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THESIS

**THE EFFECT OF STRESS INOCULATION ON
SHIP-SIMULATOR TRAINING IN NOVICE SHIP
DRIVERS**

by

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March 2020

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**THE EFFECT OF STRESS INOCULATION ON SHIP-SIMULATOR TRAINING
IN NOVICE SHIP DRIVERS**

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

In the past decade, twelve major mishaps at sea have occurred onboard U.S. Navy (USN) ships, two of which resulted in the combined loss of 17 U.S. Sailors. A comprehensive review of these incidents was conducted and the results were released in November 2017. The findings and action items from the comprehensive review were clear: integrate fatigue and stress management training into Surface Warfare Officer training and enlisted leadership development courses. The goal of this thesis is to start to address these action items, beginning with stress management, to find an effective tool to induce stress during training while driving a ship. This experiment collected data on 50 participants' ship-driving performance while navigating a scenario in a Kongsberg ship-bridge simulator located in the Human Systems Integration (HSI) lab at the Naval Postgraduate School. Physiological data was collected during the participants' time in the lab in order to analyze the effects of stress between three different groups: Control Group, Ice Bucket Group, and Cold-Water Perfusion System Group. Data extracted from the Kongsberg ship-bridge simulator allowed us to analyze standard performance metrics such as accuracy and speed for each ship-driving scenario the participants completed. The results of our analysis will allow us to make recommendations to the Surface Warfare Officer School on stress inoculation training in the context of a maritime domain.

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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Alpha Amylase
BDOC	Basic Division Officer Course
CIC	Combat Information Center
CNAP	Continuous Non-Invasive Arterial Pressure
COVE	Conning Officer Virtual Environment
CPT	Cold Pressor Test
CR	Comprehensive Review
CWPS	Cold Water Perfusion System
DBP	Diastolic Blood Pressure
EDA	Electrodermal Activity
HSI	Human Systems Integration
MAP	Mean Arterial Pressure
NPS	Naval Postgraduate School
OOD	Officer of the Deck
RPP	Rate Pressure Product
SA	Situational Awareness
SBP	Systolic Blood Pressure
SIT	Stress Inoculation Training
SWO	Surface Warfare Officer
SWOS	Surface Warfare Officer School
TA	Task Acquisition

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EXECUTIVE SUMMARY

In the past decade, twelve major mishaps at-sea have occurred onboard U.S. Navy (USN) ships, two of which resulted in the combined loss of 17 U.S. Sailors (US Fleet Forces Command, 2017). A comprehensive review (CR) of these incidents was conducted and noted that “the surface force does not have adequate training on human performance factors including fatigue, diet, and stress management” (US Fleet Forces Command, 2017, p. 42). The CRs recommendations for this finding were to “incorporate fatigue, crew endurance, and stress management into appropriate career milestone Surface Warfare Officer (SWO) training and enlisted leadership courses,” (p. 55) and “develop a plan to deliberately train and assess units under stress and fatigue conditions” (p. 105). The goal of this thesis is to address these action items, beginning with stress management, and to present an effective tool for conducting training under stress while driving a ship. This work is important because it is vital that we find a tool to assist SWOs to better learn and retain their primary function as naval officers: safely driving and navigating warships.

One standardized method for inducing stress in a laboratory setting is the Cold Pressor Test (CPT). A journal article by Schwabe and Schächinger (2018) notes that, in both males and females, analysis shows that CPT leads to increases in stress levels, autonomic arousal, and elevated cortisol levels. Research has concluded that the cold pressor is a highly effective tool to induce stress within the laboratory (Schwabe & Schächinger, 2018). The CPT normally involves the “immersion of a participant’s dominant hand in ice-cold water for a period of time” (Porcelli, 2014, par. 2) in order to induce stress.

The stress-training method used for this experiment was cold water exposure via the CPT. Two types of cold pressors were used in this study: the ice bucket and the Cold Water Perfusion System (CWPS). This experiment introduced the CWPS, which allowed the participant to wear a cold pad that continuously circulated cold water instead of being directly exposed to the ice water with the cold pressor. One goal for this study was to test the effectiveness of the CWPS versus the traditional cold pressor because this method will

be simpler to implement in a standard naval training facility such as the Basic Division Officer's Course (BDOC).

During this experiment, we collected ship-driving performance data from 50 participants while using the Kongsberg ship-bridge simulator. We then analyzed the data from each participants' scenarios using standard performance metrics such as accuracy and time. This thesis focuses on the data from both the control group and the Stressor 1 group (ice-water immersion), while Neill (2020) focuses on the data collected from the control group and the Stressor 2 experimental group, Cold-Water Perfusion System (CWPS).

Although it is difficult to establish significance with the small sample sizes in this experiment, a few insightful discoveries were made that suggest the need for further studies. First, the median systolic blood pressure (SBP) of participants in the ice bucket group increased by 6.4% from their baseline when exposed to the CPT compared to the control group, who received no cold pressor in the first task, whose SBP increased by only 0.77%. The rate pressure product (RPP), which is a product of heart rate (HR) and SBP and measures total work being done by the heart, increased by 16% from the baseline in the ice bucket group and only 9% in the control group. The saliva samples taken from ice bucket participants showed an increase of 20% of the stress hormone cortisol, while the increase from baseline in the control group was negligible. These indications suggest that the ice bucket did, in fact, induce physiological stress in the stress-trained group when compared with the control group.

Second, the analysis of the participants' performance measures showed that the stress-trained group was able to improve their performance by 52%, while the control group improved their performance by only 38%. This difference, while not statistically significant, suggests that when exposed to a significant stressor (both groups were exposed to CPT on the criterion trial), the stress-trained group was able to perform better than the control group. The results indicate that they were able to manage the stress more effectively after receiving the SIT exposure.

Third, the analysis of participants' physiological measures in the final task shows a significant difference between the two groups in heart rate increase from the participants'

baseline heart rate collected at the beginning of the study. In the final task, when all participants were exposed to the ice bucket stressor, the median of the control group's heart rate increase was 18% compared with the stress-trained group whose heart rates increased by only 5% from their baseline in the final task. This finding suggests that the ice bucket group was able to adapt to stress after having been exposed to the ice bucket previously, therefore demonstrating decreased signs of physiological stress when exposed to the cold stressor compared to the control group who had not been stress-trained.

This study began to explore the effects of stress inoculation while training novice ship drivers in a simulator. The results of this analysis suggest that training ship-drivers while inducing stress can help with the retention of training as well as decreasing the body's physical reaction to stress. Our goal is to assist the Surface Warfare Community by providing tools to effectively train SWOs to be safer and more capable warfighters, and through this experiment we have just begun to scratch the surface on the possibilities of stress inoculation training in the maritime environment.

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I. INTRODUCTION

A. PROBLEM STATEMENT

In the past decade, twelve major mishaps at-sea have occurred onboard U.S. Navy (USN) ships, two of which resulted in the combined loss of 17 U.S. Sailors. (US Fleet Forces Command, 2017). After a comprehensive review (CR) of these incidents was conducted, section 3.7.5 (Culture) noted that “the surface force does not have adequate training on human performance factors including fatigue, diet, and stress management” (US Fleet Forces Command, 2017, p. 42). The CRs recommendations for this finding were to “incorporate fatigue, crew endurance, and stress management into appropriate career milestone Surface Warfare Officer (SWO) training and enlisted leadership courses,” (p. 55) and “develop a plan to deliberately train and assess units under stress and fatigue conditions” (p. 105).

Driskell and Johnston (1998) discuss the concept on stress exposure training. They point out that, on modern Navy ships, “the amount and complexity of information that must be processed in a short period of time once a target has been detected is enormous” (p. 191). The amount and intricacy of the information to be processed, excessively high task load of watchstanders, and intense time pressure greatly increases the potential for error. Stress training is a tool that can be used to improve performance in high-stress situations, and is designed to facilitate the teaching of skills that are necessary to perform tasks effectively under stressful conditions (Driskell & Johnston, 1998). This thesis addresses the stress training aspect of the CR’s recommendation by inducing physical stressors during ship-driving training with the goal of skill retention and increased performance on a final criterion task.

B. SCOPE

The findings and action items from the USN Comprehensive Review are clear: “incorporate fatigue, crew endurance, and stress management into appropriate career milestone SWO training and enlisted leadership courses” (US Fleet Forces Command, 2017, p. 55). The goal of this thesis is to address these action items, beginning with stress

management, and to present an effective tool for conducting training under stress while driving a ship.

During this experiment, we collected ship-driving performance data from participants while using the bridge simulator. We then analyzed the data from each participants' scenarios using standard performance metrics such as accuracy and time. This thesis focuses on the data from both the control group and the Stressor 1 group (ice-water immersion), while Neill (2020) focuses on the data collected from the control group and the Stressor 2 experimental group, Cold-Water Perfusion System (CWPS).

The results of our analysis will allow us to make recommendations to the Surface Warfare Officer School (SWOS) on means of inducing stress while training ship-drivers in a simulator.

C. RESEARCH QUESTIONS

- (1) Does the Cold Pressor Test (CPT) induce signs of physiological stress in the stress-trained group compared to the control group?
- (2) Does Stress Inoculation Training (SIT) via a cold pressor improve training retention in a ship-driving simulator?
- (3) Is the cold pressor a feasible tool to be incorporated into the Surface Warfare Officer School (SWOS) ship-driving curriculum?

II. BACKGROUND AND LITERATURE REVIEW

A. COMPREHENSIVE REVIEW

Following the tragic death of the 17 U.S. Sailors in recent ship collisions, the CR published the details leading up to several recent USN ship collisions. The executive summary noted that in today's Navy, "proficiency in seamanship and navigation competes for time and attention with the expanding tactical duties of our naval professionals at sea," (US Fleet Forces Command, 2017). One of the main findings of the CR was in training gaps, especially in the way that both individual watch standers and bridge teams are trained and evaluated on seamanship and navigation skills. The report's primary recommendation to correct weaknesses is to focus on the fundamentals, including basic skills such as seamanship and navigation.

On the USS *John S. McCain* (DDG 56), the CR noted that after receiving an order "to separate the control of steering and thrust to two separate stations, Helm and Lee Helm, ...the Bridge watchstanders unintentionally transferred steering control to the Lee Helm console," (US Fleet Forces Command, 2017, p. 11) which caused the Helmsman to lose control of steering on the bridge. The leading causes of the collision with the ALNIC MC (a 30,000-ton Liberian flagged oil tanker) were found to be leadership's loss of situational awareness (SA) in a heavily trafficked area, followed by a breakdown in communication by the bridge and combat information center (CIC) watchteams and inability to "*take clear and decisive action* to avoid collision when in *extremis*" (US Fleet Forces Command, 2017, p. 13).

In the case of the USS *Fitzgerald's* (DDG 62) collision with the Philippines-flagged commercial container ship ACX CRYSTAL, the officer of the deck (OOD) gave the conning officer several orders, which were delayed because Conning Officer could not make a decision in that moment. The CR uncovered that this collision was caused by an accumulation of failures from leadership and the watchstander's *inability to effectively and deliberately respond* when in *extremis* (US Fleet Forces Command, 2017).

The USS *Lake Chaplain*'s (CG 57) collision with Nam Yang 502 (a fishing vessel with unknown crew size) occurred after the ship "turned in front of the vessel without realizing the risk of collision" (US Fleet Forces Command, 2017, p. 14), and the CR reported that "the Bridge watchteam was slow to react and executed improper and untimely maneuvers in an attempt to avoid collision" (p. 14). The CR noted that the collision occurred because of a "*failure to follow safe navigational practices*" (p. 13) and "take proper actions to avoid collision" (p. 15).

Finally, the CR found the USS *Antietam*'s (CG 54) grounding in January of 2017 was found to be the consequence of the watchteam's inability to keep the ship from heading toward shoal water, poor seamanship during an anchoring evolution, a tardy response by leadership whilst steering into a dangerous situation, and the "watchteams' *inability to provide forceful backup in an extremis situation*" (US Fleet Forces Command, 2017, p. 16).

In all cases, the CR's Summary of Findings and Actions noted that when confronted with a stressful or dangerous situation, watchstanders failed to follow standard navigational procedures, as well as failing at basic tasks such as communicating standard commands (US Fleet Forces Command, 2017).

B. BDOC

The average new SWO ensign attends the Basic Division Officer Course (BDOC) prior to checking onboard their first ship. The structure and duration of BDOC has ebbed and flowed over the years, but the overarching goal remains intact: teaching brand new Junior Officers (JOs) the basics of life onboard a ship and training them to drive and navigate a warship. BDOC emphasizes in-class instruction and uses the Conning Officer Virtual Environment (COVE) ship-driving simulator to model each class of U.S. Navy ship and the potential homeports at which the students could be stationed (Gonzalez, 2012). According to the Naval Education and Training Command (NETC), "COVE allows for the reinforcement of concepts in navigation, seamanship, and ship handling" (Gonzalez, 2012, par. 4).

Following the collisions in 2017 and the subsequent CR, 164 qualified OODs throughout the fleet were evaluated on their seamanship and navigation skills. Only 29 of

those OODs, a mere 17.6%, passed the evaluation (Lagrone, 2018). Shortly thereafter, a new career path was announced for training new SWOs that is expected to be fully in effect by 2021. The new training structure will require SWO ensigns to attend a six-week OOD course in addition to BDOC. The new plan also adds an additional ship handling evaluation for executive officers (XOs) before they are able to move on to command. The goal of the new training plan is to place more emphasis on seamanship training ashore versus the current practice of on-the-job training (OJT) conducted underway (Lagrone, 2018). The idea of placing more emphasis on training JOs on ship driving while in port inherently places a high priority on and expectancy from shore-based ship simulator training.

C. STRESS

One of the behavioral science definitions of stress proposed by Hans Seyle, known as the father of stress, is the “perception of threat, with resulting anxiety discomfort, emotional tension, and difficulty in adjustment” (Fink, 2010, p. 5). Stress has been shown to induce many physiological changes in the body, including increased heart rate and breathing difficulties. It is also known to cause negative cognitive effects including restricted attention span, prolonged reaction times, decreased alertness, and impaired problem solving (Salas & Driskell, 1996). In an *extremis* situation like the ones investigated in the CR, learning how to make clear and controlled decisions while experiencing these symptoms could quite literally be the difference between life and death.

D. STRESS INOCULATION TRAINING (SIT)

In Chapter 8 of the book titled *Making Decisions Under stress: Implications for Individual and Team Training*, Driskell and Johnston (1998) discuss the differences between training and stress training. “The primary goal of training,” they say, “is skill acquisition and retention” (p. 192). They go on to describe how, in general, training is given under conditions that are specifically designed to encourage learning and maximize retention of learned skills. For example, students learning in a quiet classroom who practice what they have learned under unchanging and predictable circumstances. Driskell and Johnston also discuss research conducted by Zakay & Wooler (1984), where they discovered that standard training techniques actually did not help to improve task

performance when those tasks needed to be performed in a stressful environment. These results suggest that the “transfer of training from classroom conditions to operational conditions may be poor when there are no stress-inclusive simulations or training” (Driskell & Johnston, 1998, p. 193).

One standardized method for inducing stress in a laboratory setting is the Cold Pressor Test (CPT). Schwabe and Schächinger (2018) note that, in both males and females, analysis shows that CPT leads to increases in stress levels, autonomic arousal, and elevated cortisol levels (2018). Research has concluded that the cold pressor is a highly effective tool to induce stress within the laboratory (Schwabe & Schächinger, 2018). The CPT normally involves the “immersion of a participant’s dominant hand in ice-cold water for a period of time” (Porcelli, 2014, par. 2) in order to induce stress. Of note, McClernon (2009) used the participant’s dominant foot and achieved the same result.

E. STRESS INOCULATION IN FLIGHT TRAINING

McClernon’s research (2009) focused on SIT in aviation flight training scenarios, with the goals of familiarizing individuals with their own physiological and psychological responses to high stress conditions, decreasing their subjective appraisal of stress, reducing the physiological perturbations caused by stress, and improving performance under conditions of stress.

Thirty participants with no previous flight experience were randomly assigned to either a stress-trained experimental group or a control group (McClernon, 2009). For the SIT groups, flight simulator training and techniques for coping with stress were given while the participant was exposed to the cold pressor. Participants in the control group received the same training without the presence of the cold pressor. All participants were then asked to perform a demanding flying task in a real airplane (Piper Archer aircraft) and were evaluated on their performance. Results from this study found that “stress-trained research participants flew the aircraft more smoothly, as recorded by aircraft telemetry data, and generally better, as recorded by flight instructor evaluations, than did control participants”(McClernon et al., 2011, p. 207). McClernon concluded that “the results of this study indicate that stress training during the acquisition of flight skills may serve to

enhance pilot performance in stressful operational flight and, therefore, might mitigate the contribution of pilot stress to aircraft mishaps” (p. 207).

The purpose of this experiment is to expand on the research conducted by McClernon and colleagues at the Human Systems Integration (HSI) laboratory located at the Naval Postgraduate School (NPS). This study replicates the experimental procedures used by McClernon and applies SIT to ship driving using a bridge simulator.

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III. METHODOLOGY AND EXPERIMENT DESIGN

A. OVERVIEW

The participants were randomly placed into one of three experimental groups: a control group with no cold exposure training, Stressor 1 (foot submerged in ice cold water), and Stressor 2 (CWPS). Participants in this study had no former knowledge of ship driving, so they received basic training on how to drive the ship in the simulator and were given two minutes to practice driving on their own (Simulator Familiarization). After completing Simulator Familiarization, the two SIT groups received a brief training session on relaxation techniques to help them control their breathing, focus attention, and make clear decisions while under stress. Participants received this stress training in the presence of the cold pressor they randomly selected at the beginning of the study. Next, participants performed a basic ship driving scenario (Task Acquisition) in the simulator. The two SIT groups completed Task Acquisition in the presence of either Stressor 1 or Stressor 2, depending on which experimental group they were randomly assigned. The final scenario (Criterion Task) repeated the exact same ship driving scenario the participants completed in Task Acquisition. During the Criterion Task, participants in all three experimental groups completed the ship driving scenario in the presence of Stressor 1 (foot submerged in ice water).

Table 1. Type of Stressor Applied by Task and Experimental Group

	Control Group	Ice-Bucket Group	CWPS Group
Simulator Familiarization	None	None	None
Stress Training	None	Ice Bucket	CWPS
Task Acquisition	None	Ice Bucket	CWPS
Criterion Task	Ice Bucket	Ice Bucket	Ice Bucket

At the end of the study, we analyzed the data to compare the effectiveness of the traditional cold pressor technique against the CWPS. Both stress inoculation groups were

compared to the control group that received no SIT. Specifically, we analyzed the data to find the impact, if any, SIT has on performance in the final ship-driving scenario.

B. APPROACH

The SIT method used for this experiment is cold water exposure via the CPT, or cold pressor. Two types of cold pressors are used in this study, the ice bucket and the Cold-Water Perfusion System (CWPS). This experiment introduces the CWPS, which allows the participant to wear a bladder that continuously circulates ice cold water versus being directly exposed to the ice water with the standard cold pressor. One goal for this study is to test the effectiveness of the CWPS versus the traditional cold pressor because this method will be simpler to implement in a standard naval training facility such as the BDOC.

Effectiveness of the CWPS was determined based on the performance outcomes of the participants in the study. For example, if CWPS participants performed significantly better than control group participants in the Criterion Task, the CWPS was considered effective.

C. EQUIPMENT

1. Kongsberg Simulator

The bridge simulator used for this research was the Kongsberg Polaris Ship bridge simulator (Kongsberg. n.d.). The participant's virtual environment consisted of four visual displays, helm, and throttle controls. The four visual displays included an integrated SPS-79 Radar, panorama view, steering panel, and forward view from bridge of ship. The participant had control of both the helm and throttle controls during the experiment.



Figure 1. Kongsberg Polaris Ship's Bridge Simulator

We developed the unique scenario for this research in order to test the participant's performance based on steering and speed control. The scenario required the participant to navigate a slalom course through a series of smoke floats and oil rigs placed in open water. Other variables, such as weather, sea state, visibility, ship traffic, ship type and capabilities, and location were held constant across all participants. The same scenario file was used for each participant for both the Task Acquisition and Criterion Task. A bird's eye view of the course is shown in Figure 2, below.

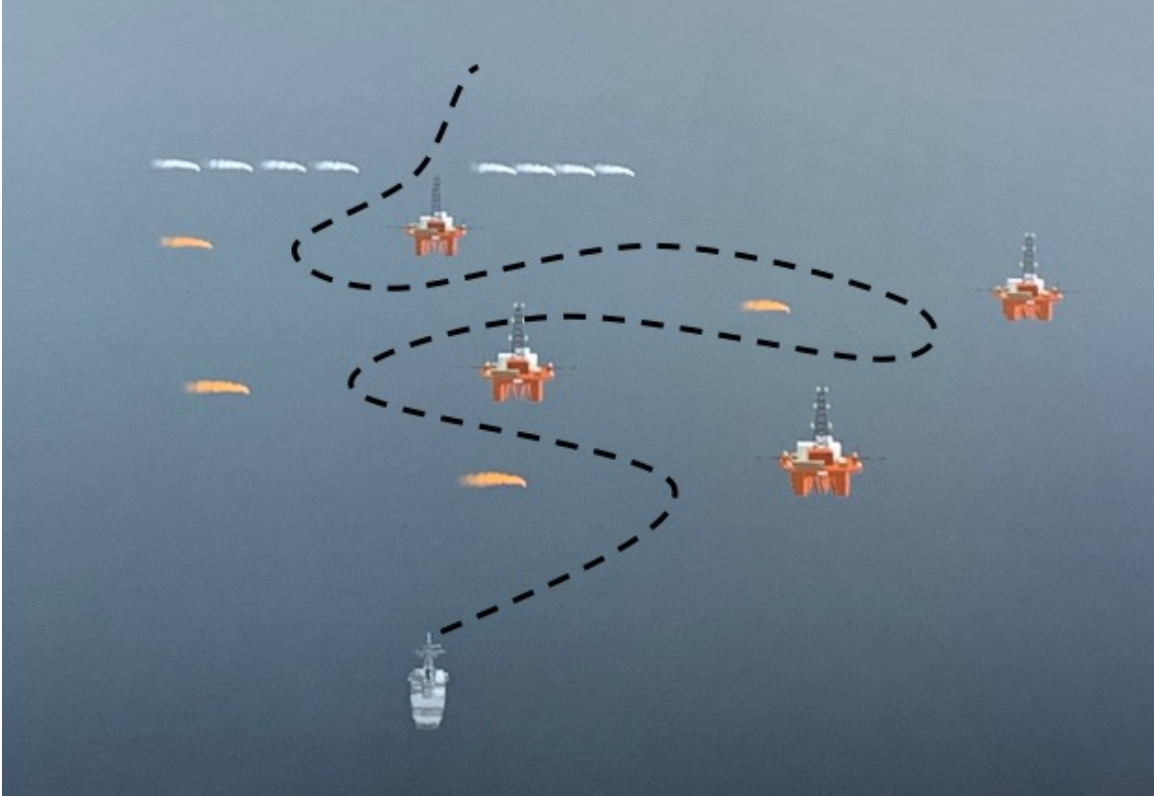


Figure 2. Slalom Course in Kongsberg Ship Bridge Simulator

The data received from the Kongsberg included the ship's latitude and longitude, ship speed, ordered speed, rudder position, rudder order, and heading, all collected in two-second intervals through the entire scenario.

2. BioNomadix Wireless Transmitters

The BioNomadix Wireless Photo Plethysmogram (PPG) and Electrodermal Activity (EDA) Transmitter (BIOPAC Systems, Inc., n.d.) were used to monitor indication of eccrine (skin sweating) activity during each scenario for each participant. We connected the EDA monitor to electrodes placed on the participant's left palm about 1 to 2 inches apart.



Figure 3. EDA Transmitter and Electrode Placement

The BioNomadix Wireless Respiration (RSP) and Electrocardiography (ECG) Transmitter were used to monitor electrical activity generated by the heart. We attached the electrodes to the participant's left and right collarbone, and below their left rib near the hip bone. The electronic signal from both transmitters was transmitted and recorded in the *AcqKnowledge* program. The *AcqKnowledge* software allowed us to view, transform, replay, and analyze data the participant's data.



Figure 4. ECG Transmitter and Electrode Placement



Figure 5. BioNomadix Wireless EDA Transmitter



Figure 6. BioNomadix Wireless ECG Transmitter

3. CNAP Monitor 500

The Continuous Non-Invasive Arterial Pressure (CNAP) Monitor 500 (CNSystems, n.d.) was used to monitor each participant's blood pressure throughout the experiment. The CNAP provided real-time systolic, diastolic, mean blood pressure and pulse rate. Each participant's left arm was stabilized using an adjustable-height table, which was altered so that their arm was at heart level. The CNAP Monitor was directly connected to the *AcqKnowledge* program for instantaneous and synchronized recording along with the EDA and ECG transmitters.



Figure 7. Participant's Left Arm Setup



Figure 8. CNAP Monitor 500

4. Salimetrics Saliva Collection Kit

We collected four saliva samples from each participant. Before and after both the Task Acquisition and Criterion Task, participants provided approximately 1.0 mL of saliva using a Salimetrics collection kit via the passive drool method (Salimetrics, 2018). The samples were collected and stored in a U.S. Scientific Under-Counter Freezer (-86°). We labeled each participant's saliva sample with the participant's ID and pre/post scenario identifier.

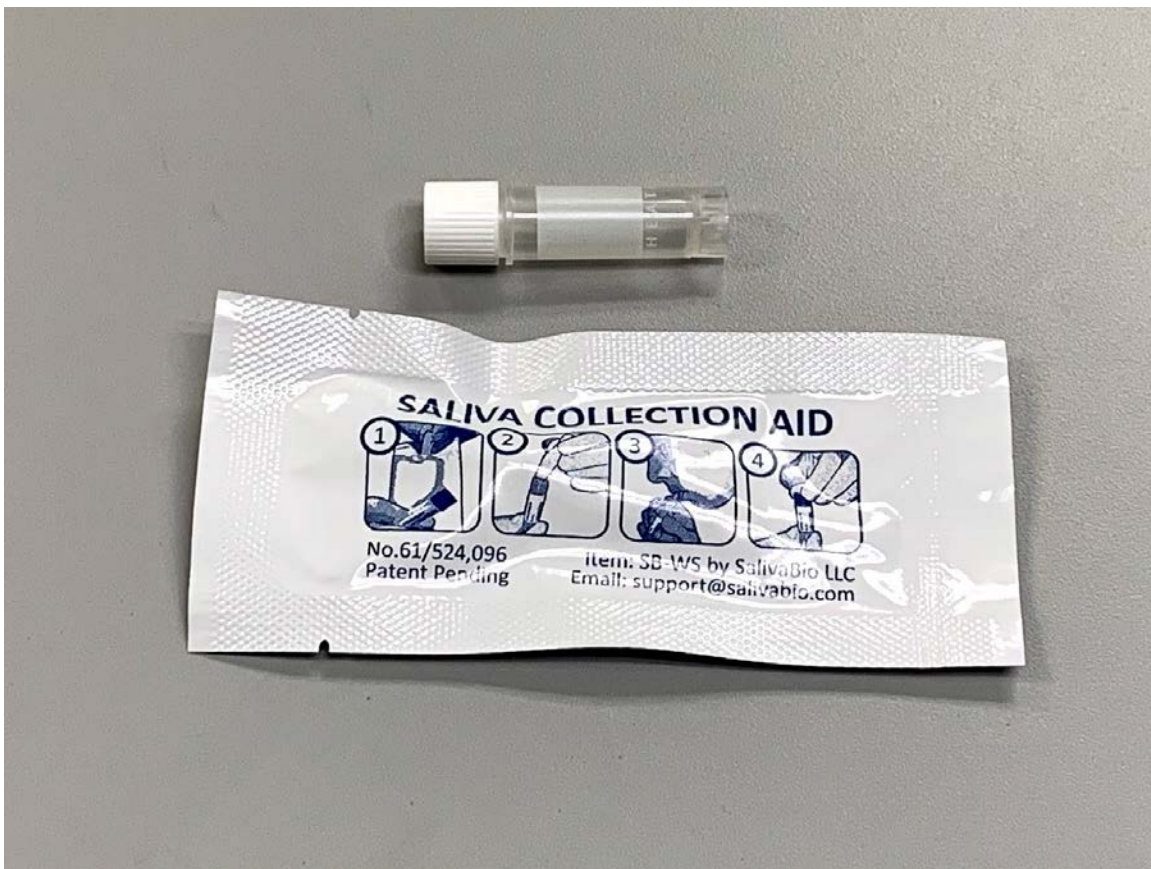


Figure 9. Salimetrics Saliva Collection Aid

5. Noldus Observer

The Noldus Media Recorder was used in order to record each participant's scenarios from three different cameras around the lab. This element of the experiment

allowed us the ability to playback each scenario in order to identify possible behaviors related to particular physiological responses or stressful situations.

The Noldus Observer XT (Noldus, n.d.) is a software package used for the behavioral research that supports the collection, synchronization, analysis, and presentation of data (Noldus, n.d.). The Media Recorder, Acq*Knowledge* data, and Kongsberg data were all uploaded into the Noldus Observer XT, which allowed for synchronized data streams and easily calculated statistics.

6. BREG Polar Care Cube

The BREG Polar Care Cube (Breg, n.d.) was used to provide a cold stressor to the participants in the CWPS experimental group. The Polar Care Cube can provide 6–8 hours of cold therapy by adding ice to the water. In this research, the Multi-Use Wrap was used to apply the cold stressor to the lower back.



Figure 10. BREG Polar Care Cube (CWPS) Applied to Participant's Lower Back

7. Bucket of Ice Water

We used a bucket of ice water to provide a cold stressor in Task Acquisition to participants in the Ice Bucket experiment group, and to all participants in the Criterion Task. The bucket was filled with two inches of water prior to adding ice. Ice was added to the bucket until the temperature of the water was recorded using a thermometer probe of $33 \pm 2^{\circ}\text{F}$.



Figure 11. Ice Bucket Cold Pressor Applied to Participant's Right Foot

8. Microsoft Excel

We wrote a macro using Microsoft Excel in the Visual Basic for Applications (VBA) (Microsoft, n.d.) coding language to transform the data exported from the Kongsberg into an easily imported format for both Noldus and R.

	A	B	C	D	E	F	G	H
1		Ownship	Ownship 1	Ownship 1	Ownship 1	Ownship 1	Ownship 1	Ownship 1
2		Parameter	Heading	Speed	Latitude	Longitude	Rudder order (1)	Rudder (1)
3			deg	kn	deg	deg	deg	deg
4			156	19.9	#DIV/0!	#DIV/0!	s2.2	s2.2
5			0	11.1	0	0	s35.0	s35.0
6			360	30.5	0	0	p35.0	p35.0
7	400	0:06:40	26	30.5	N32°42.715	W117°19.174	s17.8	s13.4
8	398	0:06:38	27	30.3	N32°42.701	W117°19.184	s14.6	s4.5
9	396	0:06:36	29	30.2	N32°42.686	W117°19.194	s1.7	p2.0
10	394	0:06:34	31	30.3	N32°42.672	W117°19.205	s1.6	p10.7
11	392	0:06:32	34	30.3	N32°42.659	W117°19.216	p13.0	p13.0
12	390	0:06:30	37	30.3	N32°42.645	W117°19.229	p13.0	p13.0
13	388	0:06:28	39	30	N32°42.632	W117°19.242	p13.0	p13.0
14	386	0:06:26	39	29.6	N32°42.619	W117°19.253	p13.0	p12.7
15	384	0:06:24	39	29.2	N32°42.606	W117°19.265	p13.0	p6.6
16	382	0:06:22	36	28.9	N32°42.592	W117°19.275	p13.0	s2.9
17	380	0:06:20	33	28.8	N32°42.579	W117°19.284	p13.3	s11.9
18	378	0:06:18	29	29	N32°42.564	W117°19.293	p11.8	s21.4
19	376	0:06:16	25	29	N32°42.550	W117°19.301	p1.2	s26.4
20	374	0:06:14	22	28.6	N32°42.535	W117°19.308	s18.0	s23.6
21	372	0:06:12	21	27.7	N32°42.520	W117°19.315	s29.5	s14.5
22	370	0:06:10	21	26.5	N32°42.507	W117°19.322	s19.3	s5.5
23	368	0:06:08	23	25.3	N32°42.494	W117°19.330	s19.3	p4.0
24	366	0:06:06	26	24.1	N32°42.481	W117°19.337	s18.8	p13.5
25	364	0:06:04	29	22.8	N32°42.470	W117°19.344	s14.6	p21.3
26	362	0:06:02	31	21.1	N32°42.460	W117°19.352	p3.1	p22.3
27	360	0:06:00	31	19.3	N32°42.449	W117°19.358	p26.3	p15.2
28	358	0:05:58	30	17.7	N32°42.441	W117°19.364	p28.1	p6.1
29	356	0:05:56	28	16.1	N32°42.432	W117°19.368	p25.4	s3.3
30	354	0:05:54	25	15.1	N32°42.423	W117°19.371	p10.2	s12.8

Figure 12. Data Exported from Kongsberg Simulator

	A	B	C	D	E	F	G
1	Time	Heading	Speed	R_Order	R_Order_Delta	R_Actual	R_Actual_Delta
2	seconds	degrees	knots	degrees	degrees	degrees	degrees
3	0	0	20	12.7	0	0	0
4	2	0	20	28.6	15.9	5.1	5.1
5	4	0	20.1	30.5	1.9	14.6	9.5
6	6	2	20.3	30.5	0	24	9.4
7	8	4	20.3	13.8	16.7	30.1	6.1
8	10	6	20.3	-3.7	17.5	28.4	1.7
9	12	9	20.3	-20.5	16.8	19.8	8.6
10	14	12	20.2	-34.6	14.1	10.8	9
11	16	15	20.3	-34.6	0	1.3	9.5
12	18	16	20.4	-34.6	0	-8.2	9.5
13	20	17	20.5	-34.6	0	-17.2	9
14	22	17	20.4	-34.5	0.1	-26.7	9.5
15	24	15	20.3	-34.6	0.1	-33.9	7.2
16	26	14	20.2	-17	17.6	-34.4	0.5
17	28	11	20.2	12.9	29.9	-28.7	5.7
18	30	8	20.3	15.1	2.2	-19.2	9.5
19	32	6	20.4	16.1	1	-10.2	9
20	34	3	20.6	16	0.1	-0.7	9.5
21	36	2	21	16.1	0.1	8.8	9.5
22	38	1	21.4	8	8.1	15.7	6.9
23	40	2	21.8	-10.4	18.4	14.7	1
24	42	3	22.2	-14.8	4.4	6.4	8.3
25	44	4	22.5	-2.6	12.2	-3.1	9.5
26	46	5	22.8	0.1	2.7	-8.4	5.3
27	48	4	23	12.7	12.6	-6.3	2.1
28	50	4	23.2	15.5	2.8	2.5	8.8
29	52	4	23.5	12.6	2.9	11.7	9.2
30	54	4	23.6	-4.4	17	14.8	3.1

Figure 13. Kongsberg Data After Running NOLDUS Macro

	A	B	C	D	E	F	G	H	I	J	K
1			degrees	minutes	seconds		degrees	minutes	seconds	Latitude	Longitude
2	0 N		32	40	941 W		117	19	147	32.92805556	117.3575
3	2 N		32	40	953 W		117	19	147	32.93138889	117.3575
4	4 N		32	40	965 W		117	19	147	32.93472222	117.3575
5	6 N		32	40	976 W		117	19	147	32.93777778	117.3575
6	8 N		32	40	987 W		117	19	147	32.94083333	117.3575
7	10 N		32	40	999 W		117	19	147	32.94416667	117.3575
8	12 N		32	41	10 W		117	19	146	32.68611111	117.3572222
9	14 N		32	41	21 W		117	19	144	32.68916667	117.3566667
10	16 N		32	41	32 W		117	19	143	32.69222222	117.3563889
11	18 N		32	41	43 W		117	19	140	32.69527778	117.3555556
12	20 N		32	41	54 W		117	19	137	32.69833333	117.3547222
13	22 N		32	41	65 W		117	19	134	32.70138889	117.3538889
14	24 N		32	41	76 W		117	19	130	32.70444444	117.3527778
15	26 N		32	41	87 W		117	19	126	32.7075	117.3516667
16	28 N		32	41	98 W		117	19	123	32.71055556	117.3508333
17	30 N		32	41	109 W		117	19	120	32.71361111	117.35
18	32 N		32	41	119 W		117	19	117	32.71638889	117.3491667
19	34 N		32	41	131 W		117	19	115	32.71972222	117.3486111
20	36 N		32	41	143 W		117	19	113	32.72305556	117.3480556
21	38 N		32	41	154 W		117	19	112	32.72611111	117.3477778
22	40 N		32	41	166 W		117	19	112	32.72944444	117.3477778
23	42 N		32	41	178 W		117	19	111	32.73277778	117.3475
24	44 N		32	41	191 W		117	19	110	32.73638889	117.3472222
25	46 N		32	41	203 W		117	19	109	32.73972222	117.3469444
26	48 N		32	41	216 W		117	19	108	32.74333333	117.3466667
27	50 N		32	41	228 W		117	19	107	32.74666667	117.3463889
28	52 N		32	41	242 W		117	19	106	32.75055556	117.3461111
29	54 N		32	41	254 W		117	19	105	32.75388889	117.3458333
30	56 N		32	41	268 W		117	19	104	32.75777778	117.3455556

Figure 14. Kongsberg Data After Running R Macro

9. R Studio

The R programming language (R-Project. n.d.) was used to calculate performance metrics for each participant. After the participant's data was transformed using the macros mentioned previously, their data was uploaded into R and compared to a base case scenario. The base case scenario data was obtained by placing waypoints along the slalom course in the Kongsberg simulator that were precisely equidistant between each oil rig and smoke float pair. The ship was placed on autopilot and navigated the course starting at 20 knots (all participants start the course at 20 knots). This latitude and longitude data were extracted from the Kongsberg simulator to create a base case file.

For each point on the base case data track, the closest point (using haversine distance) to the participant's track was calculated, squared, and appended to a vector of

squared distances. These distances were summed and divided by the number of latitude/longitude points in the base case (n) to calculate the mean of the participants' squared errors. This method is how the Mean Squared Error (MSE) for each participant was calculated.

D. PARTICIPANTS

We recruited participants for this study from a pool of NPS students, DOD personnel, military personnel, NPS civilian employees and the general public. The participants had very little to no experience to ship-driving. Basic training conducted in undergraduate commissioning sources was permissible; however, attendance at formal training (such as the BDOC) was not permissible. Pregnant women and individuals under the age of 18 were not recruited for the study. Prior to participation in any research activity, all participants were screened for contraindications to the cold pressor in accordance with the Standard Operating Procedures of the BREG Polar Care Cube Cold Water Perfusion System.

E. EXPERIMENT PROCEDURE

The timeline for the experiment followed the schedule in Table 2 below (adapted from Table 2 of McClermon's dissertation). When participants arrived at the Human Systems Integration Lab (HSIL), they completed the Informed Consent Form and Consent CPT and CWPS (Appendix B). Participants were made aware that they could decline participation at any point during the experiment. They were then given the CA Bill of Rights, Pre-Study Questionnaire, Saliva Sample Collection Notes, and Cohen Stress Scale. The Pre-Study Questionnaire collected demographic information and experience with video games, drones, and any other form of simulator experience. After participants completed their paperwork, we attached all of the physiological equipment and began the experiment.

Table 2. Participant Timeline

Event	Duration
Administrative (Participant Surveys, Informed Consent, etc.)	15 min
Physiological Equipment Hook-up	15 min
Simulator Familiarization video	7 min
Stress Training (for treatment group) or HSI Video	3 min
Break	15 min
Task Acquisition video and task	10 min
Break	15 min
Criterion Task	10 min
Total	90 min

The first part of the experiment design involved training the participant on how to navigate the ship in the simulator. While the participant stood behind the helm, they watched and listened to the Simulator Familiarization training video that taught them how to use the helm, throttles, and information provided from the screens in front of them. They also received an overview of the navigational course and specifics regarding the performance criteria on which they would be graded (Appendix A). Following the training video, the participant took a short quiz in order to test their knowledge of the skills required in the experiment. If the participant had questions, additional instruction was provided to ensure each participant began the experiment with the same level of understanding.

After watching the Simulator Familiarization training video and completing the short quiz, the participant watched another video that differed depending on which experimental group the participant had randomly selected. Both stress training experimental groups watched a 5-minute SIT video while being exposed to the cold stressor

they had randomly selected. This video taught them how to control some of the physiological markers of stress such as heart rate increase, narrowed vision, and distraction from the assigned task. Participants in the control group watched a 5-minute video about the HSI lab which was not related to SIT in order to match the timeline of the experimental groups.

Next, each participant completed Task Acquisition which was their first opportunity to navigate through the scenario. Before beginning the scenario, every participant provided a saliva sample and watched the Task Acquisition training video. Those in the experimental groups either applied the CWPS to their lower back or placed their right foot in a bucket of ice water. Immediately following the scenario, they removed the cold stressor and provided another saliva sample. Each participant was offered a chair and instructed to sit and relax for 15 minutes. This block of time was necessary in order to allow the participant's physiological stress indicators to return to their baseline levels before beginning the Criterion Task.

After 15 minutes of rest, each participant provided another saliva sample and was instructed to stand in front of the helm again. Before the Criterion Task began, participants watched the Criterion Task instruction video, removed their right shoe and sock, and placed their foot in the bucket of ice water. All participants then completed the Criterion Task in the presence of the ice bucket cold stressor. After completing the task, their foot was removed from the ice water and they collected their final saliva sample. As they collected their saliva in the collection tube, we removed the physiological monitoring devices from the participant. This step completed the participant's involvement in the experiment.

We then exported the participant's ship-driving data from the Kongsberg physiological data from the *AcqKnowledge* software. This data was then imported into the Noldus Observation for the participant. The data from the Kongsberg had to be cleaned by a Microsoft Excel macro in order to be in the proper format for upload. The same Kongsberg data was also run through a second Microsoft Excel macro in order transform it into an easily imported format for the R programming language in order to conduct data analysis.

F. VARIABLES

The independent variable in the experiment was the stress-training method (ice-bucket, CWPS, or no stress-training). Performance metrics and physiological measures were dependent variables.

G. PERFORMANCE MEASURE CALCULATIONS

The two performance measures for this experiment are Root Mean Squared Error (RMSE) and Time (Criterion Task completion). The haversine distance formula in R was used to calculate the great-circle distance between each base case coordinate and the closest point on the participant's track. RMSE % Δ was calculated to determine a participants' improvement from TA2 to the Criterion Task. The formulas for RMSE and RMSE % Δ are shown below.

Let $x_1, \dots, x_n = \text{latitude/longitude coordinates of participant}$

and $y_1, \dots, y_m = \text{latitude/longitude coordinates of basecase}$

$$X_{RMSE} = \sqrt{\frac{1}{N} \sum_{i=1}^N \min_{j=1, \dots, m} h(x_i, y_j)^2}$$

where

$$X_{RMSE} = \text{RMSE for participant } X$$

$$N = \text{number of coordinates}$$

$$RMSE \% \Delta = \frac{TA RMSE - \text{Criterion RMSE}}{TA RMSE}$$

Below is an example of the track data from one participant. The track on the left displays the participant's performance during Task Acquisition (TA) and the track on the right displays their performance during the Criterion Task. Each participant's data was graphed in this manner, with their track data exported from the Kongsberg ship-simulator overlaid on the 'perfect scenario' base case data coordinates. This participant was in the Control Group and improved their performance by 25.8% from TA to the Criterion Task.

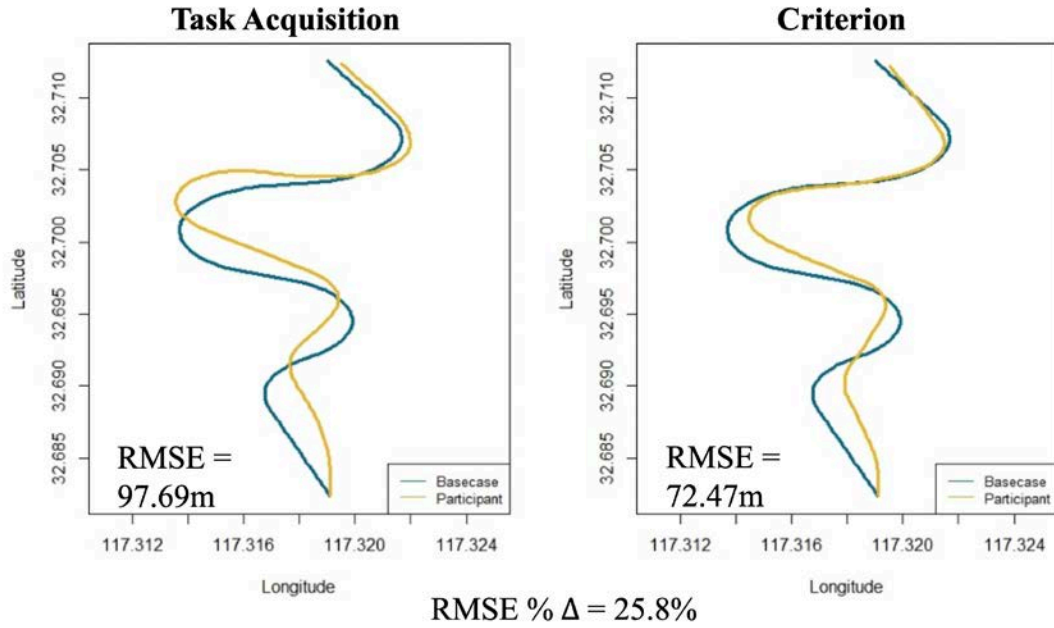


Figure 15. Participant Data Track Example

H. HYPOTHESIS

There are two hypotheses in this experiment which each address a different research question. The first research question attempts to uncover if there are heightened physiological signs of stress in the ice bucket group relative to the control group to determine if the ice bucket induced stress during TA. The physiological measures collected and tested from each participant include heart rate (HR), mean arterial pressure (MAP), systolic blood pressure (SBP), electrodermal activity (EDA), alpha amylase, and cortisol. The rate pressure product (RPP) was calculated by multiplying SBP by HR which represents total work being done by the heart. The hypothesis is as follows:

For each physiological measure m , the average increase of the stress-trained groups' (s) measure from their baseline is larger than the average increase of the control groups' (c) measure from their baseline.

$$H_0: \mu_m^s = \mu_m^c$$

$$H_a: \mu_m^s > \mu_m^c$$

The second research question addresses the accuracy and speed performance metrics calculated from each participants' ship-driving scenario. The metrics collected and tested from each participant include: time to complete the Criterion Task, Criterion MSE, and MSE % Delta, which represents the participant's improvement from the first time they completed the course in Task Acquisition to the second time they completed the task in the Criterion Task. The hypothesis is as follows:

The stress-trained group (*s*) will, on average, perform better than the control group (*c*) for each performance metric *p*.

$$H_0: \mu_p^s = \mu_p^c$$

$$H_a: \mu_p^s > \mu_p^c$$

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IV. RESULTS

A. DID THE ICE BUCKET INDUCE STRESS?

The first analysis included comparing the baseline measurements of the control and treatment groups to make sure that the two groups did not differ at baseline. I plotted the distributions for each baseline measure collected and checked for normality assumptions to determine whether to use parametric or non-parametric methods for statistical analysis.

After plotting the distributions (shown in Appendix F), I used the Wilcoxon Rank Sum method of statistical analysis due to slight skewness, non-normality, and outliers in the data. Table 3 below shows median values and interquartile ranges for the control and ice bucket groups, the Z-statistic, p-value, and effect size.

Table 3. Baseline Physiological Measures

	<i>Control (n=15) Median (IQR)</i>	<i>Ice Bucket (n=14) Median (IQR)</i>	<i>Z statistic</i>	<i>Wilcoxon Rank Sum p-value</i>	<i>Effect Size</i>
HR (bpm)	75.473 (61.675, 80.675)	73.116 (65.518, 79.851)	-0.0655	0.9478	-0.0122
MAP (mmHg)	91.099 (77.859, 107.446)	90.813 (80.331, 104.650)	0.0655	0.9478	0.0122
EDA (μS)	7.569 (3.791, 11.044)	4.396 (3.160, 7.677)	-1.2670	0.2052	-0.2353
SBP (mmHg)	134.437 (108.480, 149.140)	120.956 (102.375, 133.979)	-0.9383	0.3481	-0.1742
RPP (mmHg*HR)	9198.210 (7895.092, 9674.489)	8844.113 (6586.673, 9954.593)	-0.9820	0.3261	-0.1823
DBP (mmHg)	72.819 (65.925, 89.536)	76.671 (62.417, 90.593)	0.2837	0.7767	0.0527
TA2 AA (μg/dL)	89.777 (58.745, 205.689)	77.761 (51.324, 167.206)	-0.7201	.4715	-0.1337
TA2 Cortisol (U/mL)	0.320 (.194, .825)	0.337 (.232, .528)	0.0218	.9826	0.0041
CR AA (μg/dL)	91.840 (54.778, 294.866)	121.032 (40.639, 292.478)	0.1091	0.9131	0.0203
CR Cortisol (U/mL)	0.328 (0.150, 0.513)	0.299 (0.258, 0.760)	0.6111	0.5411	0.1135

As shown in the table, the Baseline EDA effect size is relatively large, suggesting that there is a difference between the two groups in their EDA baselines. All other physiological values are comparable among the two groups.

Next, I compared the physiological data collected in Task Acquisition between the Control Group and the Ice Bucket Group. TA was the only time in the experiment where all three groups completed the slalom course while exposed to different stressors. Before conducting analysis, I plotted the distributions of TA% Delta (relative to each participant's baseline) for each physiological measure to determine which method of statistical analysis to use. The distributions are shown in Appendix F.

After plotting the distributions, I used the Wilcoxon Rank Sum method of statistical analysis due to some skewness, non-normality, and outliers in the data. Table 4 below shows median values and interquartile ranges for the control and ice bucket groups, the Z-statistic, p-value, and effect size.

Table 4. TA % Δ Physiological Measures

	<i>Control (n=15) Median (IQR)</i>	<i>Ice Bucket (n=14) Median (IQR)</i>	<i>Z statistic</i>	<i>Wilcoxon Rank Sum p- value</i>	<i>Effect Size</i>
HR % Δ	0.038 (0.005, 0.100)	0.084 (0.012, 0.135)	0.5455	0.5854	0.1013
MAP % Δ	0.040 (-0.023, 0.282)	0.162 (0.065, 0.215)	0.7371	0.4611	0.1369
EDA % Δ	0.457 (0.039, 0.947)	0.526 (0.212, 1.556)	0.5915	0.5542	0.1098
SBP % Δ	0.008 (-0.112, 0.238)	.064 (0.057, 0.191)	1.3359	0.1816	0.2481
RPP % Δ	0.092 (-0.010, 0.293)	0.161 (0.125, 0.256)	1.5202	0.1285	0.2823
DBP % Δ	0.073 (-0.042, 0.301)	0.184 (0.071, 0.299)	0.4146	0.6784	0.0784
AA % Δ	0.214 (-0.008, 0.341)	0.083 (-0.012, 0.495)	-0.1213	0.9034	-0.0225
Cor % Δ	-0.002 (-0.302, 0.209)	0.195 (-0.279, 0.656)	1.0256	0.3051	0.1905

Although none of these p-values are statistically significant, it is interesting to explore the physiological measures where the effect size suggests there could have been a small effect (SBP % Δ , RPP % Δ , and Cortisol % Δ). The following graphs suggest that there is, in fact, a difference in stress-inducing physiological measures between the ice bucket group and the control group. The following graphs show boxplots of these three physiological measures which compare the control group to the ice bucket group. In all three boxplots, the median of the ice bucket group is higher than the median of the control group. The variance of the participant's data, represented by the whiskers of the box plot, may explain why there are not significant p-values in the data analysis despite relatively large effect sizes and differences in median values.

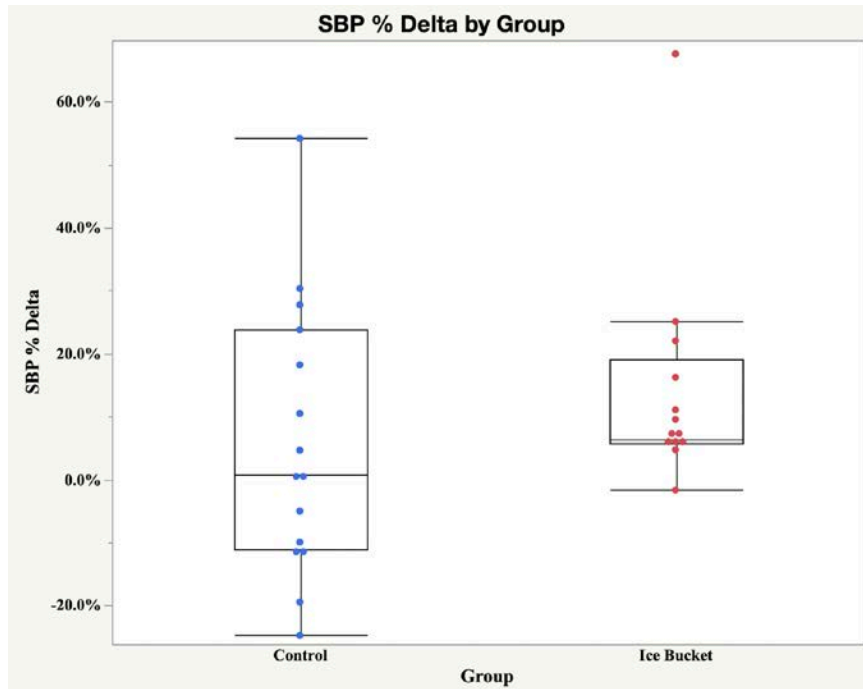


Figure 16. SBP % Delta by Group

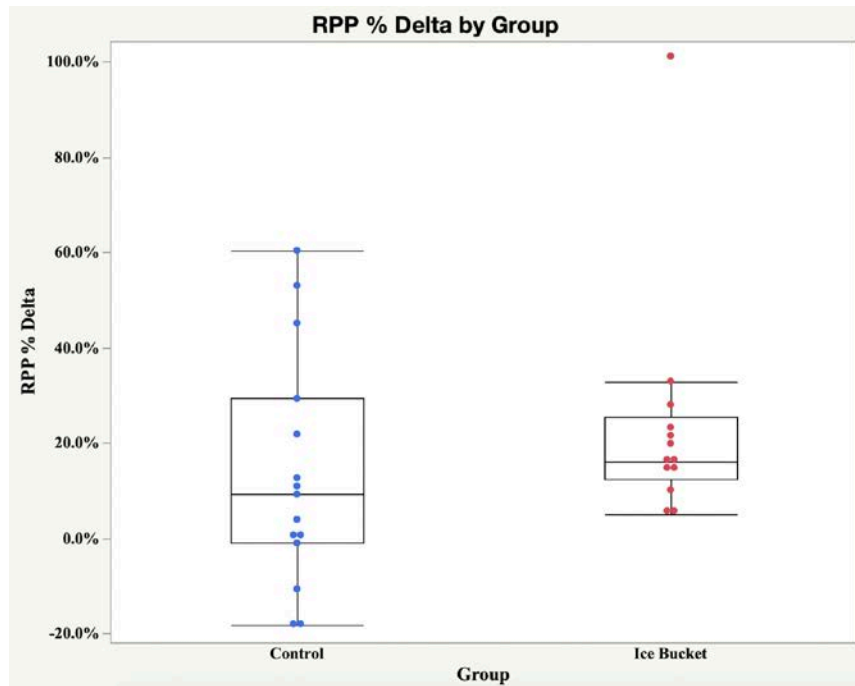


Figure 17. RPP % Delta by Group

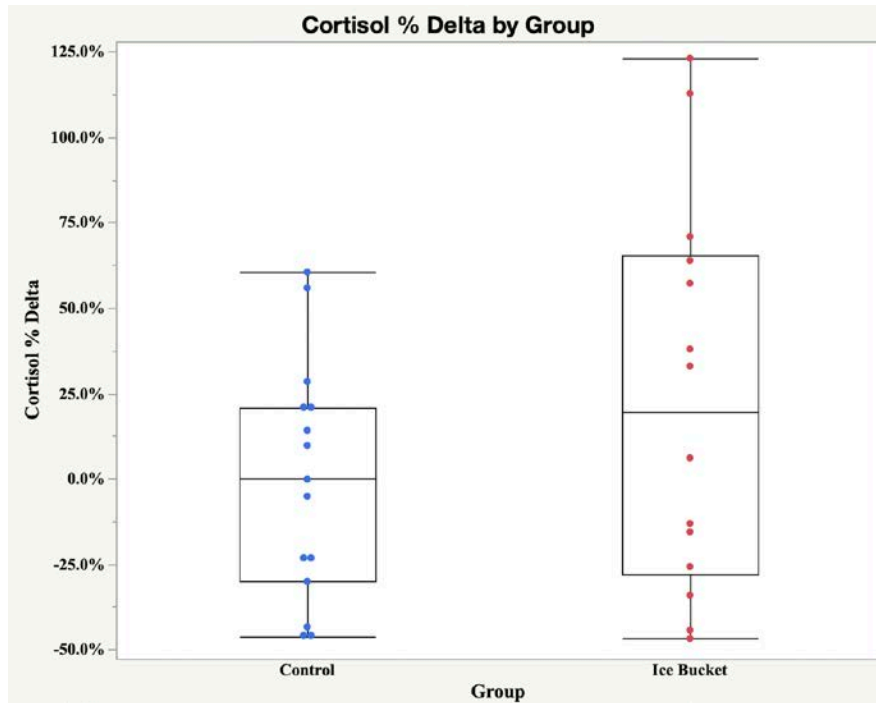


Figure 18. Cortisol % Delta by Group

B. DID THE STRESS TRAINED GROUP RETAIN SIMULATOR TRAINING BETTER THAN THE CONTROL GROUP?

First, I plotted the distributions of the performance measures between the ice bucket group and the control group to determine if I would employ parametric or non-parametric methods of statistical analysis. I began by first analyzing all of the data together, and then analyzing a subset of the data which only included those participants who passed the Criterion Task within the seven-minute time limit. These distributions can be found in Appendix F.

1. All Participants

After plotting the distributions, I used the Wilcoxon Rank Sum method of statistical analysis due to skewness, non-normality, and outliers in the data. Table 5 below shows median values and interquartile ranges for the control and ice bucket groups, the Z-statistic, p-value, and effect size.

Table 5. Performance Measures

	<i>Control (n=15) Median (IQR)</i>	<i>Ice Bucket (n=14) Median (IQR)</i>	<i>Z statistic</i>	<i>Wilcoxon Rank Sum p-value</i>	<i>Effect Size</i>
Criterion Time (s)	361 (307, 451)	350.5 (331.75, 415.25)	-0.0218	0.9826	-0.0041
TA2 RMSE (m)	81.951 (64.975, 108.756)	108.734 (74.978, 225.825)	1.2875	0.1979	0.2391
Criterion RMSE (m)	73.158 (58.717, 82.667)	72.918 (63.453, 84.341)	-0.0218	0.9826	-0.0041
RMSE % Δ	0.210 (-0.170, 0.390)	0.305 (0.074, 0.457)	0.9383	0.3481	0.1742

Though none of the performance measures are statistically significant between the two groups, TA RMSE and RMSE% Δ have a relatively large effect size which might suggest that the Ice Bucket Group performed worse in TA but were able to improve their performance in the Criterion Task more than the Control Group. The following graphs show boxplots of these two performance measures which compare the control group to the ice bucket group. In the first boxplot, the median RMSE of the ice bucket group is higher than the median of the control group, which suggests the ice bucket group performed worse than the control group during TA. In the second boxplot, the median performance of the ice bucket group is higher than the control group, which suggests that the ice bucket group was able to improve their performance from the first task more than the control group. The variance of the participant's data, represented by the whiskers of the box plots, may explain why there are not significant p-values in the data analysis despite relatively large effect sizes and differences in median values.

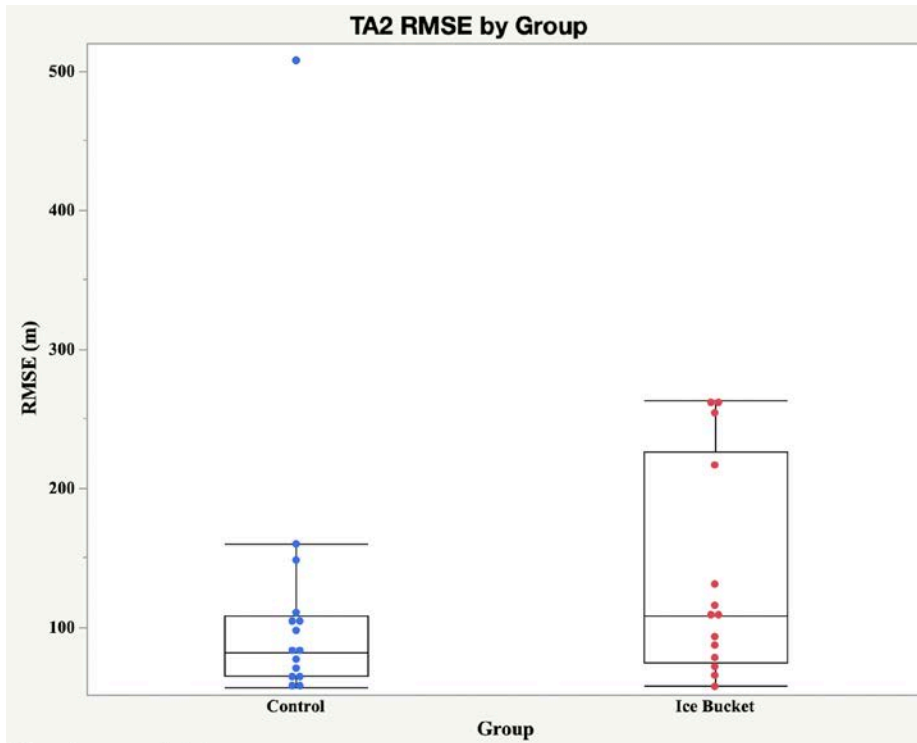


Figure 19. TA2 RMSE by Group

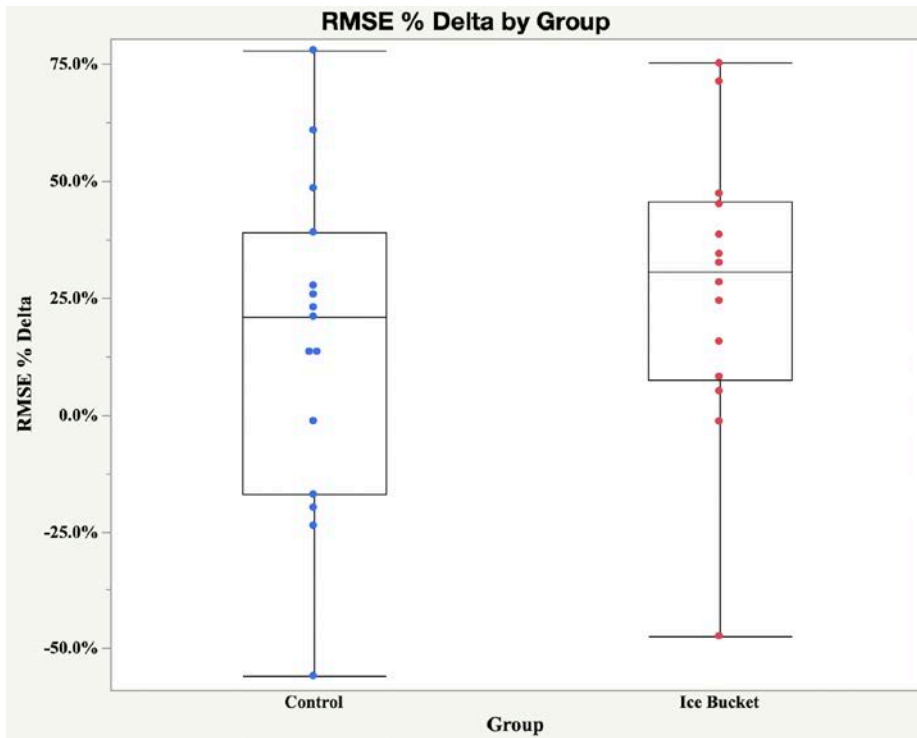


Figure 20. RMSE % Delta by Group

2. Participants Who Completed the Criterion Task Within the Time Limit

Table 6 below shows median values and interquartile ranges for the control and ice bucket groups, the Z-statistic, p-value, and effect size. This data was subset in order to analyze data from participants who successfully completed the Criterion task within the allotted seven-minute time limit.

Table 6. Performance Measures of Participants Who Passed Within Time Limit

	<i>Control (n=11) Median (IQR)</i>	<i>Ice Bucket (n=11) Median (IQR)</i>	<i>Z statistic</i>	<i>Wilcoxon Rank Sum p-value</i>	<i>Effect Size</i>
Criterion Time (s)	336 (307, 384)	342 (322, 363)	0.1971	0.8437	0.0420
TA2 RMSE (m)	76.256 (63.075, 97.693)	90.170 (69.991, 115.705)	1.4446	0.1486	0.3080
Criterion RMSE (m)	71.181 (57.900, 76.024)	66.446 (60.751, 77.995)	0.1970	0.8438	0.0420
RMSE % Δ	0.131 (-0.198, 0.275)	0.284 (0.082, 0.386)	1.3789	0.1679	0.2940

Though none of the performance measures is statistically significant between the two groups, TA RMSE and RMSE% Δ have a relatively large effect size which might suggest that the Ice Bucket Group performed worse in TA but were able to improve their performance in the Criterion Task more than the Control Group. These effect sizes were even more prevalent when the data was subset to analyze participants who successfully completed the Criterion task within the seven-minute time limit. The following graphs show boxplots of these two performance measures which compare the control group to the ice bucket group. In the first boxplot, the median RMSE of the ice bucket group is higher than the median of the control group, which suggests the ice bucket group performed worse than the control group during TA. In the second boxplot, the median performance of the ice bucket group is higher than the control group, which suggests that the ice bucket group was able to improve their performance from the first task more than the control group. The

variance of the participant's data, represented by the whiskers of the box plots, may explain why there are not significant p-values in the data analysis despite relatively large effect sizes and differences in median values.

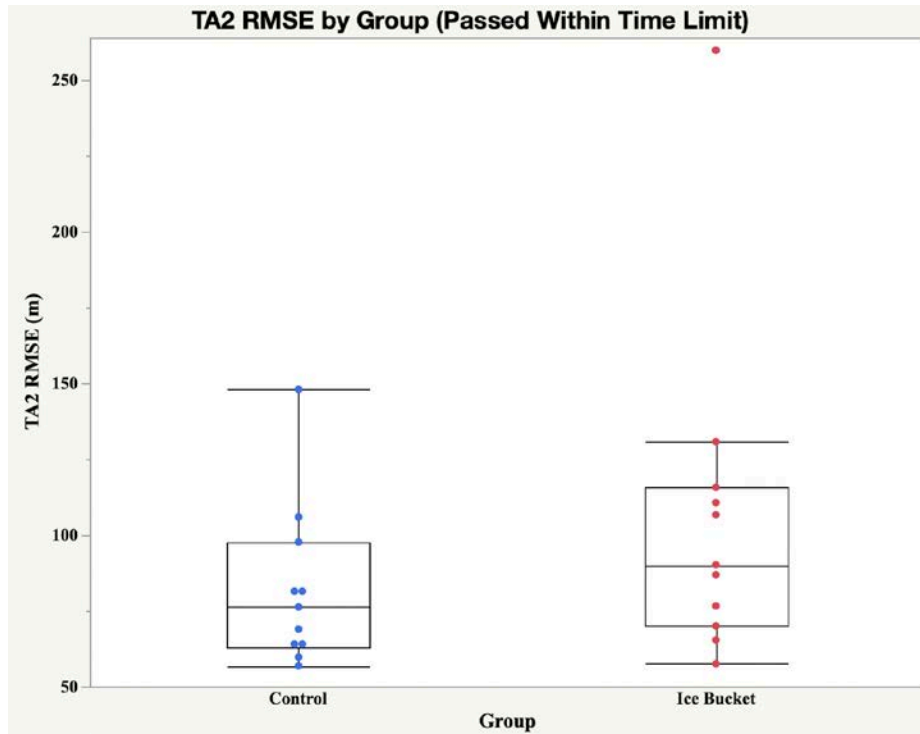


Figure 21. TA2 RMSE by Group (Passed Within Time Limit)

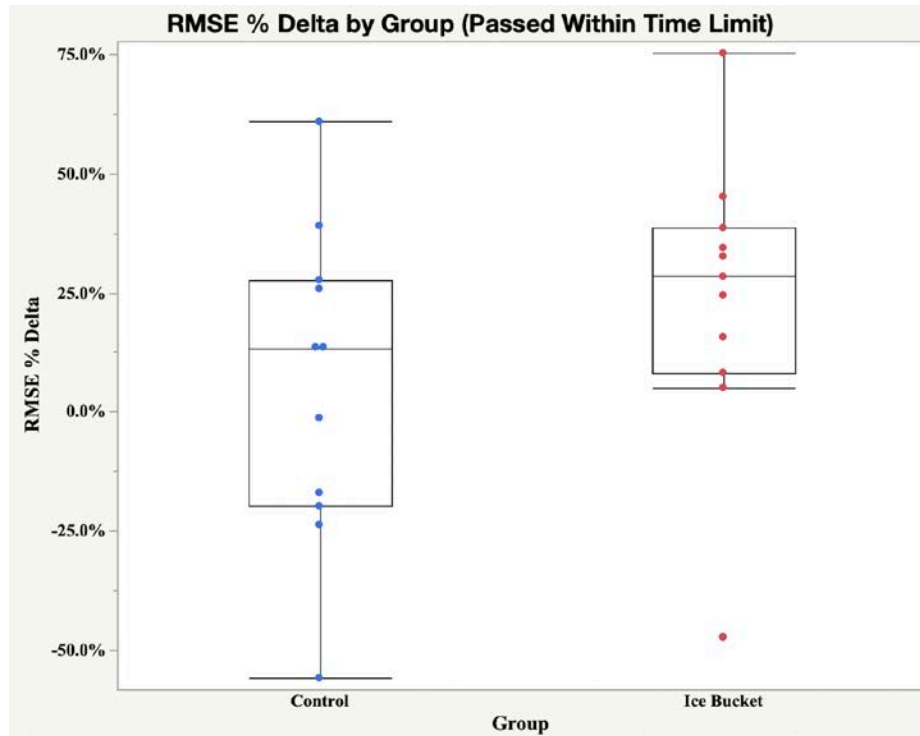


Figure 22. RMSE % Delta by Group (Passed Within Time Limit)

C. DID THE STRESS TRAINED GROUPS DECREASE THEIR APPRAISAL TO STRESS IN THE CRITERION TASK?

This finding was not one of our initial research questions, but the data analysis suggested interesting results with respect to SIT and one’s ability to adapt to stress. For this analysis, I first plotted the distributions of the criterion task physiological measures between the ice bucket group and the control group to determine if I would employ parametric or non-parametric methods of statistical analysis. These distributions can be found in Appendix F.

After plotting the distributions, I used the Wilcoxon Rank Sum method of statistical analysis due to skewness, non-normality, and outliers in the data. Table 7 below shows median values and interquartile ranges for the control and ice bucket groups, the Z-statistic, p-value, and effect size.

Table 7. Physiological Measures in the Criterion Task

	<i>Control (n=15) Median (IQR)</i>	<i>Ice Bucket (n=14) Median (IQR)</i>	<i>Z statistic</i>	<i>Wilcoxon Rank Sum p- value</i>	<i>Effect Size</i>
HR % Δ	0.179 (0.065, 0.263)	0.055 (-0.002, 0.099)	-2.4659	0.0137*	-0.4579
MAP % Δ	0.261 (0.051, 0.398)	0.155 (0.032, 0.364)	-0.8947	0.3710	-0.1661
EDA % Δ	0.699 (0.168, 1.108)	0.779 (0.021, 2.052)	0.2171	0.8282	0.0403
SBP % Δ	0.154 (0, 0.315)	0.127 (0.023, 0.242)	-0.3273	0.7434	-0.0608
RPP % Δ	0.017 (-0.056, 0.193)	-0.056 (-0.178, 0.019)	-1.5057	0.1321	-0.2796
DBP % Δ	0.220 (0.017, 0.599)	0.213 (-0.075, 0.384)	-0.6328	0.5268	-0.1175
AA % Δ	0.248 (-0.045, 0.732)	0.142 (0, 0.283)	-0.7201	0.4715	-0.1337
Cor % Δ	0.057 (-0.107, 0.467)	0.060 (-0.181, 0.230)	-0.1091	0.9131	-0.0203

The results of this analysis show the HR % Δ in the ice bucket group to be lower, on average than the control group with a p-value of 0.0137. The control group experienced about an 18% increase in heart rate from their baseline taken at the beginning of the study compared to the ice bucket group whose heart rates increased only about 5% from their baseline. These results suggest that the ice bucket group was able to decrease their response to stress, experiencing about a 9% increase in heart rate during TA and only a 5% increase in heart rate during the criterion task. The plot below shows a boxplot of the Criterion Task Heart Rate % Δ of both the control group and the ice bucket group.

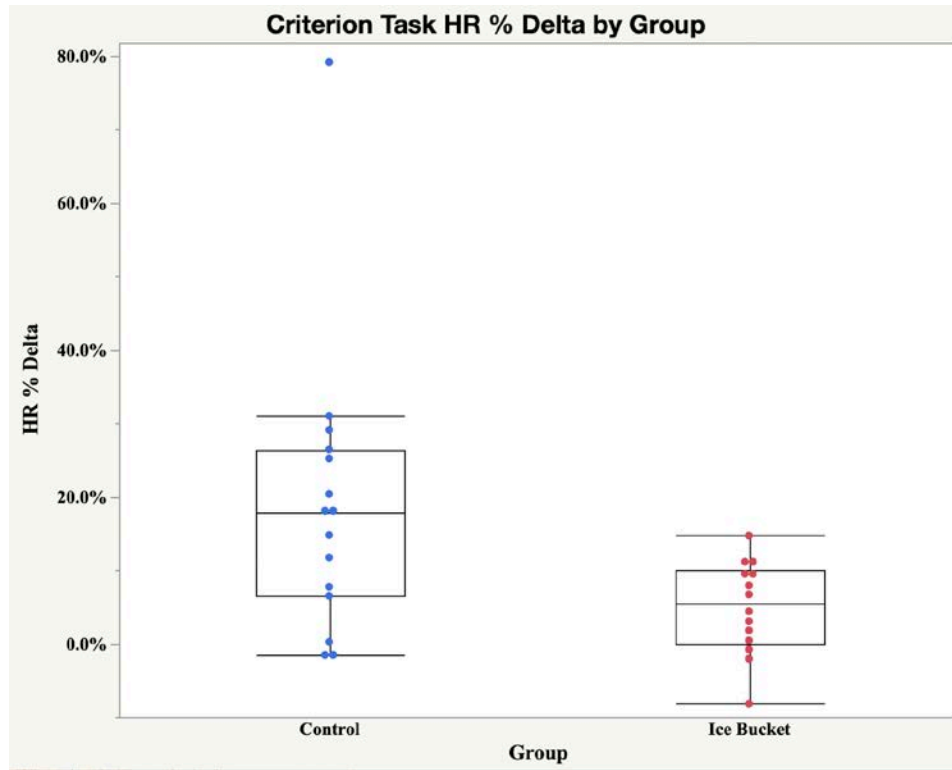


Figure 23. Criterion Task HR % Delta by Group

V. CONCLUSIONS

The goal of this experiment was to help find a useful tool for inducing stress in a ship-driving simulator environment, and to discover if inducing stress during a ship-driving training task would increase participants' ability to handle stress so they could perform better on a final ship-driving task. This work is important because it is vital that we find a tool to assist SWOs to better learn and retain their primary function as naval officers: safely driving and navigating warships. Although difficult to establish significance with the small sample sizes in this experiment, a few insightful discoveries were made that lend themselves to future studies.

First, the median SBP of participants in the ice bucket group increased by 6.4% from their baseline when exposed to the CPT compared to the control group whose SPB increased by only 0.77% during TA. The Rate Pressure Product (RPP), which is a product of HR and SBP and measures total work being done by the heart, increased by 16% from the baseline in the ice bucket group and only 9% in the control group during TA. The saliva samples taken from ice bucket participants showed an increase of 20% of the stress hormone cortisol, while the increase from baseline in the control group was negligible. These indications suggest that the ice bucket did, in fact, induce physiological stress in the stress-trained group when compared with the control group.

Second, the analysis of the participants' performance measures showed that the stress-trained group was able to improve their performance from TA to the Criterion Task by 52%, while the control group improved their performance by only 38%. This difference, while not significant, suggests that the stress-trained group was able to retain their ship-driving training better than the control group.

Third, the analysis of participants' physiological measures in the criterion task shows a significant difference between the two groups in heart rate increase from the participant's baseline heart rate collected at the beginning of the study. In the criterion task, when all participants were exposed to the ice bucket stressor, the median of the control group's heart rate increase was 18% compared with the stress-trained group whose heart

rates increased by only 5% from their baseline in the criterion task. This finding suggests that the ice bucket group was able to decrease their response to stress after having been exposed to the ice bucket previously, therefore demonstrating decreased signs of physiological stress when exposed to the cold stressor compared to the control group who had not been stress-trained.

VI. DISCUSSION AND RECOMMENDATIONS FOR FUTURE WORK

A. BENEFITS OF THE STUDY

This study began to explore the effects of stress inoculation while training novice ship drivers in a simulator. The results of this analysis suggest that training ship-drivers while inducing stress can help decrease the body's physical reaction to stress. Our goal is to assist the Surface Warfare Community by providing tools to effectively train SWOs to be safer and more capable warfighters, and through this experiment we have just begun to scratch the surface on the possibilities of stress inoculation training in the maritime environment.

B. FUTURE WORK RECOMMENDATIONS

The findings of this study suggest that SIT might be an effective tool for training ship-drivers in a simulator environment. To further expand on these findings, the recommendation is to conduct a larger study with more participants to enable researchers with enough data to make more concrete conclusions about their data analysis findings. We also recommend that this study be expanded to the BDOC, where hundreds of new SWOs are receiving simulator ship-driving training each year. The last recommendation is to explore other types of SIT not specifically involving cold pressors for easier implementation in the fleet, such as auditory stress or stress induced by the presence of an authority figure. These stressors might be more realistic for the bridge environment on a ship where alarms are sounding in emergency situations or OODs need to take decisive action while an authority figure is nearby or questioning their decisions.

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APPENDIX A. TRAINING VIDEO SCRIPTS

The scripts presented in this appendix were derived in part from McClernon (2009).

A. TASK ACQUISITION I

We will now begin the first phase of the experiment. During this phase you will be read instructions regarding how to use the controls and instruments for the bridge simulator. The ship you will be driving for this experiment will be a Flight II Arleigh Burke Destroyer.

This is the Kongsberg Ship Bridge Simulator. There are three screens in front of you. The screen to your right is the panorama screen, which indicates rudder position and ship speed. The screen to your left is the ships' SPS-73 RADAR, which will provide you with situational awareness of your surroundings. The screen in the center is your viewpoint while standing centerline on the bridge of the Arleigh Burke Destroyer.

The ship you will be driving will be controlled at the helm. Please step up to the helm and place your right hand on the wheel. Please practice each skill as I describe how to use each control.

To turn the ship to the right, gently turn the helm to the right. By adjusting the helm, you are directly swinging the ship's rudder. To turn left, gently turn the helm left.

As you are swinging your rudder, you will notice a notch in the helm. At this point, the helm is indicating the rudder to amidships. At this time, turn your rudder to amidships.

The screen on the helm, directly in front of you, will indicate the Rudder Command in red and green font. The red numbers indicate a left degree rudder angle and the green indicate a right degree rudder angle. These numbers reflect the rudder ordered by you at the helm. The Rate of Turn indicator on the screen will give you an indication of how fast the ship is turning.

The throttles to the right on the helm will allow you to control the speed of the ship. By pushing the throttles forward, you will increase the speed of the ship. By pulling toward you, you will decrease the speed. As you pull back on the throttles you will notice a notch

at 0. This is the point where all engines are at zero power and any point beyond this point will be a reverse engine order.

The screen to your right, the panorama screen, will give you an indication of the speed of the ship through the water. This may vary from the speed ordered with the throttles due to ocean current or if the ship is in a tight turn. Do you have any questions regarding the simulator controls? (Pause video if questions arise)

QUIZ

You will now take a short quiz regarding the training you just received.

What information will you receive from the panorama view, the screen to your left?

Answer: Rudder and Speed

Increase the speed of the ship using the throttle controls.

Turn the ship using a left 15 degree rudder.

During the scenario, you will be placed at the start of a course which you will navigate using the helm and throttle controls. During the course, you will pass through pairs of oil rigs and orange smoke floats. You will always pass the orange smoke floats to your left and oil rigs on your right.

Your goals throughout the course is to remain centerline between oil rigs and smoke floats and to complete the course under seven minutes. You will complete the course when you pass through the white smoke floats after the fourth oil rig.

You have 7 minutes to complete the course. If you hit an oil rig or smoke float, your scenario will end and you will continue to the next phase of the experiment.

You will now be given 2 minutes to practice driving the ship. This time should be used to become familiar with the way the ship moves as you adjust the helm and throttles.

This concludes your training. Do you have any questions at this time?

B. TASK ACQUISITION II

You are about to begin the second test session. This session will be similar to the previous practice session you just accomplished, and it will last approximately 10 minutes. Please wait to ask any other questions you may have until after the session, although do let me know if you become ill, are very confused, or need to stop for any other reason.

To review, please try to maintain the following parameters:

Stay in the center of the course by driving center between oil rigs and smoke floats. The smoke floats should always pass on your left and oil rigs on the right.

Complete the course in 7 minutes or less.

Do you have any questions before we begin?

The simulator will begin at the entrance of the course. Are you ready?

If a participant is in the treatment group apply the cold pressor now.

This concludes the second test session. No additional simulator guidance will be provided at this time, but you are welcome to relax. The next part of the experiment will begin in 15 minutes.

C. STRESS EXPOSURE

For the following test session, you will be exposed to a stressful cold pressor. During exposure to the cold pressor, or any stress, it is important to, first, maintain your normal breathing as best as possible. This will help calm and relax you. Next, attempt to focus on the task at hand, and ignore the distractions of the stressor. Focus on navigating the course and staying as close to the center of the course as possible.

Now, the cold pressor will be applied.

Wait one minute.

Notice how your breathing has increased. For the next few minutes focus on slowing and

regulating your breathing while attempting to relax.

Wait a few minutes.

Now, attempt to ignore the stress of the cold and focus your attention on the ship driving task you have been assigned.

Wait a few minutes.

Finally, visualize the performance parameters you will have to maintain during the next session. They are:

Staying in the center of the course by driving center between the oil rigs and smoke floats.

Completing the course in 7 minutes or less.

Wait a few minutes.

You may now remove the cold pressor.

The next phase of the experiment will begin in 15 minutes.

D. CRITERION TASK

You are about to begin the third and final test session. For the following test session, you will be exposed to a stressful cold pressor. This session will be similar to the previous test sessions you have accomplished, and it will last approximately 10 minutes. Please wait to ask any other questions you may have until after the session, although do let me know if you become ill, are very confused, or need to stop for any other reason.

You are required to maintain the following parameters:

Staying in the center of the course by driving center between oil rigs and smoke floats.

Completing the course in 10 minutes or less.

The simulator will begin at the entrance of the buoy course. Are you ready?

Now, the cold pressor will be applied.

This concludes the experiment.

APPENDIX B. COHEN PERCEIVED STRESS SURVEY

Participant ID: _____

COHEN PERCEIVED STRESS SCALE

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate how often you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer each question fairly quickly. That is, don't try to count up the number of times you felt a particular way, but rather indicate the alternative that seems like a reasonable estimate.

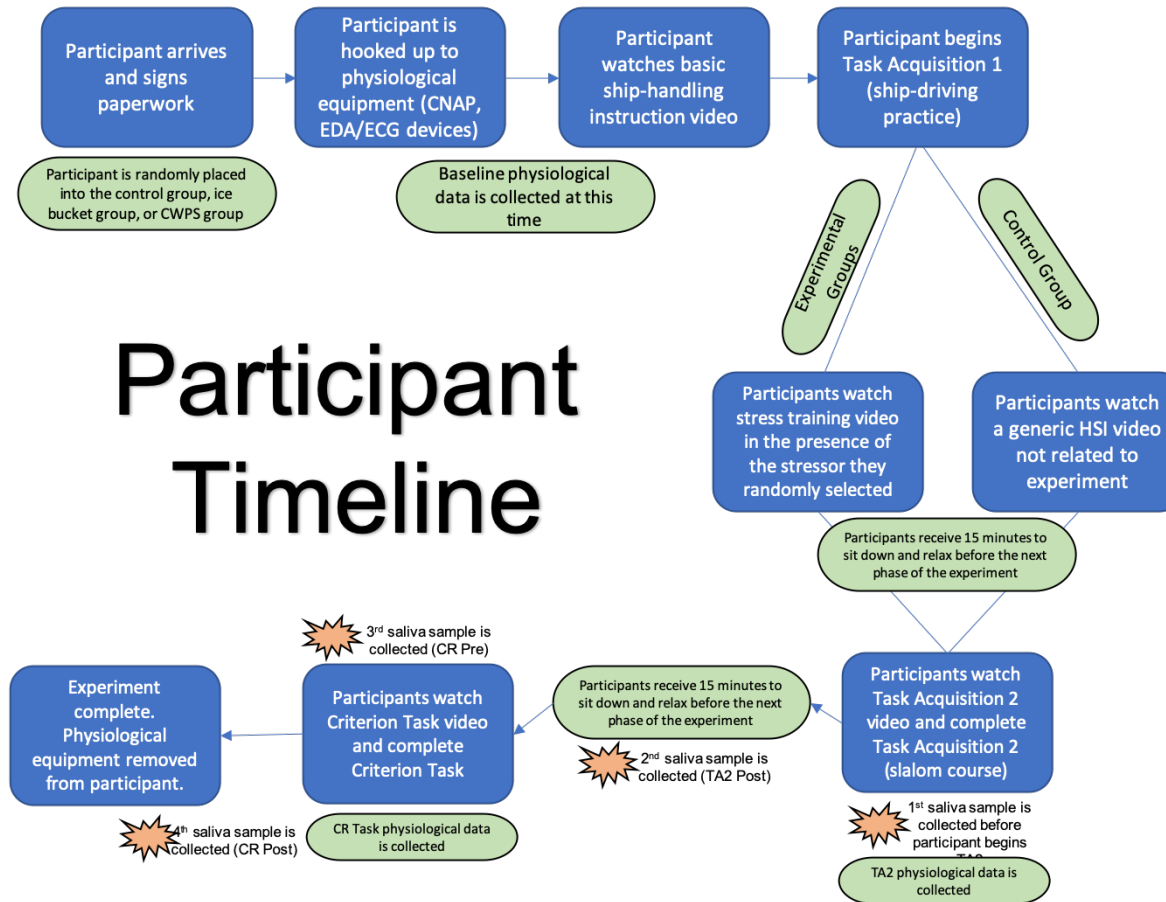
For each question choose from the following alternatives:

- 0 = Never
- 1 = Almost Never
- 2 = Sometimes
- 3 = Fairly Often
- 4 = Very Often

	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
1. In the last month, how often have you been upset because of something that happened unexpectedly?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. In the last month, how often have you felt that you were unable to control the important things in your life?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. In the last month, how often have you felt nervous and "stressed"?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. In the last month, how often have you felt confident about your ability to handle your personal problems?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. In the last month, how often have you felt that things were going your way?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. In the last month, how often have you found that you could not cope with all the things that you had to do?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. In the last month, how often have you been able to control irritations in your life?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. In the last month, how often have you felt that you were on top of things?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. In the last month, how often have you been angered because of things that were outside of your control?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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APPENDIX C. PARTICIPANT TIMELINE



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APPENDIX D. DATA DISTRIBUTIONS

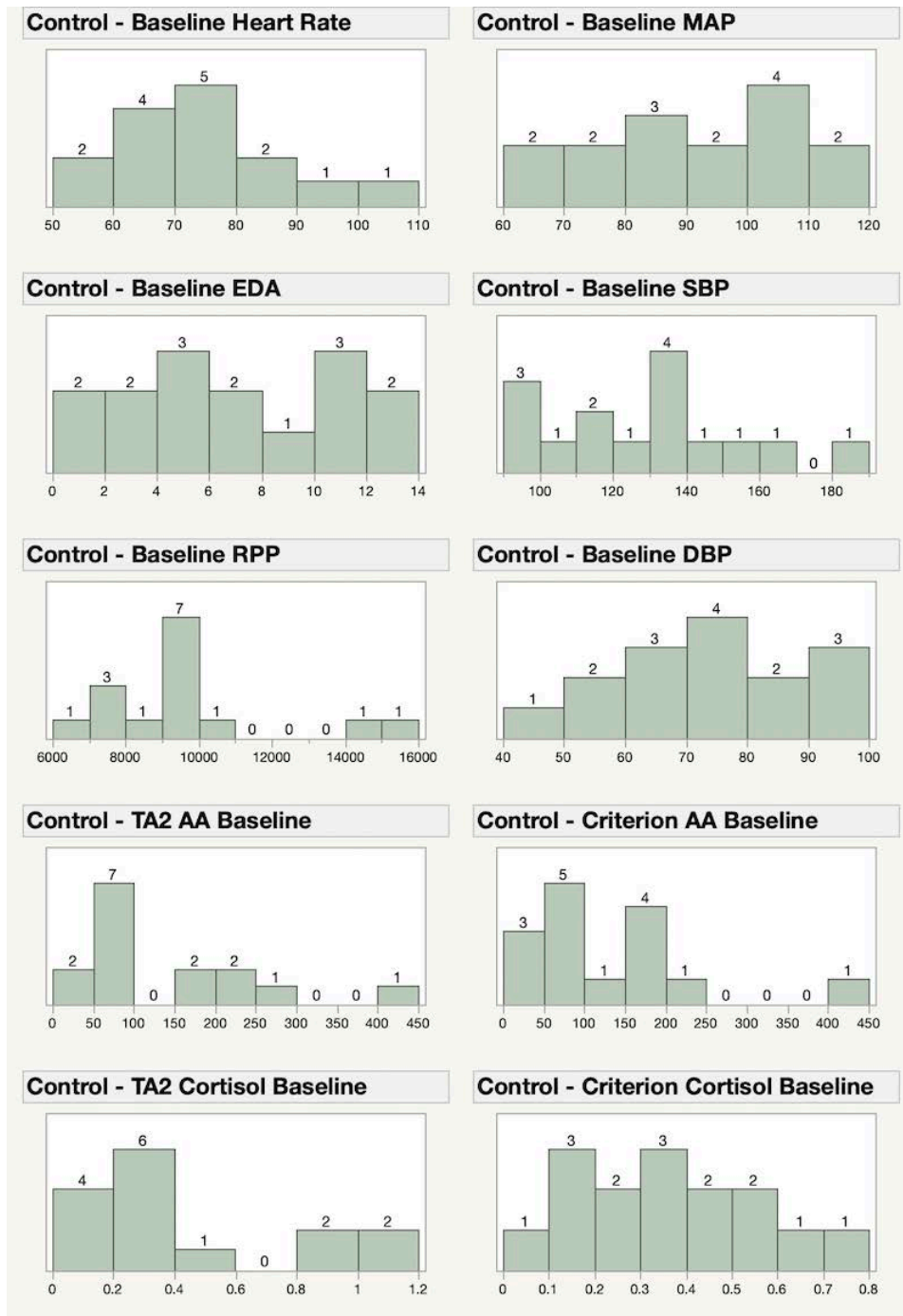


Figure 24. Baseline Physiological Measurement Distributions (Control Group)

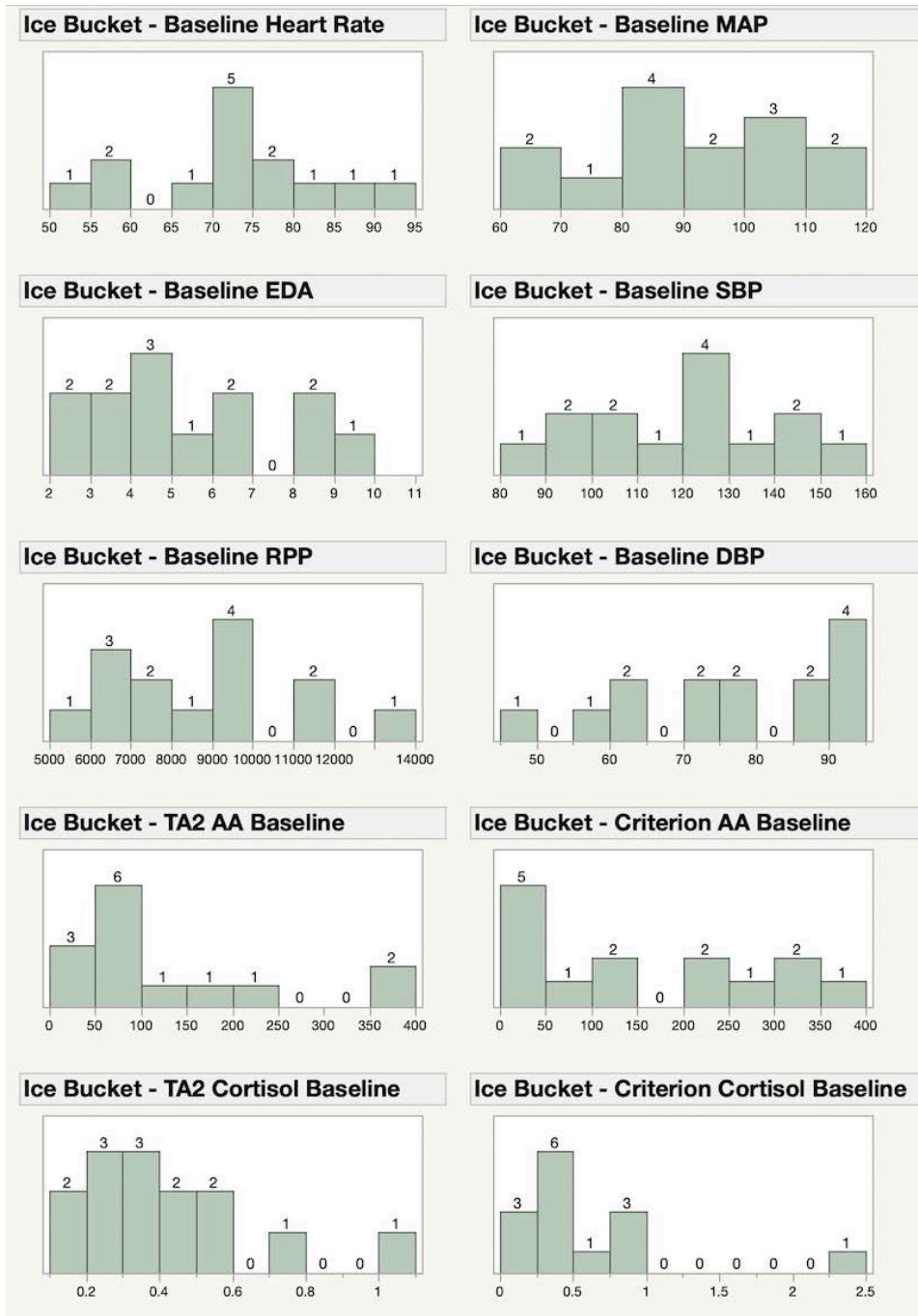


Figure 25. Baseline Physiological Measurement Distributions (Ice Bucket Group)

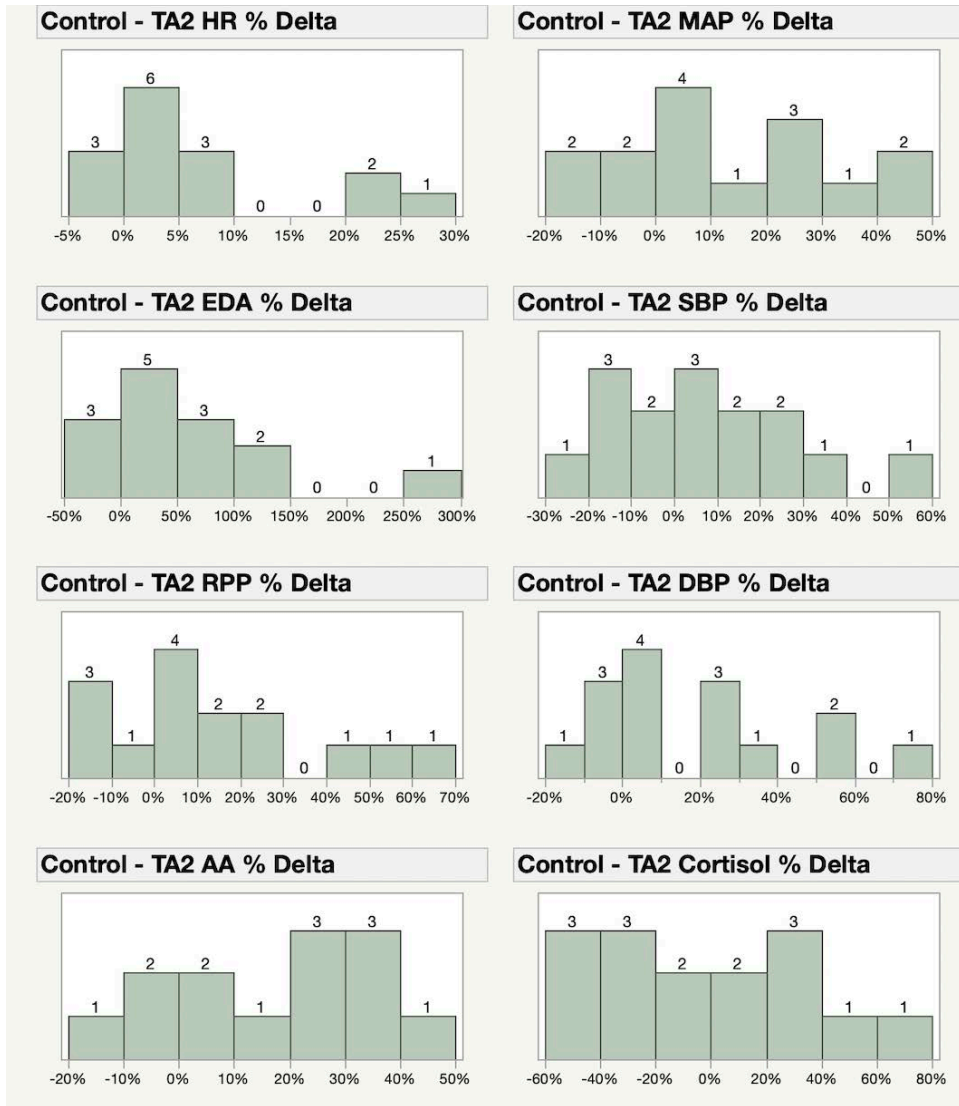


Figure 26. TA2 % Delta Physiological Measurement Distributions (Control Group)

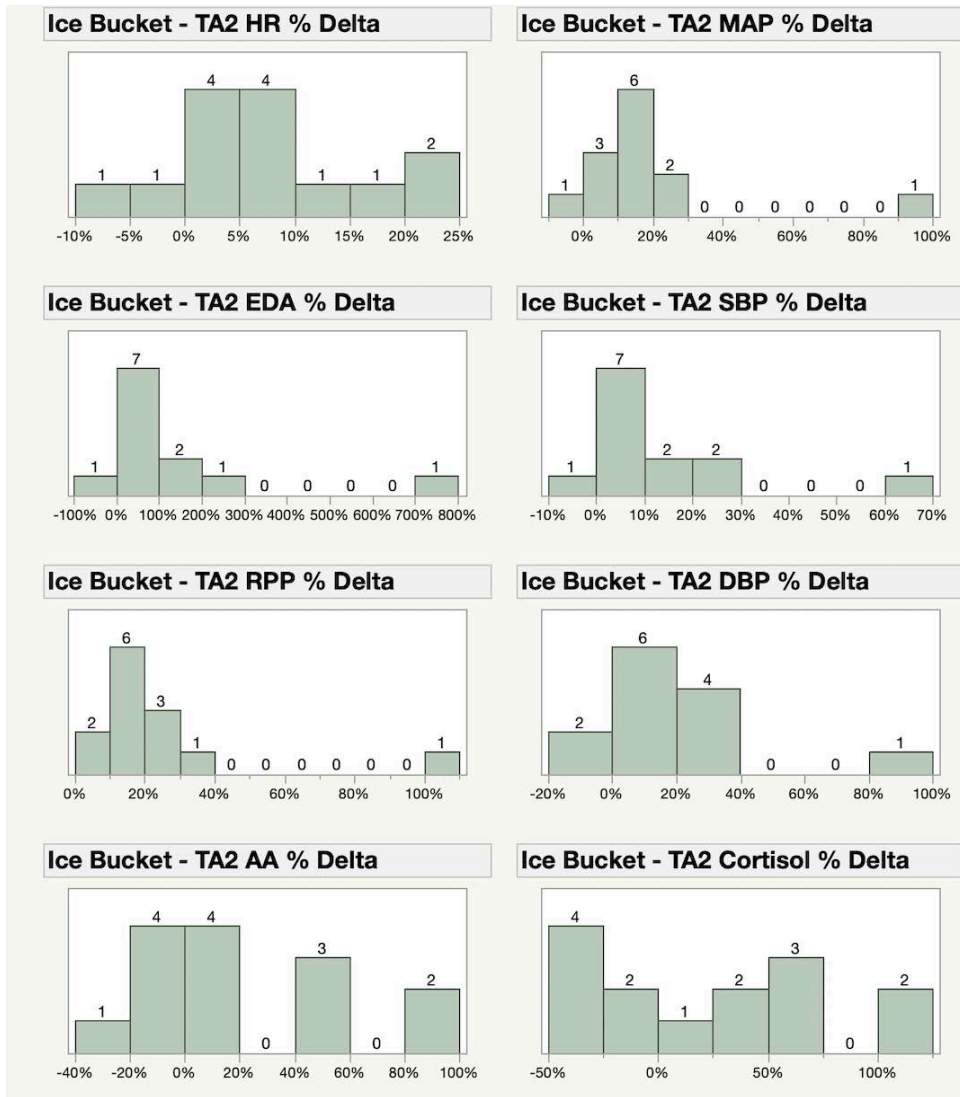


Figure 27. TA2 % Delta Physiological Measurement Distributions (Ice Bucket Group)

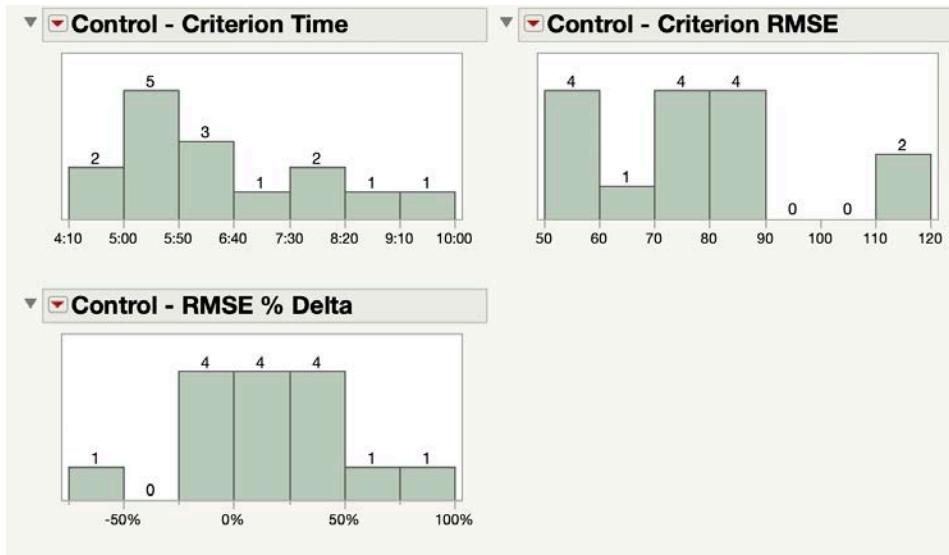


Figure 28. Control Group Performance Measurement Distributions

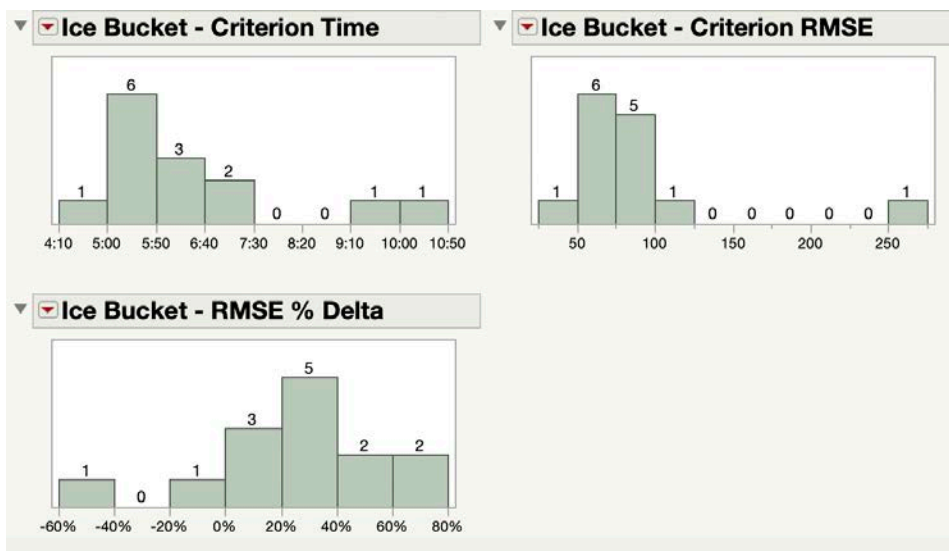


Figure 29. Ice Bucket Group Performance Measurement Distributions

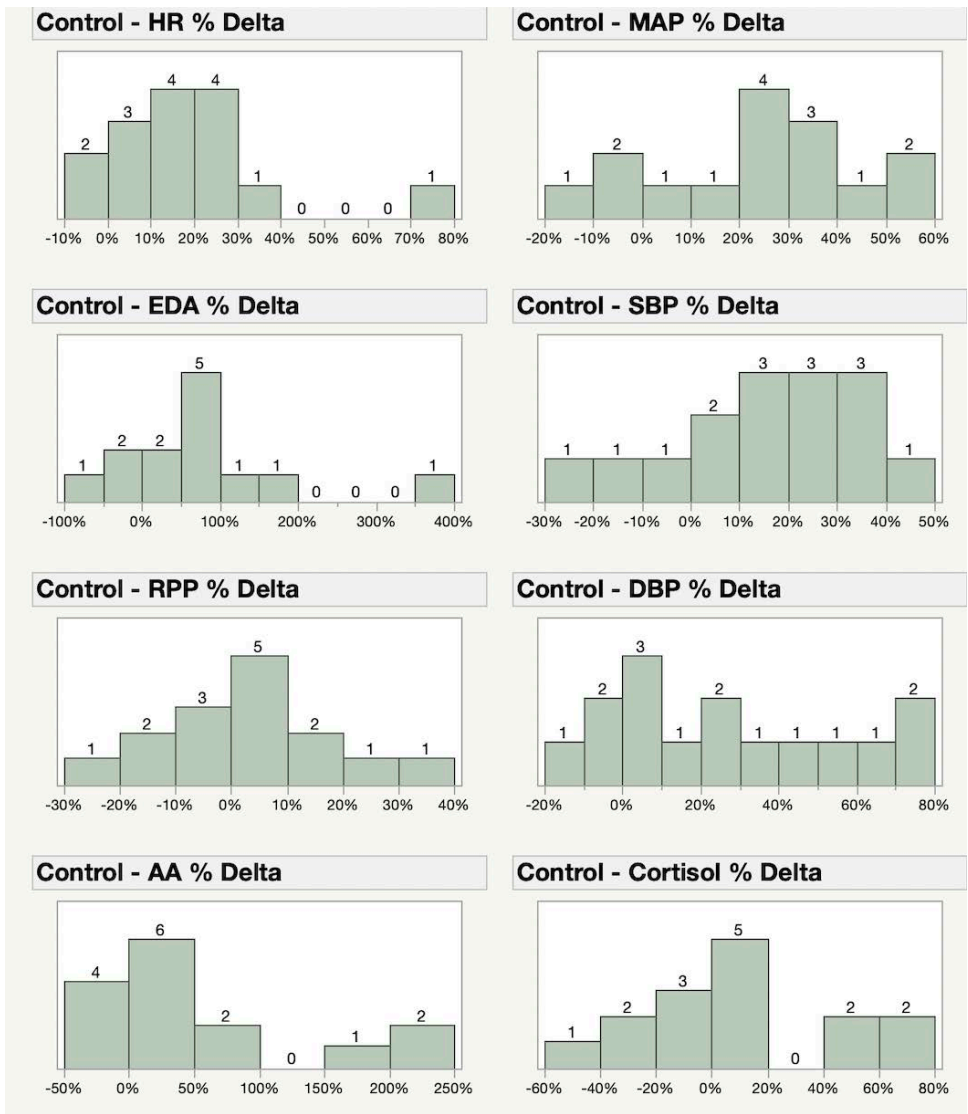


Figure 30. Control Group Criterion Task Physiological Measure Distributions

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