EFFECTS OF AMBIENT LIGHTING ON PERFORMANCE AND LEARNING OF UNDERWATER HELICOPTER ESCAPE SEQUENCES DURING SIMULATION TRAINING

by © Stefanie Dawn Martina

A Thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of

Master of Kinesiology

School of Human Kinetics and Recreation

Memorial University of Newfoundland

October 2019

St. John's, Newfoundland and Labrador

ABSTRACT

This project aimed to evaluate effects of ambient lighting during practice and performance of dry, simulated helicopter escape sequences. Participants were randomized to one of the following groups to practice a standard helicopter underwater escape sequence: Light (with room lights on), Dark (with room lights off), or Graduated (in the light for the first half and then in the dark for the second half of the trials). Following practice, participants had a minimum of thirty minutes break, followed by retention testing in the dark and then in the light. Dependent measures included accuracy, movement time, state anxiety index, breathing rate, and heart rate variability. Results indicated that participants performed more accurately during the dark retention trial than during the light retention trial. This could be due to increased arousal elicited by performance in the dark or, alternatively, may suggest that performance of helicopter escape sequences is not visually mediated. Anxiety level did not differ between conditions. Based on findings, it appears that training in the light is suitable for potential performance in the dark.

Keywords: learning specificity, helicopter escape, simulation, HUET, training

ACKNOWLEDGEMENTS

Thank you to the National Sciences and Engineering Research Council for funding this project. I want to also express my appreciation to Zale Parry and the Academy of Underwater Arts and Sciences for honoring me as the 2017 scholar and supporting me through my studies.

Thank you to my supervisor, mentor, and friend, Dr. Heather Carnahan. Your support has truly changed my life, both professionally and personally. You are truly one of the strongest individuals I know.

Thank you to Dr. Gal Ziv, Dr. Liz Sanli, and Dr, Linda Rohr for your mentorship throughout my studies. Thank you to Dan LaCour, Fred Anstey, and staff at the Offshore Safety and Survival Centre.

Thank you to my sister and brother-in-law, Tara and Tim White, and my father, Joseph Martina, for always supporting my dreams no matter where it might take me. Thank you to Dad (Dobbin), Sue, and John Olivero for taking in this Southern girl and making me an honorary Newfoundlander. I would never have survived through my first winter without you all.

Thank you to my fiancée, Cas Dobbin, for supporting my passions unequivocally. Your patience and love are unmatched. I am forever grateful for you joining me, sometimes seemingly blindly, on this roller coaster.

Last, but not least - thank you to my mom, Robin Martina - how I wish you were physically here to see this. I know you are proud regardless. You are the reason I am who I am today.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

FSW	Feet of Seawater
HEEL	Helicopter Emergency Escape Lighting
HUEBA	Helicopter Underwater Escape Breathing Apparatus
HUET	Helicopter Underwater Escape Training
LSD	Least Significance Difference
MI	Marine Institute
OSSC	Offshore Safety and Survival Centre
STAI	State Trait Anxiety Index

LIST OF APPENDICES

Chapter 1. Literature Review

1.1 Introduction

Safety training for high-risk industries and scenarios requires an approach that optimizes learning for enhanced skill learning and retention. An example is helicopter underwater escape training (HUET) for surviving a ditching over water. HUET is mandatory for offshore oil and gas employees and relevant military personnel. Currently, no universal training standard exists (Taber, 2014).

When a helicopter crashes in water, it rapidly inverts and begins to sink. The inversion away from daylight, along with the reduced transmissivity of light in water, increased water turbidity, and the presence of debris, inherently leads to reduced visibility (O'Neill, Kozey, & Brooks, 2010). Intuitively, night flights would further elicit dark conditions. Research has demonstrated that night flying is associated with reduced survival rates (Brooks, MacDonald, Baker, Shanahan, & Haaland, 2014; Taber, 2014). One study reported that survival rates for a nighttime and daytime crash were 41% and 77%, respectively. Limited vision during egress was hypothesized as contributing to the reduced survival rate at night (Taber, 2014).

To help mitigate this, emergency exit lighting has been incorporated in helicopter design, known as helicopter emergency escape lighting (HEEL). Some studies have demonstrated reduced escape times with HEEL in the laboratory setting (Allan, 1988; Luria, Ryack, & Neri, 1982; O’Neill, Kozey, & Brooks, 2004; Ryack, Smith, Champlin, & Noddin, 1977). However, the effectiveness of HEEL remains a concern, as there is some evidence to suggest that lights may not be detectable when seated by the aisle even with bright ambient lighting conditions (O’Neill et al., 2004).

1.2 Historical Relevance - Cougar Flight 491

The 2009 Cougar Flight 491 helicopter crash off the Newfoundland coast prompted an increased focus on identifying and mitigating safety threats such as night flying. Following the accident, the Commissioner’s report recommended the restriction of night flying until adequate safety improvements were made (Wells, 2010). A ban on night flights in the province has remained in effect; however, discussions between the Canada - Newfoundland & Labrador Offshore Petroleum Board and provincial leaders of the oil industry regarding improvements needed to repeal the ban and implementation strategies have been ongoing.

Another recommendation made was increased simulation fidelity of training. Simulation fidelity refers to "the degree of faithfulness between entities" (Grierson, 2014). The similarities between entities, or conditions, governs the degree of learning transfer (Barnett, Ross, Schmidt, & Todd, 1973; Henry, 1968). A high degree of simulation fidelity may be particularly important for optimizing learning when training for high-stress scenarios (Gratch & Marsella, 2003; Grierson, 2014; Taber, 2014).

Although it was required that pilots demonstrate successful ditching during night flights, no attention has been given to the ability of passengers to demonstrate escape during low- or no-light conditions or to the fidelity of HUET to prepare for these conditions. Limited nighttime ditching training was identified as a potential factor contributing to the reduced survival rate (Taber, 2014). Given the challenge of limited visibility during escape, it is plausible that training in dark conditions may be beneficial to learning and performance.

1.3 Motor Learning

Motor skill learning and performance is integral to human life. Motor learning refers to the changes in internal processes that occur with practice or experience, which affects an individual's ability to execute a motor task. Motor learning depends on the integration and interpretation of sensory stimuli. Retention testing is the preferred method to assess learning, which involves evaluation of a trained task after some time interval. Performance is the observable production of a motor skill, which is influenced by transient factors such as fatigue, motivation, and affective state (Issurin, 2013; Movahedi, Sheikh, Bagherzadeh, Hemayattalab, & Ashayeri, 2007; Schmidt & Lee, 2004; Schmidt & Wrisberg, 2008). Although related, it is important to note that performance and learning are distinct processes (Schmidt & Lee, 2004; Schmidt & Wrisberg, 2008).

1.3.1 Principle of learning specificity.

Since helicopter egress generally occurs in a low-light setting, the principle of learning specificity suggests that HUET would be most effective if also conducted in low- or no-light conditions. According to the principle of learning specificity, the most efficient sensory information available during acquisition dominates over other feedback sources and is utilized to develop a sensorimotor plan. Once developed, the sensorimotor plan remains sensitive to the optimal sensory information available during practice (Elliot, Chua, Pollock, & Lyons, 1995; Mackrous & Proteau, 2007; Proteau, Marteniuk, & Lévesque, 1992) and the learner's emotional state (Bower, Monteiro, & Gilligan, 1978;

Schare, Lisman, & Spear, 1984). Proteau et al. (1987) first demonstrated this principle when participants who had practiced a manual aiming task with vision performed more poorly on transfer tests when vision was withdrawn, suggesting that vision is the dominant and preferred sensory source (Proteau, 2005; Proteau & Carnahan, 2001). Accordingly, lack of visual feedback due to low ambient light levels and high anxiety levels during performance, but not practice, would result in decrements.

1.3.2 Anxiety and stress effects on learning.

The role of anxiety on motor learning has not been clearly delineated. Lawrence, Cassell, Beattie, Woodman, Hardy, and Gottwald (2016) demonstrated that participants who practiced a complex motor skill with anxiety performed better in an anxiety condition transfer test compared to those who practiced without anxiety. Performance was best when anxiety was introduced later compared to earlier in practice. This finding supports evidence that acclimatization to anxiety may reduce its effects (Baumeister, 1984); thus, graduated, or progressive, learning may be beneficial to optimize training and retention in anxiogenic conditions.

Anxiety and stress contribute to arousal and affect learning. Anxiety is often defined as negative emotions and concerns about oneself, a situation, and outcomes (Morris, Davis, & Hutchings, 1981). State anxiety is characterized by subjective apprehension or tension that results from an individual's context-specific perception of a present threat and promotes physiologic arousal (Schwenkmezger & Steffgen, 1989). Stress is traditionally defined as a physiological response to perceived demands, relative to available coping resources (Stokes & Kate, 2001).

From the limited repertoire of investigations, impacts of anxiety and stress on learning vary. It has been suggested that there is an optimal amount of anxiety and stress to facilitate learning. Conditions with low or excessively elevated levels of arousal are thought be detrimental (Frankenhaeuser & Gardell, 1976; Weinberg & Ragan, 1978). Research has demonstrated inconsistent findings - that anxiety and stress can have beneficial (Duncko, Cornwell, Cui, Merikangas, & Grillon, 2007; Hordacre et al., 2016; Marteniuk & Wenger, 1970; Oudejans & Pijpers, 2009; Oudejans & Pijpers, 2010; Sage & Bennett, 1973), detrimental (Cox, 1983; Noteboom, Barnholt, & Enoka, 2001), and even neutral effects on learning (Calvo, Alamo, & Ramos, 1990; Carron & Morford, 1968; Pemberton & Cox, 1981).

One challenge in defining the role of anxiety in learning is isolating it from stress effects. Both anxiety and stress impact attention, action selection, and performance (Nieuwenhuys & Oudejans, 2012); however, anxiety and stress are distinct variables that may elicit different responses during learning (Tepas & Price, 2001; Watson & Clark, 1997). It has been suggested that physiological stress responses may benefit learning by inducing a heightened awareness state (Coombs, Gamble, Cauraugh, & Janelle, 2008; Lang, Bradley, & Cuthbert, 1998). Stress and anxiety may also promote action readiness (Schupp, Junghofer, Weike, & Hamm, 2003; Coombes, Higgins, Gamble, Cauraugh, & Janelle, 2009; Schutter, Hofman, & Van Honk, 2008). Intuitively, increased action readiness appears beneficial by priming the motor system, resulting in faster response times (Hordacre et al., 2016; Nieuwenhuys & Oudejans, 2012). However, it may also cause higher levels of muscle activation and stronger fatigue, resulting in slower and less coordinated movements (Beuter

& Duda, 1985; Pijpers, Oudejans, Holsheimer, & Bakker, 2003; Yoshie, Kudo, Murakoshi, & Ohtsuki, 2009).

Considerable attention must be allocated to a task to ensure optimal recall (Schmidt & Bjork, 1992). State anxiety has been shown to affect cognitive (Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007) and motor performance (Hardy, Mullen, & Jones, 1996; Miller, 1992). Anxiety may hinder learning by affecting cognition, such as concentration and information processing ability (Eysenck & Calvo, 1992; Eysenck et al., 2007; Frings, Rycroft, Allen, & Fenn, 2014; Hancock, 1989; Moore, Vine, Wilson, & Freeman, 2012; Vine, Freeman, Moore, Chandra-Ramanan, & Wilson, 2013). An increase in attentional demands may redirect cognitive resources to focus on present threats, which could distract from the task and cause performance decrement (Wine, 1971). Alternatively, anxiety may benefit learning by inducing the allocation of more cognitive resources for task completion, which could attenuate aversive threat effects (Eysenck et al., 2007). Anxiety may promote self-awareness which could be both beneficial by increasing attention given to the task (Eysenk & Calvo, 1992) or be detrimental by disrupting automatic processes (Oudejans & Pijpers, 2009).

Anxiety may have different impacts depending on learning stage. Anxiety adversely affects early stages of learning but may have positive or neutral effects during late learning (Hardy, Mullen, & Jones, 1996; Masters, 1992; Vine et al., 2013). This may be partially explained by the *challenge point framework*, which states that learning is dependent on the presence of an optimal amount of information. A task that exceeds the optimal point for a given individual will result in an overload of information processing and resultant performance decrements (Guadagnoli & Lee, 2004). Task difficulty and experience level influence optimal levels. A novice experiences rapid performance decrements as an initially easy task increases in difficulty, while experts exhibit less dramatic performance declines. Experts may benefit more so than novices from an increase in task complexity since it provides additional information to elicit attention. Anxiety may be a beneficial challenge to experts but may impair processing to novices. Additionally, if practice and performance conditions differ, evidence suggests that experts may experience greater performance decrements than novices (Krigolson & Tremblay, 2009; Proteau et al., 1998; Proteau, Marteniuk, Girouard, & Dugas, 1987; Tremblay & Proteau, 2001). Although experts were not included in this project, it is reasonable that progressive learning, the gradual increase in task complexity as experience increases, may be beneficial for HUET training for all skill levels.

While numerous variables impact anxiety, it is plausible that a no- or low-vision condition may amplify anxiety level. Darkness has been associated with feelings of vulnerability by concealing potential threats (Blobaum & Hunecke, 2005; Gray, 1987; Nasar & Jones, 1997; Warr, 1990); thus, darkness may exacerbate anxiety effects.

1.3.3 Role of vision.

Ambient vision is thought not to be affected by low levels of light (Schmidt & Wrisberg, 2008). However, decreased light levels could theoretically reduce the acuity of visual feedback. This may consequently affect aspects of sensory feedback such as eye and head movement patterns. Helsen, Tremblay, Berg, and Elliot (2004) conducted a study to examine the specific patterns of eye and head movements utilized to acquire and perform goal-directed skills. Findings suggested that end-position information is more critical than motion trajectories. Changes in lighting can affect perception and object appearance, for example by shadow production (Hietanen, Perrett, Oram, Benson, & Dittrich, 1992). Thus, it is plausible that low lighting may reduce visibility range, which could affect end-target sight or object recognition. For goal-directed movements where visual terminal feedback is imperative for movement calibration, performance would decline (Behan & Wilson, 2008). It is possible that learning may be similarly affected.

To examine the role of visual feedback on learning specificity, studies have typically examined effects of manipulated visual feedback (e.g. by distortion or narrowing) or withdrawn vision during motor tasks. Proteau et al. (1987; 1992) had participants practice a manual aiming task, which required the movement a stylus to an end target while mechanically perturbed and time constrained, in either a light or dark room. When participants trained in the dark and then performed a retention transfer test in the light, performance deteriorated. This demonstrated the impact of training condition for transfer and retention. Importantly, the end-target was always visible in the dark condition. Additionally, subjects performed over 1000 practice trials and were given knowledge of results following each trial. These conditions may not be generalizable to real-life contexts.

1.4 Summary

The main topics discussed in this literature review were the principle of learning specificity, the roles of anxiety and stress in learning, and the utility for motor skill learning. The subsequent chapter will detail a project designed to assess the application of concepts for HUET. The study aim was to utilize findings to inform training programs and standards.

Chapter 2. Research Manuscript

2.1 Introduction

When a helicopter ditches in water, it typically inverts and sinks (Brooks, MacDonald, Donati, & Taber, 2008; Ryack, Luria, & Smith, 1986; Taber & McCabe, 2006). Crew and passengers often have less than 15 seconds of notice to make an underwater escape (Brooks, MacDonald, Baker, Shanahan, & Haaland, 2014). Not surprisingly, drowning has been identified as the leading cause of death following a ditching (Coleshaw, 2012). Disorientation and limited vision have been hypothesized as contributing to reduced survival (Cheung, Hofner, Brooks, & Gibbs, 2000; Taber, 2014). These factors are influenced by darkness, which has been linked with higher mortality rates during egress (Brooks et al., 2014; Taber, 2014).

Arguably, all egress occurs in low-light conditions. A nighttime helicopter ditching would obviously occur in dark conditions. However, regardless of time of day, numerous factors degrade light availability and consequently may impact visibility. The inversion of the helicopter directs windows away from daylight. Transmissivity of light through water is much less than light through air. As the helicopter sinks, light penetrance degrades. At 35 feet of sea water (few), only approximately 20% of light penetrates clear ocean water (Butler, 1995). Debris presence (O’Neill, Kozey, & Brooks, 2004) and water turbidity (Butler, 1995; O’Neill et al., 2004) further impact light attenuation. Even at shallow depths with bright sunlight, very high turbidity can degrade visibility to less than one foot of distance (Butler, 1995). Presumably, darkness would augment challenges that are exacerbated by poor visibility such as finding exits and getting oriented to the water's surface, thereby impacting survival.

In addition to physical effects, darkness has been associated with feelings of vulnerability by concealing potential threats (Blöbaum & Hunecke, 2005; Gray, 1987; Nasar & Jones, 1997) and may heighten anxiety or fear in stressful situations. State anxiety is characterized by subjective apprehension or tension that results from an individual's context-specific perception of a present threat and promotes physiologic arousal (Schwenkmezger & Steffgen, 1989). The Yerkes-Dodson Law explains that the effects of arousal on performance follow a U-shaped pattern – very low and high levels may be detrimental. In a life-or-death scenario, as with helicopter egress, it is reasonable that if darkness further increases arousal, egress may be adversely affected.

To help prepare for an emergency egress, many military organizations and industries have mandated that relevant personnel complete helicopter underwater escape training (HUET). However, no universal training standard or assessment standard exists (Taber & Mcgarr, 2013); thus, whether trainees practice egress in low-light conditions will vary based on the best practices of individual training facilities. Limited research exists on optimal training curriculums to improve performance and survivability. The principle of learning specificity states that practice is most effective when it closely matches actual performance conditions (Proteau, Marteniuk, & Lévesque, 1992). Skill learning is contingent upon the development of a sensorimotor plan that is sensitive to sensory information available during practice (Elliott, Chua, Pollock, & Lyons, 1995; Mackrous & Proteau, 2007; Proteau et al., 1992) and the learner's emotional state (Bower, Monteiro, & Gilligan, 1978; Schare, Lisman, & Spear, 1984). According to these principles, helicopter egress practice should be conducted in low-light and anxiogenic conditions to optimize learning.

One challenge is achieving the optimal level of arousal or anxiety during learning. Conditions with very low or excessively elevated levels of arousal are thought be detrimental to learning (Frankenhaeuser & Gardell, 1976; Weinberg & John, 1978). HUET is generally perceived as stressful, resulting in a reluctance to further increase task difficulty (Taber & Mcgarr, 2013). Graduated learning involves increases in task complexity as practice progresses (Guadagnoli, & Lee, 2004; Schmidt & Lee, 2004). Thus if anxiety impairs learning during HUET, then employing graduated learning by introducing potentially anxiety-inducing elements, such as darkness, later in practice may help mitigate negative effects.

This study aimed to evaluate the effects of lighting on retention and practice performance and on state anxiety during conduct of simulated helicopter egress sequences in a dry simulator. Retention involves evaluation of a trained task after some time interval, which serves to remove effects of transient performance-influencing factors such as fatigue, motivation, and affective state (Issurin, 2013; Movahedi, Sheikh, Bagherzadeh, Hemayattalab, & Ashayeri, 2007; Schmidt & Lee, 2004; Schmidt & Wrisberg, 2008). As a result, testing is the preferred method to assess learning. Practice occurred either with all trials in the light (Light Group), all trials in the dark (Dark Group), or half of the trials in the light followed by half in the dark (Graduated Group). The influence of lighting during learning on state anxiety and performance was assessed. We hypothesized that: a) the Dark Group would have superior retention performance in the dark compared to the Light

Group, supporting the principle of learning specificity; b) higher anxiety levels during practice would be observed in the Dark Group and during the retention test in the dark; and c) the Graduated Group (who practiced in the light and then the dark) would have similar performance to both the Light and Dark Groups in the respective retention tests.

2.2 Methods

2.2.1 Participants.

Thirty-eight participants (20 females, 18 males; average age (SD): 31 (11) years, range: 19-58) were recruited from the local community. All participants had self-reported normal vision and gave written consent. Procedures complied with the Declaration of Helsinki and ethics was approved by the Interdisciplinary Committee on Ethics in Human Research at Memorial University protocol 20180377-HK.

2.2.2 Task & apparatus.

Experimental procedures were conducted at the Marine Institute's Offshore Safety and Survival Centre (MI-OSCC), Conception Bay South, Newfoundland, Canada. Trials were conducted in the dry Help Quest Helicopter Ditching Simulator (Virtual Marine, St. John's, NL) without use of the motion platform or simulated helicopter noise. The interior of the simulator replicates a Silorsky S-92, which is used commonly for operational purposes internationally. For practical reasons, the simulator contains only four seats (two seats each by a starboard side window and two each by a port side window, forming two rows) compared to 19 in the S-92.

Practice trials were conducted in the front and rear port window seats and front starboard window seat since these seats had push-out window exits. Retention trials were conducted in the front port window seat. The front port seat was always in a crash attenuated position (stroked), which is low to the ground. Evidence suggests that egress from a stroked seat position is more challenging than from a normal position (Taber, Sweeney, Bishop, & Boute, 2017; Taber & Mcgarr, 2013).

Participants performed a standardized escape sequence (Appendix 1) during a simulated submerged helicopter ditching. The sequence included the following: taking off a headset; putting on a hood; putting on a scuba-type mask; crossing arms and tucking the head to brace for “impact”; putting a scuba-type regulator (mouthpiece attached to a compressed air-filled cylinder) in the mouth; preparing to exit by pushing the window; and unbuckling a four-point harness. Participants were prompted to execute sequence steps by the following verbal commands (given in the order listed): "*ditching, ditching, ditching"*; "*brace, brace, brace"*; and "*impact, impact, impact"*. Cues were given at regular elapsed time intervals - the *ditching* call was given 30-45 seconds after the *brace* call (time interval based on completion of ditching steps), and the *impact* call was given 15 seconds after the *brace* call.

2.2.3 Procedures.

Permuted block randomization was used to allocate participants into one of the following training groups: with room lights on for all trials (Light); with room lights off for all trials (Dark); or in the light for half of the trials and in the dark for the other half (Graduated). The Graduated group was intended to evaluate effects of progressive learning (Guadagnoli & Lee, 2004)

The experiment consisted of a didactic session followed by simulator-based trials.

The didactic session consisted of a 20-minute pre-recorded training video in which a qualified and experienced instructor presented adapted material from the existing HUET course offered by the MI-OSSC. Information relevant to helicopter egress using helicopter underwater escape breathing apparatus (HUEBA) was maintained, while other non-pertinent material was removed. Didactic sessions included up to four participants. HUET is regularly taught using group instruction format.

Participants performed simulator trials individually. Each participant was allotted one orientation trial with real-time feedback immediately preceding practice trials. The orientation trial was conducted in the rear starboard position, which was not used for practice or retention trials. No feedback was given once practice trials commenced.

Prior to practice, participants were equipped with a Medtronics Zephyr Bioharness (Zephyr Technology Corporation, Annapolis, MD, US), which allowed for continuous recording of heart rate variability (HRV) and breathing rates. Practice trials consisted of six total sequence executions, which is similar to the amount of practice performed during a HUET course. Participants rotated through each seat position (front and back port side; front starboard side) twice. Seat position order was counterbalanced. Practice trials took approximately 30 minutes to complete.

Following practice trials, participants were given approximately a 30- to 60-minute break prior to retention testing. During this time, participants remained onsite and were permitted to engage in leisure activities of choice (e.g. reading, browsing on internet). For all participants, the retention tests consisted of one trial in the stroked seat in the dark followed by one trial in the light. Retention tests took approximately 10 minutes to complete. All practice and retention trials were recorded with a Flir T430sc series infrared video camera.

2.2.4 Dependent variables.

Measures of performance included accuracy and movement time. Movement time was defined as the time in seconds (s) from the first action taken after the *ditching* command to when movement ceased. Participants were instructed to pause in the final position when he or she felt that the sequence was completed. Accuracy was measured with a checklist (refer to Appendix 1) where participants were awarded a point for every task in the sequence that was correctly performed. All subtasks had to be performed correctly and in the appropriate sequence to be awarded the point. Maximum possible score was seven. This checklist was developed through consultation with experienced HUET instructors at the OSSC and the training requirements of the Canadian Association of Petroleum Producers.

The State-Trait Anxiety Inventory (STAI) Form Y was used to measure state anxiety (Spielberger, 1983). Participants were asked to fill out this form at the following timepoints: 1) post-practice trials, 2) pre-retention tests, 3) post-dark retention test, and 4) post-light retention test. The inventory consists of 40 statements such as "I feel at ease" or "I am a steady person". Participants selected one of four options on a Likert scale (ranging from "not at all" to "almost always" about how much they agree with the statement in that moment. Summation of the scores gave an estimate of anxiety, with higher cumulative scores indicating greater anxiety levels.

2.2.5 Analysis.

For every trial, heart rate variability and breathing rate were averaged across the first 10 seconds following each verbal command ('ditching', 'brace', 'impact'). Since movement time differed for each participant, averaging the first 10 seconds allowed standardization and ensured that action execution was predominantly captured

Dependent measures during practice were analyzed by separate 3 (Group: Dark; Light; Graduated) X 3 (seat-position; front starboard; back port; front stroked port) Analyses of Variances (ANOVAs) with repeated measures on the seat-position factor.

Learning was evaluated by comparing practice trials conducted in the stroked seats, the dark retention test, and the light retention test. Data were analyzed in separate 3 (Group: Dark; Light; Graduated) X 3 (phase: practice trials in front stroked port seat; dark retention in stroked port seat; light retention in stroked port seat) ANOVAs with repeated measures on the phase factor.

State anxiety was evaluated by a 3 (Group: Dark, Light, Graduated) X 4 (timepoint: post-practice trials, pre-retention trials, post-dark retention trial, post-light retention trial) ANOVA with repeated measures on the last factor. Tests for the assumptions of normality, homogeneity of variance, and sphericity were conducted for each ANOVA.

2.3 Results

Data from thirty-six participants were included in the analysis. Two participants were excluded due to loss of performance data.

2.3.1 Comparison of practice trials.

Accuracy: There was no main effect of Group (F (2, 29) = 2.368, p = .112, η^2_p = .140) or seat (F (2, 58) = .865, p = .426, η^2_p =.029). There was a significant Group by seat-position interaction (*F* (4, 58) = 2.79, *p* = .035, η^2_p = .161). Plots of each independent variable were used to assess interactions and inform post-hoc procedures. Post-hoc analysis was done by using three separate one-way ANOVAs for each seat positions. No significant effects were found (starboard (*F* (2, 30) = 1.327, *p* = .280, η^2_p = .264); back port (*F* (2, 30) = 3.19, *p* = .055, η^2_p = .175); and front stroked port: *(F* (2, 29) = 1.758, *p* = .190, η^2_p = .108).

Movement time: There were no statistically significant main effects for Group (*F* (2, 29) = .510, *p* = .606, η^2_p = .034) or seat position (*F* (2, 58) = .325, *p* = .722, η^2_p = .011), or for the interaction of these two factors (*F* (4, 58) = .580, *p* = .678, η^2_p = .038).

Breathing rate: No statistically significant main effects for Group (*F* (2, 58) = .205, *p* = .816, eta^2 = .014) or seat position (*F* (2, 58) = .374, *p* = .690, η^2_p = .013) were found. As well, the interaction of these factors (*F* (4, 58) = 1.166, *p* = .335, η^2_p = .074) was not statistically significant.

Heart rate variability: There were no statistically significant differences for Group (F (2, 26) = 1.930, p = .165, η2p = .933), seat position (F (2, 52) = .956, p = .391, η2p = .035), or for the interaction of condition and seat position, (F (4, 52) = .048, p = .996, η2p = .004).

2.3.2 Comparison of practice, dark, and light retention - evaluation of learning.

Accuracy: Analysis revealed a statistically significant main effect of phase (F (2, 58) = 6.012, p = .004, η^2_p = .172). Least Significance Difference (LSD) post hoc tests revealed that accuracy during the dark retention trial (mean = 4.9 was significantly better than during the practice trials (mean = 4.4; p = .006, Figure 1) and the light retention trial (mean = 4.6; p = .033; *Figure 1*). There was no significant main effect of Group (F (2, 29) = 1.168, p = .325, η^2_p = .075) or interaction effect of Group and phase (F (4, 58) = .819, p = .518, η^2_p = .053).

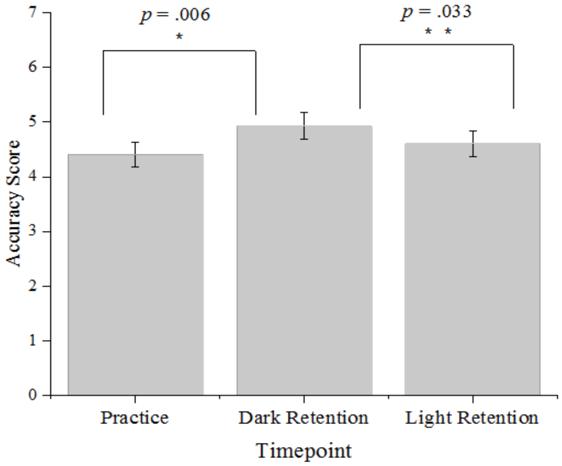

Figure 1. Comparison of accuracy scores in the stroked seat during practice trials, dark retention test, and light retention tests. Standard error is represented by error bars.

Movement time: Mauchly's test indicated that the assumption of sphericity has been violated for the main effect of trial ($\chi^2(2) = 7.067$, p = .029); therefore, degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (ε = .920). A significant main effect of phase was found (F (1.839, 53.335) = 5.911, p = .006, η^2_p = .169). LSD post hoc tests indicated that participants took significantly longer during the practice trial (mean =

44.5 s) than during the light retention trial (mean = 39.2 s; *p* = .001; *Figure 2*). No significant main effect of Group (*F* (2, 29) = .544, *p* = .586, η^2_p = .036) or an interaction of phase and condition were found (*F* (3.678, 53.335) = .819, *p* = .625, η^2_p = .042).

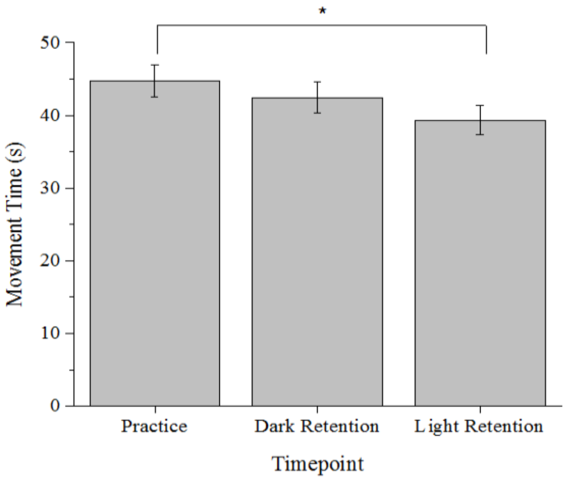

Figure 2. Comparison of movement time during practice trials in the stroked seat, the dark retention test, and the light retention test. Standard error is represented by error bars.

Breathing rate: No statistically significant differences were revealed for the main effects of Group (*F* (2, 24) = 1.055, *p* = .364, η^2_p = .081) or phase (*F* (2, 48) = 1.017, *p* = .369, η^2_p = .041) as well as the interaction of these two factors (*F* (4, 48) = .155, *p* = .960, η^2_p = .013).

Heart rate variability: No statistically significant differences were revealed for the main effects of Group (F (2, 22) = 1.069, p = .360, η2p = .089 or phase (F (2, 44) = 2.302, *p* = .112, η^2_p = .095) or the interaction of these variables (*F* (4, 44) = 1.356, *p* = .265, η^2_p = .110).

State anxiety: Mauchly's test indicated that the assumption of sphericity had been violated for the main effects ($\chi^2(2) = 13.197$, $p = .022$) and therefore, degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .895$). A significant main effect of phase was found ($F\,(2.685, 91.289) = 3.738$, $p = .017$, $\eta^2_p = .099$). LSD post hoc tests revealed that participants reported a significantly lower level of state anxiety after the light retention trial (mean = 26.047) than post practice trials (mean = 30.125, $p = .008$) and pre dark retention tri (mean = 29.033, $p = .024$; *Figure 3*). No significant main effect of Group ($F\,(2, 34) = .536$, $p = .590$, $\eta^2_p = .031$) or an interaction of Group and Timepoint were revealed ($F\,(5.370, 91.289) = .819$, $p = 1.196$, $\eta^2_p = .066$).

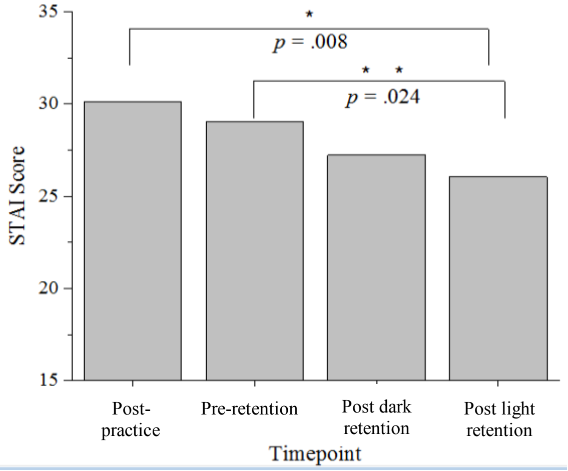

Figure 3. Comparison of average reported state anxiety index scores post-practice trials, pre-retention trials, post dark retention test, and post light retention test.

2.4 Discussion

This is the first study aimed to evaluate performance of simulated helicopter escape sequences conducted in the dark and in the light after practice occurred either in the light, in the dark, or with half the trials in the light followed by half in the dark (Graduated). We hypothesized that in comparison to the Light Group, the Dark Group would demonstrate superior overall retention, higher anxiety during practice trials, and higher anxiety during the dark retention test. We also hypothesized that the Graduated Group would perform equivalently to both the Light and Dark Groups in the respective retention test. Results did not support our hypotheses. Performance, learning, and state anxiety did not differ significantly across groups, indicating that ambient lighting during practice does not appear to impact performance. Based on findings, training in the light appears to be appropriate for performance and learning of helicopter escape sequences. Findings may inform training standards and be relevant to other extreme environments domains, such as within the search and rescue and cave diving, where ambient light levels may vary and may impact performance.

Ambient lighting level during practice did not appear to have a significant effect on anxiety levels during practice of helicopter escape sequences. It is plausible that this may be because study procedures, conducted in a motionless and dry simulator, did not appear to increase participant stress or anxiety as would be expected during a HUET course (conducted in water) or an actual helicopter ditching (Robinson, Sünram-Lea, Leach, & Owen-Lynch, 2008; Tipton, Gibbs, Brooks, Roiz de Sa, & Reilly, 2010). Overall, participants reported very low levels of state anxiety. STAI scores were highest after learning trials (mean (SD) = 29.95 (11.46)); however, this is still lower than the average normative scores from working adults (mean (SD) = 35.46 (10.51)) and from college students (mean (SD) = 37.62 (10.99)) (Spielberger, 1983). Anxiety was significantly lower post-light retention trial compared to post-practice trials and pre-retention trials. This may reflect familiarization with procedures. The STAI was not administered before the practice trials; therefore it cannot be determined if state anxiety significantly differed pre-study compared to post-study. Testing effects also cannot be ruled out; it is possible that state anxiety decreased as participants knew the study was nearing completion.

Interestingly, all participants performed more accurately during the dark retention trial than during the light retention trial or during the practice trials conducted in the stroked seat; however, movement times were significantly shorter during the light retention trial. This is indicative of a speed-accuracy trade-off. It is possible that the dark retention trial conditions promoted more optimal arousal conditions than the light retention trial conditions. The Yerkes-Dodson law states that increased arousal will improve performance until optimal performance is achieved, after which point performance will decline as arousal further increases. An increase in attentional demands may redirect cognitive resources to focus on the threat, which may distract from the task and cause performance decrement (Wine, 1971). Alternatively, attentional resources may be directed towards the task as self-awareness increases with anxiety. This may be detrimental to performance by disrupting automatic processes (Eysenck & Calvo, 1992); however, it can also benefit learning by inducing the allocation of more cognitive resources for task completion, which may attenuate aversive threat effects (Eysenck, Derakshan, Santos, & Calvo, 2007).

The principle of learning specificity has been primarily demonstrated in studies where participants have extensive practice. Evidence suggests that specificity effects are positively correlated with experience level, and thus are predominantly seen after the sensorimotor plan for a skill has been engrained and is automated (Krigolson & Tremblay, 2009; Proteau, 2005; Proteau, Marteniuk, Girouard, & Dugas, 1987; Tremblay & Proteau, 2001). Participants in this study had either limited or no HUET experience. It is likely that experts would experience performance decrements if escape occurred in the dark, but training had previously been conducted in the light. Another explanation may be that helicopter escape is visually mediated. Future studies should aim to include both experts and novices and evaluate the dominant sensory source required for motor plan development.

There were several limitations to this study. The retention period in this study was approximately 30 minutes. A longer retention period that permitted sleep consolidation would be realistic and may have impacted results. Also, as mentioned, this study was conducted in a dry, motionless simulator. It is anticipated that the inclusion of more naturalistic stressors such as noise and motion from the helicopter, heat stress and discomfort from the flight suits, and, perhaps most importantly, escape while underwater would have greater effects.

In summation, our results suggest that practice of helicopter escape sequences in .the light may be sufficient for performance during a dry simulation. It is interesting to note, however, that the average accuracy across groups for the dark and light retention test were both 5 points out of a maximum of 7 points. Arguably, any score less than 7 could have severe consequences in the real-world. Higher fidelity studies would help to better characterize optimal practice conditions to further inform training standards.

2.4 References

Allan, J. R. (1988). An illuminated guide bar as an aid for underwater escape from helicopters. *RAF Institute of Aviation Medicine Report*, 566.

Barnett, M. L., Ross, D., Schmidt, R. A., & Todd, B. (1973). Motor skills learning and the specificity of training principle. *Research Quarterly, American Association for Health, Physical Education and Recreation, 44*(4), 440-447.

Baumeister, R. F. (1984). Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology*, *46*(3), 610-620.

Behan, M., & Wilson, M. R. (2008). State anxiety and visual attention: The role of the quiet eye period in aiming to a far target. *Journal of Sport Sciences*, 26, 207-215.

Beuter, A., & Duda, J. L. (1985). Analysis of the arousal/motor performance relationship in children using movement kinematics. *Journal of Sport Psychology, 7*, 229-243.

Blöbaum, A., & Hunecke, M. (2005). Perceived Danger in Urban Public Space. *Environment and Behavior*, *37*(4), 465-486.

Bower, G. H., Monteiro, K. P., & Gilligan, S. G. (1978). Emotional mood as a context for learning and recall. *Journal of Verbal Learning and Verbal Behavior*, *17*(5), 573-585.

Brooks, C. J., MacDonald, C. V., Donati, L., & Taber, M. J. (2008). Civilian Helicopter Accidents into Water: Analysis of 46 Cases, 1979-2006. *Aviation, Space, and Environmental Medicine*, *79*(10), 935-940.

Brooks, C. J., MacDonald, C. V, Baker, S. P., Shanahan, D. F., & Haaland, W. L. (2014).

Helicopter Crashes into Water: Warning Time, Final Position, and Other Factors Affecting Survival. *Aviation, Space, and Environmental Medicine*, *85*(4), 440-444.

Butler, F. (1995). Diving and Hyperbaric Ophthalmology. *Survey of Ophthalmology*, *39*(5), 347-66.

Calvo, M. G., Alamo, L., & Ramos, P. M. (1990). Test anxiety, motor-performance and learning - attentional and somatic interference. *Personality and Individual Differences*, *11*(1), 29-38.

Carron, A. V., & Morford, W. R. (1968). Anxiety, stress and motor learning. *Perceptual and Motor Skills*, *27*(2), 507-511.

Cheung, B., Hofner, K., Brooks, C. j, & Gibbs, P. (2000). Underwater Disorientation as Induced by Two Helicopter Ditching Devices. *Aviation, Space, and Environmental Medicine*, *71*(9), 879-888.

Coleshaw, S. R. K. (2012). Minimum performance requirements for helicopter underwater breathing systems. *Journal of Ocean Technology*, *7*(3), 60-73.

Coombes, S. A., Higgins, T., Gamble, K. M., Cauraugh, J. H., & Janelle, C. M. (2009). Attentional control theory: Anxiety, emotion, and motor planning. *Journal of Anxiety Disorders, 23*(8), 1072-1079.

Cox, R. H. (1983). Consolidation of pursuit rotor learning under conditions of induced arousal. *Research Quarterly for Exercise and Sport, 54*(3), 223-228.

Duncko, R., Cornwell, B., Cui, L., Merikangas, K. R., & Grillon, C. (2007). Acute exposure to stress improves performance in trace eyeblink conditioning and spatial learning tasks in healthy men. *Learning and Memory*, *14*(5), 329-335.

Elliott, D., Chua, R., Pollock, B. J., & Lyons, J. (1995). Optimizing the use of vision in manual aiming: the role of practice. *The Quarterly Journal of Experimental Psychology Section A*, *48*(1), 72-83.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and Performance: the Processing Efficiency Theory. *Cognition & Emotion*, *6*(6), 409-434.

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: attentional control theory. *Emotion*, *7*(2), 336-353.

Frankenhaeuser, M., & Gardell, B. (1976). Underload and overload in working life: outline of a multidisciplinary approach. *Journal of Human Stress*, *2*(3), 35-46.

Frings, D., Rycroft, N., Allen, M. S., & Fenn, R. (2014). Watching for gains and losses: the effects of motivational challenge and threat on attention allocation during a visual search task. *Motivation and Emotion*, *38*(4), 1-10.

Gratch, J., & Marsella, S. (2003). Fight the way you train: the role and limits of emotions in training for combat. *The Brown Journal of World Affairs*, *10*(1), 63-75.

Gray, J. A. (1987). Gray, J. A. (1987). Problems in the behavioural sciences, Vol. 5. The psychology of fear and stress (2nd ed.). New York, NY, US: Cambridge University Press.

Grierson, L. E. (2014). Information processing, specificity of practice, and the transfer of learning: considerations for reconsidering fidelity. *Advances in Health Sciences Education*, *19*(2), 281-289.

Guadagnoli, M. A., & Lee, T. D. (2004). Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor*

Behavior, *36*(2), 212-224.

Hancock, P. A. (1989). A dynamic-model of stress and sustained attention. *Human Factors*, *31*(5), 519-537.

Hardy, L., Mullen, R. and Jones, G. (1996). Knowledge and conscious control of motor actions under stress. *British Journal of Psychology, 87*(4), 621-636.

Helsen, W. F., Tremblay, L., Berg, M. V. D., & Elliott, D. (2004). The role of oculomotor information in the learning of sequential aiming movements. *Journal of Motor Behavior*, *36*(1), 82-90.

Henry, F. M. (1968). Specificity vs. generality in learning motor skill. In R. C. Brown, Jr., & G. S. Kenyon, *Classical Studies in Physical Activity* (pp. 328-331). Englewood Cliffs, NJ: Prentice-Hall.

Hietanen, J. K., Perrett, D. I., Oram, M. W., Benson, P. J., & Dittrich, W. H. (1992). The effects of lighting conditions on responses of cells selective for face views in the macaque temporal cortex. *Experimental Brain Research, 89*(1), 157-171.

Hordacre, B., Immink, M. A., Ridding, M. C., & Hillier, S. (2016). Perceptual-motor learning benefits from increased stress and anxiety. *Human Movement Science*, *49*, 36-46.

Issurin, V. B. (2013). Training transfer: scientific background and insights for practical application. *Sports Medicine*, *43*(8), 675-694.

Krigolson, O. E., & Tremblay, L. (2009). The amount of practice really matters: specificity of practice may be valid only after sufficient practice. *Research Quarterly for Exercise and Sport*, *80*(9), 197-204.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1998). Emotion, motivation, and anxiety: Brain mechanisms and psychophysiology. *Biological Psychiatry*, *44*(12), 1248-1263.

Lawrence, G. P., Cassell, V. E., Beattie, S., Woodman, T., Khan, M. A., Hardy, L., & Gottwald, V. M. (2014). Practice with anxiety improves performance, but only when anxious: Evidence for the specificity of practice hypothesis. *Psychological Research, 78*(5), 634-650.

Luria S. M., Ryack B. L., & Neri D. F. (1982). *Desirable characteristics of underwater lights for helicopter escape hatches* (No. NSMRL-990). Groton, CT: Naval Submarine Medical Research Laboratory.

Mackrous, I., & Proteau, L. (2007). Specificity of practice results from differences in movement planning strategies. *Experimental Brain Research*, *183*, 181-193.

Marteniuk, R. G., & Wenger, H. A. (1970). Facilitation of pursuit rotor learning by induced stress. *Perceptual and Motor Skills, 31*(2), 471-477.

Masters, R. S. W. (1992). Knowledge, nerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology, 83*(3), 343-358.

Moore, L. J., Vine, S. J., Wilson, M. R., & Freeman, P. (2012). The effect of challenge and threat states on performance: An examination of potential mechanisms. *Psychophysiology*, *49*(10), 1417-1425.

Morris, L. W., Davis, M. A., & Hutchings, C. H. (1981). Cognitive and emotional components of anxiety: Literature review and a revised worry-emotionality scale.

Journal of Educational Psychology, *73*(4), 541.

Movahedi, A., Sheikh, M., Bagherzadeh, F., Hemayattalab, R., & Ashayeri, H. (2007). A practice-specificity-based model of arousal for achieving peak performance. *Journal of Motor Behavior*, *39*(6), 457-462.

Nasar, J. L., & Jones, K. M. (1997). Landscapes of Fear and Stress. *Environment and Behavior*, *29*(3), 291-323.

Nieuwenhuys, A., & Oudejans, R. R. (2012). Anxiety and perceptual-motor performance: toward an integrated model of concepts, mechanisms, and processes. *Psychological Research*, *76*(6), 747-759.

Noteboom, J. T., Barnholt, K. R., & Enoka, R. M. (2001). Activation of the arousal response and impairment of performance increase with anxiety and stressor intensity. *Journal of Applied Physiology*, *91*(5), 2093-2101.

O'Neill, B. D., Kozey, J. W., & Brooks, C. J. (2004). Underwater detectability of a lighting system on a helicopter escape exit. *Aviation, Space, and Environmental Medicine*, *75*, 526-530.

Oudejans, R. R. D., & Pijpers, J. R. (2009). Training with anxiety has a positive effect on expert perceptual-motor performance under pressure. *Quarterly Journal of Experimental Psychology, 62*(8), 1631-1647.

Oudejans, R. R. D., & Pijpers, J. R. (2010). Training with mild anxiety may prevent choking under higher levels of anxiety. *Psychology of Sport & Exercise, 11*, 44-50.

Pemberton, C. L., & Cox, R. H. (1981). Consolidation theory and the effects of stress and anxiety on motor behavior. *International Journal of Sport Psychology*, *12*(2), 131-

139.

Pijpers, J. R., Oudejans, R. R. D., Holsheimer, F., & Bakker, F. C. (2003). Anxiety-performance relationships in climbing: A process-oriented approach. *Psychology of Sport and Exercise*, *4*(3), 283-304.

.Proteau, L. (2005). Visual afferent information dominates other sources of afferent information during mixed practice of a video-aiming task. *Experimental Brain Research*, *161*(4), 441-456.

Proteau, L., & Carnahan, H. (2001). What causes specificity of practice in a manual aiming movement: Vision dominance or transformation errors?. *Journal of Motor Behavior*, *33*(3), 226-234.

Proteau, L., Marteniuk, R. G., Girouard, Y., & Dugas, C. (1987). On the type of information used to control and learn an aiming movement after moderate and extensive training. *Human Movement Science*, *6*, 181-199.

Proteau, L., Marteniuk, R. G., & Lévesque, L. (1992). A sensorimotor basis for motor learning: Evidence indicating specificity of practice. *The Quarterly Journal of Experimental Psychology Section A*, *44*(3), 557-575.

Robinson, S. J., Sünram-Lea, S. I., Leach, J., & Owen-Lynch, P. J. (2008). The effects of exposure to an acute naturalistic stressor on working memory, state anxiety and salivary cortisol concentrations. *The International Journal on the Biology of Stress*, *11*(2), 115-124.

Ryack, B. L., Luria, S. M., & Smith, P. F. (1986). Surviving helicopter crashes at sea: A review of studies of underwater egress for helicopters. *Aviation, Space, and*

Environmental Medicine, *57*, 603-609.

Sage, G. H., & Bennett, B. (1973). The effects of induced arousal on learning and performance of a pursuit motor skill. *Research Quarterly*, *American Association for Health, Physical Education and Recreation, 44*(2), 140-149.

Schare, M. L., Lisman, S. A., & Spear, N. E. (1984). The effects of mood variation on state-dependent retention. *Cognitive Therapy and Research*, *8*(4), 387-407.

Schmidt, R. A., & Bjork, R. A. (1992). New conceptualizations of practice: Common principles in three paradigms suggest new concepts for training. Psychological Science, *3(*4), 207-218.

Schmidt, R. A., & Lee, T. D. (2004). *Motor control and learning: A behavioral emphasis*. (4th ed.). Champaign, IL: Human Kinetics.

Schmidt, R. A., & Wrisberg, C. A. (2008). *Motor learning and performance: A situation-based learning approach* (4th ed.). Human Kinetics.

Schupp, H. T., Junghofer, M., Weike, A. I., & Hamm, A. O. (2003). Emotional facilitation of sensory processing in the visual cortex. *Psychological Science*, *14*(1), 7-13.

Schutter, D., Hofman, D., & Van Honk, J. (2008). Fearful faces selectively increase corticospinal motor tract excitability: A transcranial magnetic stimulation study. *Psychophysiology, 45*(3), 345-348.

Schwenkmezger, P., & Steffgen, G. (1989). Anxiety and motor performance. In *Normalities and Abnormalities in Human Movement* (Vol. 29, pp. 78-99). Karger Publishers.

Spielberger, C. (1983). *Manual for the State-Trait Anxiety Inventory. rev. ed.* Palo Alto:

Consulting Psychologists Press.

Stokes, A. F., & Kite, K. (2001). On grasping a nettle and becoming emotional. In *Stress, Workload, and Fatigue. Mahwah, NJ: L. Erlbaum*, 162-181.

Taber, M. J. (2014). Simulation fidelity and contextual interference in helicopter underwater egress training: An analysis of training and retention of egress skills. *Safety Science*, *62*, 271-278.

Taber, M. J., & Mcgarr, G. W. (2013). Confidence in future helicopter underwater egress performance: An examination of training standards. *Safety Science*, *60*, 169-175.

Taber, M. J., Sweeney, D., Bishop, N., & Boute, R. (2017). Factor effecting the capability to jettison an S92 push-out window. *International Journal of Industrial Ergonomics*, *58*, 79-89.

Taber, M., & McCabe, J. (2006). Helicopter ditching: Time of crash and survivability. *Journal of Safety Research*, *34*, 5-10.

Tepas, D., & Price, J. (2001). What is stress and what is fatigue. In *Stress, Workload, and Fatigue.* Mahwah, NJ: Erlbaum.

Tipton, M. J., Gibbs, P., Brooks, C., Roiz de Sa, D., & Reilly, T. J. (2010). ECG during helicopter underwater escape training. *Aviation, Space, and Environmental Medicine*, *81*, 399-404.

Tremblay, L., & Proteau, L. (2001). Specificity of practice in a ball interception task. *Canadian Journal of Experimental Psychology, 55*(3), 207-218.

Tremblay, L., & Proteau, L. (1998). Specificity of practice: The case of powerlifting. *Research Quarterly for Exercise and Sport*, 69(3), 284-289.

Vine, S. J., Freeman, P., Moore, L. J., Chandra-Ramanan, R., & Wilson, M. R. (2013). Evaluating stress as a challenge is associated with superior attentional control and motor skill performance: Testing the predictions of the biopsychosocial model of challenge and threat. *Journal of Experimental Psychology: Applied*, *19*(3), 185-194.

Warr, M. (1990). Dangerous situations: Social context and fear of victimization. *Social Forces*, *68*(3), 891-907.

Watson, D., & Clark, L. A. (1997). Measurement and mismeasurement of mood: Recurrent and emergent issues. *Journal of Personality Assessment, 68*(2), 267-296.

Wells, R. (2010). Canada-Newfoundland and Labrador offshore helicopter safety inquiry (Vol. 1). St. John's, NL: Canada-Newfoundland and Labrador Offshore Petroleum Board.

Weinberg, R. S., & John, R. (1978). Motor performance under three levels of trait anxiety and stress. *Journal of Motor Behavior*, *10*(3), 169-176.

Wine, J. (1971). Test anxiety and direction of attention. *Psychological Bulletin, 76*(2), 92-104.

Yoshie, M., Kudo, M., Murakoshi, T., & Ohtsuki, T. (2009). Music performance anxiety in skilled pianists: Effects of social evaluative performance situation on subjective, autonomic, and electromyographic reactions. *Experimental Brain Research*, *199*(2), 117-126.

2.5 Appendix - Accuracy Assessment

Simulated Helicopter Escape Sequence Checklist (max score = 7 points)

Call 1: Ditching

1) Performed actions to get watertight
    - Took off headset
    - Put on hood (positioned correctly & tucked all hair inside hood)
    - Pulled up hood zipper
    - Put on mask (positioned correctly & placed skit of mask below hood)

Call 2: Brace

2) Assumed brace position
    - Crossed arms with fingers under shoulder harness (placed arm closest to exit on top & hooked HUEBA hose with thumb on hand farthest from the window)
    - Placed feet flat on the floor and clear of seats

Call 3: Impact

3) Gazed out window & maintained gaze throughout subsequent steps
4) Opened window
5) Placed hand or elbow closest to exit on window corner & maintained contact throughout subsequent steps
6) Deployed HUEBA
    - Removed dust cap from regulator with appropriate hand
    - Placed HUEBA in mouth
7) Released harness