Nelson AG, *Life Sciences*, 58: 833-83.

Effects of Caffeine Ingestions on Endurance Racing in Heat and Humidity. (1996) Cohen BS, Nelson AG, **Prevost MC**, Thompson GD, Marx BD, Morris GD, *European Journal of Applied Physiology*, 73: 358-363.

The Effect of Two Days of Velocity-Specific Isokinetic Training on Torque Production. (1999) **Prevost MC**, Nelson AG, and Maraj BK, *Journal of Strength and Conditioning Research*, 13(1), 35-39.

Presentations

The Effects of Caffeine Consumption Upon Performance While Running the Heat and Humidity.
Cohen BS, Nelson AG, **Prevost MC**, Thompson GD, Southeast ACSM, Greensboro, NC, January 1994.

Effect of Continuous Caffeine Intake on Prolonged Exercise to Exahustion. Cohen BS, Nelson AG, **Prevost MC**, Southwest ACSM, San Diego, CA, November 1995.

Cocaine Affects Myosin Isoform Expression in the Rat Soleus (1993), **Prevost MC**, Nelson AG, Kelly KP, Han DH, Conlee RK, FASEB J. A:226.

Cocaine and Cardiac Isomyosin Distribution (1994), Nelson AG, **Prevost MC**, Morris GS, Kelly KP,
Han DH, Conlee RK, *Medicine and Science in Sports and Exercise* 26:5, p. 69.

Three Days of Practice Improves Peak Torque at a Fast but Not at a Slow Velocity of Contraction,
Nelson AG, **Prevost MC**, (1997), Southeast ACSM (Top 30 Abstract).

Night Imaging and Threat Evaluation Laboratory Instructor: Awarded by Air Force Research Laboratory/Marine Air Weapons and Tactics Squadron One, May 1998.
Hyperbaric Medical Officer: Awarded by the Naval Diving and Salvage Training Center, August 1996.
Aviation Safety Officer: Awarded by the Naval Postgraduate School, February 1999.
Master Training Specialist: Awarded by the Naval Operational Medicine Institute, December 1998.
Contracting Officer Representative: Awarded by the Fleet Industrial Supply Center, San Diego, CA, December 1996.

Publications

Cocaine Alters Myosin Isoform Expression In the Rat Soleus. (1995), **Prevost MC**, Nelson AG, Kelly KP, Han DH, and Conlee RK, *Journal of Applied Physiology*, 79 (2): 514-517.

Creatine Supplementation Enhances Intermittent Work Performance. (1997), **Prevost MC**, Nelson AG, Morris, GS, *Research Quarterly for Exercise and Sport*, 68 (3): 233-240.

Myosin Isoenzyme Distribution in Striated Muscle of Cocaine-Conditioned Rats. (1995), Morris GS, **Prevost MC**, Nelson AG, Kelly KP, Han DH, and Conlee RK, *Research Communications in Alcohol and substances of Abuse*, 16(3): 133-143.

Moderate Diabetes Alters Myosin Isoenzyme Distribution in Cardiac But Not Skeletal Muscle of Male Rats. (1996), Morris GS, **Prevost MC**, Nelson AG, *Life Sciences*, 58: 833-83.

Effects of Caffeine Ingestions on Endurance Racing in Heat and Humidity. (1996) Cohen BS, Nelson AG, **Prevost MC**, Thompson GD, Marx BD, Morris GD, *European Journal of Applied Physiology*, 73: 358-363.

The Effect of Two Days of Velocity-Specific Isokinetic Training on Torque Production. (1999) **Prevost MC**, Nelson AG, and Maraj BK, *Journal of Strength and Conditioning Research*, 13(1), 35-39.

Presentations

The Effects of Caffeine Consumption Upon Performance While Running the Heat and Humidity.
Cohen BS, Nelson AG, **Prevost MC**, Thompson GD, Southeast ACSM, Greensboro, NC, January 1994.

Effect of Continuous Caffeine Intake on Prolonged Exercise to Exahustion. Cohen BS, Nelson AG, **Prevost MC**, Southwest ACSM, San Diego, CA, November 1995.

Cocaine Affects Myosin Isoform Expression in the Rat Soleus (1993), **Prevost MC**, Nelson AG, Kelly KP, Han DH, Conlee RK, FASEB J. A:226.

Cocaine and Cardiac Isomyosin Distribution (1994), Nelson AG, **Prevost MC**, Morris GS, Kelly KP,
Han DH, Conlee RK, *Medicine and Science in Sports and Exercise* 26:5, p. 69.

Three Days of Practice Improves Peak Torque at a Fast but Not at a Slow Velocity of Contraction,
Nelson AG, **Prevost MC**, (1997), Southeast ACSM (Top 30 Abstract).

An Analysis of AV-8B "Harrier" Ejection Injuries (1998) **Prevost MC**, McCormack WP, Annual Meeting of
Aerospace Medical Association, Seattle, WA.

Evaluation of a 10-foot Oxygen Hose Extension for KC-130 Loadmasters (1998) McCormack WP,
Prevost MC, Annual Meeting of the Aerospace Medical Association, Seattle, WA.

Spatial Disorientation Phenomena in Naval Helicopter Pilots, Revisited (2000), **Prevost MC**, Folga RV,
Olmo OJ, Annual Meeting of the Aerospace Medical Association, Houston, TX.

Nutritional Supplement Use in Aircrew, Considerations for the Aerospace Professional (2001)
Prevost MC, Folga RV, Annual Meeting of the Aerospace Medical Association, Reno, NV.

BIOGRAPHICAL SKETCH

Provide the following information for the key personnel.
Photocopy this page or follow this format for each person.

NAME	POSITION TITLE
David J. Blower, Ph.D.	Senior Research Psychologist

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training).

INSTITUTION(S) AND LOCATION	DEGREE(S) (if applicable)	YEAR(S)	FIELD(S) OF STUDY
Ohio State University	B.Sc.	1968	Psychology
Stanford University	Ph.D.	1979	Psychology

RESEARCH AND PROFESSIONAL EXPERIENCE:

Positions

Research Scientist (1995 to 2002), Institute for Human and Machine Cognition, University of West Florida, Pensacola, FL. IPA assignment to Naval Aerospace Medical Research Laboratory.

Senior Research Scientist (1994 to 1995), GEO-CENTERS, Inc., Newton Centre, MA. Consulting work to Naval Aerospace Medical Research Laboratory on Naval personnel selection and classification.

Aerospace Experimental Psychologist (1977 to 1994) in the Medical Service Corps of the US Navy.

1988-1994 Naval Aerospace Medical Research Laboratory, Pensacola, FL. Improved psychological tests for the selection of naval aviators and other operators of complex equipment. Promoted advanced techniques for data analysis and inference.

1985-1988 Naval Training Systems Center, Orlando, FL. Collaborated with University of Central Florida on developing artificial intelligence and computer graphics for F-14 tactics. US Navy representative to NATO Research Study Group on Man-Machine Interaction in Weapons Systems.

1982-1985 Naval Air Development Center, Warminster, PA. Developed knowledge-based software systems using LISP and rule-based pattern-directed approach to assist tactical planners in the airborne military environment.

1977-1982 Naval Aerospace Medical Research Laboratory, Pensacola, FL. Investigated vision problems associated with head-up displays, assisted in the development of a battery of vision tests, wrote computer programs for the statistical analysis of data, and used computer simulation to solve visual stimulus presentation problems.

1976-1977 College of Medicine, Ohio State University, Columbus, OH. Provided statistical consultation to faculty and students on medical research problems..

Teaching and Research assistant while a Ph. D. candidate.(1971 to 1976). Stanford University, Palo Alto, CA.

Counterintelligence agent (1968 to 1971). US Army, West Berlin, Germany.

PUBLICATIONS

Books

An Introduction to Scientific Inference: Vol. I The Bayesian Fundamentals:, Third Millennium Inferencing, Pensacola, FL. 1998 (draft)

An Introduction to Scientific Inference: Vol.II The Maximum Entropy Principle:, Third Millennium Inferencing, Pensacola, FL. 1999 (draft)

An Introduction to Scientific Inference: Vol.III Linear Regression:, Third Millennium Inferencing, Pensacola, FL. 2000 (draft)

Technical Articles

A General Theory of Inference for Personnel Selection and Classification. Monograph for Office of Naval Research and Naval Health Research Center. Core funding project on optimal data analytic techniques to be used in the selection and training of Naval and Marine Corps aviators and other flight crew personnel. Draft version June30, 2002.

A Bayesian Approach to Navy Enlisted Compensation Models. Monograph for Naval Personnel Research Studies and Technology Command project on Bayesian approaches to military compensation issues. Draft version of May 15, 2001.

Race, Gender, and Probability of Success in Naval Aviation Flight Training, NAMRL Technical Report (draft), 2001.

The Statistical Foundation of the Pilot Prediction System, NAMRL Special Report 01-1, 2001.

An Update to the Landing Craft Air Cushion (LCAC) Selection System Prediction Algorithm, NAMRL Special Report 00-3, 2000.

A Cost-Benefit Analysis of the LCAC Selection System, NAMRL Special Report, 2000.

Predicting Primary Flight Grades by Averaging Over Linear Regression Models :Part 1, NAMRL Technical Report-1410, 2000.

Predicting Primary Flight Grades by Averaging Over Linear Regression Models :Part 2, NAMRL Technical Report-1411, 2000.

Statistical Analysis of Isoperformance Issues in Navy Flight Training, NAMRL Technical Report-1408, 2000.

Some General Quantitative Considerations for the Statistical Analysis of Isoperformance Curves, NAMRL Technical Report-1406, 1999.

Selection of Officers for U.S. Naval Aviation Training (co-author), NATO Human Factors and Medicine Panel Workshop, Monterey, CA, 1999.

Analysis of Rejection and Attrition Data from the Landing Craft Air Cushion (LCAC) Selection System, NAMRL Special Report 99-1, 1999.

Monitoring Operational Selection Systems Through Frequency Counts: An Application of Bayesian Predictive Inference, NAMRL Technical Report-1405, 1999.

Probability of Success in Primary Flight Training as a Function of ASTB Scores and API Grades: An Example of the Statistical Inferencing Component of the Pilot Prediction System, NAMRL Technical Report-1404, 1998.

The Effect of Presentation Medium on Pilot Selection Test Battery Scores, NAMRL Technical Report-1400, 1998.

Landing Craft Air Cushion (LCAC) Navigator Selection System: Initial Model Development, NAMRL Technical Report-1399, 1998.
The Development and Initial Validation of the Unmanned Aerial Vehicle (UAV) External Pilot Selection System, NAMRL Technical Report-1398, 1998.

A Quantitative Framework for Conducting Cost-Benefit Analyses of Selection Tests, NAMRL Technical Report-1397, 1997

The Prediction Algorithm for the Landing Craft Air Cushion Vehicle (LCAC) Selection System, NAMRL Technical Report, NAMRL-1395, 1996.

Performance-Based Testing and Success in Naval Advanced Flight Training, NAMRL Technical Report 1378, 1992.

Operational Implementation of a Validated Personnel Selection System for a Landing Craft Air Cushion Vehicle Operators, Proceedings of the 13th Psychology in the Department of Defense, Colorado Springs, CO, 1992.

Using Constraint Satisfaction Networks to Study Aircrew Selection for Advanced Cockpits, NAMRL Special Report 92-1, 1992.

An Evaluation of Performance-Based Tests Designed to Improve Naval Aviation Selection, NAMRL Technical Report 1363, 1991.

Naval Aviation Selection Test Scores and Female Aviator Performance, Proceedings of the 69th AGARD Symposium, Tours, France, April 1990.

An Evaluation of Performance-Based Tests Designed to Predict Success in Primary Flight Training, Proceedings of the 34th Annual Human Factors Society, Orlando, FL, 1990.

Analysis of Naval Aviation Selection Test Data with Non-Linear Models Part I: Parameter Estimation, NAMRL Technical Report, 1990.

Embedded Training and Help: Opportunities for User Support. Proceedings of the NATO Panel VIII Workshop on Computer-Human Interaction in Command and Control, Berchtesgaden, Germany, 1987.

An Educational Animation System Based on Class Inheritance. Proceedings Computer Graphics 87, Orlando, FL, 1987.

A Spreadsheet-Based Visual Language for Freehand Sketching of Complex Motions. Proceedings of the Workshop on Visual Languages, Linkoping, Sweden, 1987.

Expert Systems: A Potential Asset to Maintainability Design. Proceedings of the NATO Defense Research Group Conference, Shrivenham, England, April 1984.

The Maximum Amount of Measurement Error Allowable in Visual Acuity Threshold Estimates. Proceedings of the 1982 meeting of the Aerospace Medical Association, Bal Harbour, FL, May 1982.

Determining Visual Acuity Thresholds: A Simulation Study of Stimulus Presentation Strategies. NAMRL Technical Report 1282, August 1981.

The Bias in the Presentation of Stimuli when the Up-and-Down method is used with Forced Choice Responding. NAMRL Technical Report 1269, July 1980.

Ph.D. DISSERTATION

Investigating Information Processing in a Simple Visual Choice Task with Cortical Evoked Potentials. Ph.D. Dissertation, Stanford University, 1979.