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**THE EFFECT OF MENTAL SKILLS TRAINING
ON FIREFIGHTER PERFORMANCE UNDER STRESS**

by

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September 2023

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**THE EFFECT OF MENTAL SKILLS TRAINING
ON FIREFIGHTER PERFORMANCE UNDER STRESS**

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Submitted in partial fulfillment of the
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ABSTRACT

Firefighters must make time-pressured, critical decisions under physically, mentally, and emotionally demanding conditions, but most lack tools and techniques to mitigate the effects of stress on performance. This study investigated the effect of a firefighter-specific mental skills training curriculum in a population of recruits at an urban fire department training academy. Participants who received the mental skills training had a statistically significant decrease in the magnitude of their physiological stress response. The findings of this study are consistent with previous research on the techniques presented and suggest that they would be a valuable addition to firefighter training curricula. Fire departments should incorporate mental skills training into their teaching methods to improve the ability of their firefighters to operate effectively in high-stress environments.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	analysis of variance
ANS	autonomic nervous system
FD	fire department
GSR	galvanic skin response
GST	goal-setting theory
HR	heart rate
HRV	heart rate variability
JPR	job performance requirement
LUNAR	location, unit, name, air supply, resources
MST	mental skills training
OC	oleoresin capsicum
PASS	personal alert safety system
PSNS	parasympathetic nervous system
RMSSD	root mean square of successive differences
SCBA	self-contained breathing apparatus
SDNN	standard deviation of normal-normal (intervals)
SNS	sympathetic nervous system

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EXECUTIVE SUMMARY

Firefighting is a physically, mentally, and emotionally demanding profession. Firefighters make time-pressured, high-consequence decisions while performing physically challenging tasks, often under extreme environmental conditions. However, training efforts focus primarily on strategy, tactics, and physical performance and do not offer firefighters strategies for mitigating the negative effects of stress on human performance. Therefore, the firefighting profession needs research-backed methods that can improve decision-making, judgment, and outcomes under stress for this population.

This randomized control study tested the effect of mental skills training (MST), an approach used by other demanding professions, such as medicine, aviation, and military special operations, on firefighter performance under stress. Participants were recruited from the recruit academy of a large metropolitan fire department. In total, 46 recruits were included in the data collection: 26 in the experimental group and 20 in the control group. The groups were normalized for sex and prior experience. While the recruits in the intervention group were given an MST curriculum of approximately 60 minutes, those in the control group received a lecture on the effects of nutrition and cardiovascular disease on performance. After receiving classroom training, all participants donned firefighting gear and completed a firefighting exercise in a training building with live actors. This study collected data on task completion times, quality of task performance, physiological stress levels, and other metrics for analysis.

The framework for this study's MST curriculum for urban firefighters was developed by correlating the combined expertise from military, medical, law enforcement, and athletic programs with a relevant structural firefighting subtask. Like MST programs in other fields, this firefighter-specific MST curriculum focused on the four pillars of arousal control, visualization, goal setting, and self-talk. Arousal control techniques targeted breathwork, including diaphragmatic breathing, box breathing, and prolonged exhalation. Visualization presented the benefits of simulated mental practice paired with a guided example exercise. Goal setting identified the key components of high-quality goals and how setting interim and outcome goals could help successfully complete complex tasks

during high-stress emergency response. Self-talk strategies included instructional self-talk, motivational self-talk, and preparatory arousal. After the lecture, participants were divided into small groups and given opportunities to practice each technique in a series of breakout sessions.

During the experiment scenario, participants encountered a simulated collapse and found their crew replaced with training mannequins trapped under a large piece of concrete. Each participant then had to transmit a mayday message via portable radio. Task completion times were recorded by evaluators, and mayday transmissions were digitally recorded and later graded by independent assessors. At the conclusion of the scenario, participants completed an exit survey about their self-assessed performance and level of stress. Heart rate data were collected with a Polar H10 heart rate monitor chest strap during a rest period and throughout the evolution. The data from the heart rate monitors were later analyzed for changes in heart rate variability (HRV), a reliable index of stress.

As hypothesized, MST was shown to be effective in reducing the effects of stress across several physiological indicators, despite the short duration of the applied intervention. A statistical analysis of HRV during rest and work periods across both control and intervention groups examined three different HRV metrics: the root mean square of the successive differences between heartbeats, the standard deviation of normal-normal (SDNN) intervals, and the Baevsky stress index. Across all three metrics, the intervention group showed statistically significant improvements in HRV, indicating that the training was effective in mitigating the body's stress response and better preparing the group's members to respond to the emergency encountered.

Task times for locating the trapped firefighters and transmitting a distress signal did not differ significantly, likely due to the low level of difficulty in this experimental set up. The recorded emergency radio messages were graded by independent fire academy instructors using a rubric developed for this study. The intervention group showed a trend toward higher instructor-assigned grades that fell just shy of statistical significance. Some participants in both groups could reasonably be expected to have been exposed to the MST concepts through previous experiences in sports or prior professions. Nevertheless, the results of the post-exercise survey supported the a priori hypothesis that the intervention

group would utilize the MST techniques more heavily than the control group, even after only one hour of instruction. Those in the intervention group were significantly more likely to report both the use and perceived helpfulness of MST techniques.

MST is a highly effective, easy-to-implement methodology with proven effects on stress response in other high-demand fields. This study adds to that body of evidence by demonstrating the effect of MST on human performance in a firefighter population. Fire departments should incorporate these techniques into their teaching methods to improve the ability of their firefighters to operate effectively in high-stress environments. Further studies should examine the magnitude and longevity of stress response mitigation offered by MST when the training is delivered over multiple sessions with an opportunity for practice and reinforcement.

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In Memory of Lt. Steve Acton

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I. INTRODUCTION

Firefighting is a profession in which lives can hang in the balance, but training efforts overwhelmingly focus on strategy, tactics, and physical performance. There is a real need for development and implementation of research-backed methods that can improve decision-making, judgment, and outcomes under stress. This study tested the effect of one such method and offers a blueprint for fire departments to integrate training focused on mental performance into existing programs.

By its nature, firefighting is a demanding job. Firefighters must make time-pressured, high-consequence decisions with limited or incomplete information while working in unfamiliar surroundings. Fighting fires involves completing physically challenging tasks for sustained periods while wearing heavy and restrictive protective equipment, sometimes while exposed to extreme heat. Emergency response requires firefighters to exert themselves physically and psychologically while facing the threat of death or injury to themselves, their comrades, or civilian victims. Although safer than it was for previous generations, the profession is still dangerous. American firefighters suffered 60,815 line-of-duty injuries and 62 deaths in 2019.¹

Increased levels of physiological and emotional stress result from operational pressures during high-stakes incidents, and the industry is beginning to recognize the effects of this stress on human performance on the fireground. Recent investigative reports issued after line-of-duty deaths in residential fires in Frederick County and Baltimore, Maryland, include sections titled “Human Performance under Stress” and specifically recommend that departments implement training to improve firefighters’ and fire officers’ ability to manage heightened levels of stress.² Despite growing recognition of the need for

¹ U.S. Fire Administration, *Firefighter Fatalities in the United States in 2019* (Emmitsburg, MD: U.S. Fire Administration, 2020), 8.

² Frederick County Division of Fire and Rescue Services, *Captain Joshua Laird Line of Duty Death (LODD): After Action Report and Improvement Plan (AAR/IP)* (Frederick, MD: Frederick County Division of Fire and Rescue Services, 2022), <https://frederickcountymd.gov/24/Division-of-Fire-Rescue-Services-DFRS>; Baltimore City Fire Service Board of Inquiry, *205 S. Stricker Street* (Baltimore, MD: Baltimore City Fire Service Board of Inquiry, 2022), <https://www.bcitscripts.com/boireport.pdf>.

stress mitigation training, there is currently a dearth of evidenced-based guidance on techniques and strategies specific to firefighters that can be incorporated into routine practice. Because failure to successfully complete their tasks in the field can have fatal consequences for firefighters and civilians, this study was designed to identify specific, tangible methods that can be added to firefighter training curricula to improve their ability to perform under stress.

Before ever responding to their first emergency, firefighting recruits receive theoretical and skill-based training, with the average curriculum lasting 270 hours.³ Recruits must demonstrate proficiency in a series of job performance requirements that cover a range of minimum competencies from rolling hoses and raising ladders to rescuing victims and mitigating firefighter emergencies. Recruit training courses also include physical conditioning, often focusing on cardiovascular stamina and building strength. However, the basic firefighting curriculum outlined by the National Fire Protection Association neither addresses the mental strain associated with the job nor outlines short- or long-term stress-reduction techniques.⁴ Incorporating these techniques, particularly short-term stress-management strategies, into training may benefit firefighters and the greater community by improving fireground performance, which in turn may reduce line-of-duty injuries and deaths. Research in other fields, including the military, law enforcement, and medicine, provides insight into potential techniques for improving performance under stress that may be translatable to the field of firefighting. Bolstering the mental performance of firefighters completing tactically challenging tasks in a stressful, dangerous environment might be directly linked to measurable performance metrics.

The potential of mental skills training (MST) has been explored in fighter pilots, special forces' soldiers, surgeons, and others, leading to the development of programs shown to improve performance.⁵ Although the relationship between some of these

³ "Analysis of Recruit/Initial Fire Fighter Training Curricula: Executive Summary," National Fire Protection Association, March 2015, <https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Executive-summaries/ExecSumFireFighterTrainingCurricula.ashx>.

⁴ National Fire Protection Association.

⁵ Mental skills training (MST) and psychological skills training (PST) are synonymous in the relevant literature. For consistency, MST is used throughout this thesis.

techniques and perceived performance has been studied in firefighters, experimental data on their practical application are lacking. This study sought to evaluate the effectiveness of MST by delivering a block of instruction to a cohort of firefighting recruits and evaluating their performance on a range of metrics during a physically and psychologically demanding training exercise. By comparing their performance to a control group of recruits who did not receive the MST instruction, this thesis aimed to identify the value of including this kind of training in the basic firefighting curriculum. The results of this study support the established body of MST research and suggest that by adding an MST component to their existing curricula, fire departments could improve their members' ability to process situational stress and negotiate challenging scenarios, thus reducing injuries and saving lives.

A. RESEARCH QUESTION

Can the delivery of a brief MST curriculum tailored to firefighters impact the performance of job-related functions under stressful conditions?

B. LITERATURE REVIEW

To understand the potential benefit of MST and how it might be implemented in the fire service, first, it is important to explore the physiological basis of stress and the prior application of these techniques in other fields. Such an exploration reveals how MST might be applied in the unique environment of firefighter decision-making. The current uses of MST make it a promising candidate for application in the fire service.

1. Physiology of Stress and Decision-Making

Although high levels of stress can have a negative effect on performance, moderate stress can improve it. In 1908, Robert Yerkes and John Dodson proposed that increased stress has a linear correlation with performance on simple tasks. For complex tasks, however, performance increases only to a point and then begins to decrease. Past the point

of optimal performance, the effect of stress begins to negatively affect cognitive abilities.⁶ The Yerkes–Dodson curve, as shown in Figure 1, depicts the linear and non-linear relationships between arousal and performance based on task difficulty.

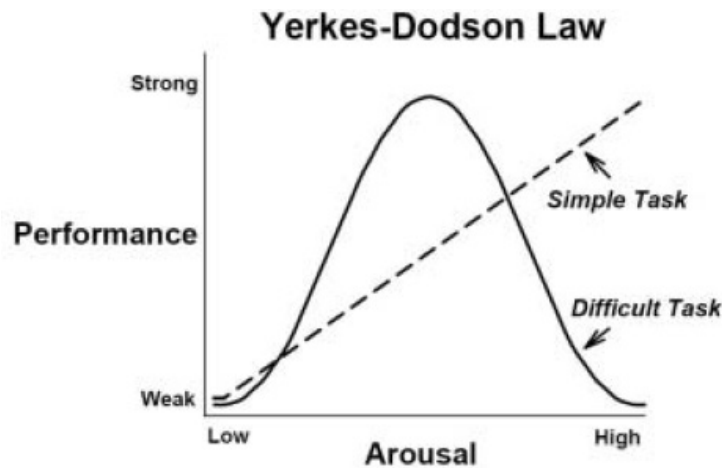


Figure 1. Yerkes–Dodson Curve.⁷

More recent research on the effects of glucocorticoids, stress hormones that play a role in arousal and cognition, has supported this inverted-U hypothesis. The relationship between circulating levels of glucocorticoids and memory function has been shown to follow a similar pattern, with memory performance initially increasing as glucocorticoid receptors begin to fill with the stress signal hormone. However, after the higher affinity Type I receptors are completely saturated and the lower affinity Type 2 receptors are 50 percent occupied, memory performance eventually decreases.⁸ In an experiment conducted to examine the effects of stress on cognitive agility, military officers played a video game while eye-tracking data were collected to examine attention-allocation patterns and

⁶ David M. Diamond et al., “The Temporal Dynamics Model of Emotional Memory Processing: A Synthesis on the Neurobiological Basis of Stress-Induced Amnesia, Flashbulb and Traumatic Memories, and the Yerkes–Dodson Law,” *Neural Plasticity* 2007 (2007): 60803, <https://doi.org/10.1155/2007/60803>.

⁷ Source: David M. Diamond, “Cognitive, Endocrine and Mechanistic Perspectives on Non-linear Relationships between Arousal and Brain Function,” *Nonlinearity in Biology, Toxicology, Medicine* 3, no. 1 (2005): 2, <https://doi.org/10.2201/nonlin.003.01.001>.

⁸ S. J. Lupien et al., “The Effects of Stress and Stress Hormones on Human Cognition: Implications for the Field of Brain and Cognition,” *Brain and Cognition* 65, no. 3 (December 2007): 209–37, <https://doi.org/10.1016/j.bandc.2007.02.007>.

cognitive load. The highest performers reported being more stressed by the game timer than their counterparts, which is consistent with the theory that a certain amount of stress improves performance. This study did not identify a threshold beyond which performance declined. Studies of athletes exposed to elevated levels of stress support the Yerkes–Dodson hypothesis of diminishing performance on the backside of the curve, with excessive stress causing decreases in peripheral vision and fine motor control and increases in state anxiety and heart rate.⁹

The autonomic nervous system (ANS) plays a key role in the body’s response to stress. The ANS comprises the parasympathetic nervous system (PSNS), which is activated during “rest and digest” periods, and the sympathetic nervous system (SNS), which generates the “fight or flight” response.¹⁰ As the ANS balance changes in response to stress, the SNS sends stronger signals than the PSNS, and measurable physiological changes take hold, including increases in heart rate (HR), respiration, and perspiration. With increasingly strong SNS signals, the interval between heartbeats becomes more regular. Heart rate variability (HRV), as measured by the average of normal-normal intervals and the low frequency/high frequency ratio, is therefore a biometric marker for short-term stress.¹¹ HRV has been shown to change in response to various stressors. Low parasympathetic activity leads to a decrease in the high-frequency band and an increase in the low-frequency band. This relationship makes HRV a leading variable in assessing psychological stress.¹²

One key measure of HRV is the root mean square of successive differences (RMSSD) between normal heartbeats. The successive time difference between heartbeats is measured in milliseconds, each value is squared, the results are averaged, and the square

⁹ Mark Bille Andersen, “Psychosocial Factors and Changes in Peripheral Vision, Muscle Tension, and Fine Motor Skills during Stress” (PhD diss., University of Arizona, 1988), <https://repository.arizona.edu/handle/10150/184446>.

¹⁰ Jacob Tindle and Prasanna Tadi, “Neuroanatomy, Parasympathetic Nervous System,” in *StatPearls* (Treasure Island, FL: StatPearls Publishing, 2022), <http://www.ncbi.nlm.nih.gov/books/NBK553141/>.

¹¹ Susana Rodrigues et al., “Wearable Biomonitoring Platform for the Assessment of Stress and Its Impact on Cognitive Performance of Firefighters: An Experimental Study,” *Clinical Practice and Epidemiology in Mental Health* 14, no. 1 (2018): 250–62, <https://doi.org/10.2174/1745017901814010250>.

¹² Hye-Geum Kim et al., “Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature,” *Psychiatry Investigation* 15, no. 3 (March 2018): 235–45, <https://doi.org/10.30773/pi.2017.08.17>.

root of this total serves as the measure.¹³ The conventional minimum collection period to calculate RMSSD is five minutes, but some researchers have proposed shorter periods.¹⁴ Another similar measure of HRV is the standard deviation of the inter beat intervals of normal sinus beats (SDNN).¹⁵

A subject's exposure to stressors changes the electrical conductance of the skin as sweat glands are activated, so galvanic skin response (GSR) often serves as a measure of emotional arousal caused by SNS activation.¹⁶ Firefighting tasks have been associated with high energy expenditure as well as elevated values of GSR, which peak during the exercise but may not return to normal for 12 hours or more afterward.¹⁷ A study of Portuguese firefighters used a wearable biometric platform to collect electrocardiograph data as the participants experienced a stressful stimulus for 15 minutes. After a baseline measurement of stress and timed reactions, the subjects underwent a Trier social stress test—a laboratory procedure developed to induce stress in human subjects by placing them in a social evaluation scenario—before repeating the timed reaction test. The Spielberg state-trait anxiety inventory was used to assess psychological stress, and the visual analogue scale was used to measure perceived stress. This study found that increased stress levels correlated with a reduction in performance on the timed reaction test.¹⁸ The stress induced by the Trier social stress test was intended to increase cortisol production in the same

¹³ Fred Shaffer and J. P. Ginsberg, “An Overview of Heart Rate Variability Metrics and Norms,” *Frontiers in Public Health* 5 (September 2017): 1–17, <https://doi.org/10.3389/fpubh.2017.00258>.

¹⁴ Hyun Jae Baek et al., “Reliability of Ultra-Short-Term Analysis as a Surrogate of Standard 5-Min Analysis of Heart Rate Variability,” *Telemedicine Journal and E-Health* 21, no. 5 (May 2015): 404–14, <https://doi.org/10.1089/tmj.2014.0104>; Michael R. Esco and Andrew A. Flatt, “Ultra-Short-Term Heart Rate Variability Indexes at Rest and Post-exercise in Athletes: Evaluating the Agreement with Accepted Recommendations,” *Journal of Sports Science & Medicine* 13, no. 3 (September 2014): 535–41.

¹⁵ Orsolya Kiss et al., “Detailed Heart Rate Variability Analysis in Athletes,” *Clinical Autonomic Research: Official Journal of the Clinical Autonomic Research Society* 26, no. 4 (August 2016): 245–52, <https://doi.org/10.1007/s10286-016-0360-z>.

¹⁶ Atlee Fernandes et al., “Determination of Stress Using Blood Pressure and Galvanic Skin Response,” in *Proceedings of the 2014 International Conference on Communication and Network Technologies* (Piscataway, NJ: IEEE, 2014), 165–68, <https://doi.org/10.1109/CNT.2014.7062747>.

¹⁷ Marta Del Sal et al., “Physiologic Responses of Firefighter Recruits during a Supervised Live-Fire Work Performance Test,” *Journal of Strength and Conditioning Research* 23, no. 8 (2009): 2396–404, <https://doi.org/10.1519/JSC.0b013e3181bb72c0>.

¹⁸ Rodrigues et al., “Wearable Biomonitoring Platform for the Assessment of Stress.”

manner induced by firefighting activities. Simulating firefighting tasks in a realistic environment would be expected to produce similar effects. Another implication of the study is the viability of wearable biometric devices for the assessment of significant HRV parameters that can serve as markers of stress levels.

2. Stress and Decision-Making in the Fire Service

As stressors increase, working memory can become overloaded and impair the ability to perform skilled tasks, especially ones requiring a high degree of cognitive skill. Novices are even more susceptible to this effect than those with a higher degree of expertise because they have not acquired the pattern recognition skills that help experts automate their acquired skills.¹⁹ Pattern recognition can be a useful heuristic for experienced decision-makers. A study of tenured fire department officers in New Zealand has shown that tactical commanders tend to react to cues to make sense of unsafe work environments.²⁰ This finding conforms with the naturalistic decision-making model proposed by Gary Klein in 1989.²¹ Using the recognition-primed decision model, Klein sought to explain how experts make more effective decisions than novices do when faced with time pressure. Klein argues that experts can assess a situation and, drawing on relevant past experiences, generate a potential course of action. Experts then conduct a mental simulation to determine the viability of the proposed solutions given the constraints of the situation and accept the first viable solution. The success of this strategy depends on the decision-maker's having access to relevant experiences or memories to properly identify the salient elements of the problem and recognize appropriate or inappropriate courses of action.

Firefighting tasks are physically and psychologically demanding, often requiring lifting and moving large objects, dragging heavy hoses or victims, negotiating unfamiliar

¹⁹ Thomas Loveday et al., "Pattern Recognition as an Indicator of Diagnostic Expertise," in *Pattern Recognition—Applications and Methods*, ed. Pedro Latorre Carmona, J. Salvador Sánchez, and Ana L. N. Fred (Berlin: Springer, 2013), 1–11, https://doi.org/10.1007/978-3-642-36530-0_1.

²⁰ John Ash and Clive Smallman, "A Case Study of Decision Making in Emergencies," *Risk Management* 12, no. 3 (2010): 185–207, <https://doi.org/10.1057/rm.2010.2>.

²¹ Gary Klein, *Sources of Power: How People Make Decisions* (Cambridge, MA: MIT Press, 1999).

surroundings, and climbing stairs or ladders. Dangerous conditions, darkness, and heat also contribute to mental and physical strain. A 2001 study published in *Ergonomics* examined subjects who completed a series of strenuous firefighting tasks in a training building with live fires and were assessed on HR, aortic blood flow, perceived exertion, respiratory and thermal distress, reaction time, and error rate before and after each trial as well as during the recovery period.²² The findings demonstrate that performing such work not only is physiologically taxing but also can impair cognitive function.²³ In another study, a firefighting exercise simulating victim rescue generated high blood lactate levels and a high volume of oxygen uptake, both indicators of intense physical activity.²⁴ Implementing techniques to help firefighters cope with the psychological and physiological demands of these situations would increase their success rate in mitigating emergencies.

3. Mental Skills Training

Instructors from the U.S. Army's Modern Army Combatives Program rated stress control as the most important mental skill in the success of soldiers engaged in hand-to-hand combat during operations.²⁵ In this context, the Modern Army Combatives Program defines stress control as the ability to modulate the intensity of one's psychological and physiological reactions to stress inputs to optimize performance. Instructors also emphasize the importance of deliberate, controlled respirations, a technique known as tactical breathing. This breathing control strategy is a component of several MST programs across the military.

MST has been used to better prepare pilots to survive immersion in cold water in the event of a ditched and inverted helicopter in rough seas. One of the body's responses

²² D. L. Smith, T. S. Manning, and S. J. Petruzzello, "Effect of Strenuous Live-Fire Drills on Cardiovascular and Psychological Responses of Recruit Firefighters," *Ergonomics* 44, no. 3 (2001): 244, <https://doi.org/10.1080/00140130121115>.

²³ Smith, Manning, and Petruzzello.

²⁴ Erna D. von Heimburg, Anna Kari R. Rasmussen, and Jon Ingulf Medbø, "Physiological Responses of Firefighters and Performance Predictors during a Simulated Rescue of Hospital Patients," *Ergonomics* 49, no. 2 (2006): 111–26, <https://doi.org/10.1080/00140130500435793>.

²⁵ Peter Jensen and Susan Goodman, "Combat Feedback from US Army Combatives Instructors," *Infantry* 106, no. 3 (September 2017): 14–18, ProQuest.

to cold water immersion is an initial inspiratory gasp and hyperventilation. This increased respiratory rate reduces one's breath hold time, which is critical if the pilot must perform an underwater escape from the cockpit or avoid water in the airway during a wave splash. In a 2006 study, researchers tested the effects of MST by conducting cold water immersion tests seven days apart.²⁶ Half of the participants underwent a psychological skills intervention consisting of goal setting, arousal regulation, mental imagery, and positive self-talk training while the other half served as a control. After completing four one-hour training sessions over the course of the week, the test group improved its breath hold time on immersion by 80 percent compared to the control group. This outcome demonstrates the capacity of MST to help individuals overcome strong signals from the ANS.

Some evidence suggests that even shorter training can produce tangible results. After undergoing two 75-minute lectures on stress-reduction techniques, including breathing, visualization, and attentional focus, police cadets participated in a series of tactical exercises while being sprayed with oleoresin capsicum (OC). By design, the physiological effects of OC spray overwhelm subjects and make the completion of physically and mentally demanding tasks challenging. After exposure, subjects completed four tactical stations where they had to demonstrate hands-on law enforcement techniques. Researchers also placed novel items and signs throughout the testing area that were later used to evaluate memory recall. During these tests, the recruits who had received the MST lectures demonstrated not only higher performance but also better memory recall of the event and items in the testing area than did those in the control group.²⁷ The authors speculate that the effect of MST may be even more pronounced than the results indicate, because the control group used some MST skills as well, particularly tactical breathing, which is emphasized throughout the police academy training.

²⁶ Martin J. Barwood et al., "Breath-Hold Performance during Cold Water Immersion: Effects of Psychological Skills Training," *Aviation, Space, and Environmental Medicine* 77, no. 11 (November 2006): 1136–42.

²⁷ Jonathan W. Page et al., "Brief Mental Skills Training Improves Memory and Performance in High Stress Police Cadet Training," *Journal of Police and Criminal Psychology* 31, no. 2 (2016): 122–26, <https://doi.org/10.1007/s11896-015-9171-8>.

4. Potential Moderators of MST Effectiveness

In addition to MST, factors such as experience level and gender have been proposed as potential mediators of the performance impacts of stress. Some research suggests that men and women may react differently to stress and may employ different mental skills when coping with stressors.²⁸ Therefore, accounting for potential gender differences in studies on the effects of stress is important. In a pre-race survey of triathletes, men and women showed similar appraisals of types of threat and overall stress levels but differed significantly on perceived control of threats as well as coping strategies.²⁹ Some evidence also suggests a stronger link between cognitive anxiety and performance among men than women.³⁰ Just as gender impacts how subjects react to stress, it also influences the efficacy of MST, with women achieving greater benefit from it than men in a study of recruits in basic combat training.³¹ In the 2016 police study, cadets with a brief MST intervention were blocked into groups based on whether they had been sprayed with OC in the past, creating experienced and novice cohorts, which were then divided evenly between the experimental and control groups.³² Previous experience also plays a significant role in the present study, supporting the need to distribute novice and experienced subjects equally between trial and control groups.

5. MST in the Fire Department

In a recent examination of the potential effects of MST within fire departments, 68 firefighters were surveyed using the mental readiness scale to determine the correlation of traditional military mental preparation strategies with performance and stress. The

²⁸ Jon Hammermeister and Damon Burton, “Gender Differences in Coping with Endurance Sport Stress: Are Men from Mars and Women from Venus?,” *Journal of Sport Behavior* 27, no. 2 (June 2004): 148–64, ProQuest.

²⁹ Hammermeister and Burton.

³⁰ Tim Woodman and Lew Hardy, “The Relative Impact of Cognitive Anxiety and Self-Confidence upon Sport Performance: A Meta-Analysis,” *Journal of Sports Sciences* 21, no. 6 (2003): 443–57, <https://doi.org/10.1080/0264041031000101809>.

³¹ Amy B. Adler et al., “Mental Skills Training with Basic Combat Training Soldiers: A Group-Randomized Trial,” *Journal of Applied Psychology* 100, no. 6 (2015): 1752–64, <https://doi.org/10.1037/apl0000021>.

³² Page et al., “Brief Mental Skills Training Improves Memory.”

researchers predicted that strategies more easily applicable in a military setting, namely self-talk and goal setting, would not correlate significantly with firefighter success. However, visualization and arousal control were both predicted to have significant effects.³³ Firefighters using these mental preparation strategies might improve task performance and increase the odds of safely and successfully mitigating emergencies. The authors suggest that future research use firefighter simulation tests to examine the relationship between mental preparation strategies tailored to the population and the effect on performance as measured by safety-relevant indicators, such as reaction times and recognition of sudden situational changes.

³³ Nicki Marquardt, Lisa Krämer, and Verena Schürmann, “Mental Preparation Strategies and Firefighter’s Performance under Stress,” *International Journal of Safety and Security Engineering* 9, no. 3 (2019): 332–43, <https://doi.org/10.2495/SAFE-V9-N4-332-343>.

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II. DESIGNING AN MST PROGRAM FOR THE FIRE DEPARTMENT

This study tested the impact of brief MST on firefighters' ability to execute job-related functions under stressful conditions. While there has been no published research to date on designing a tailored MST program for fire service use, programs in other professions that have similar physically and psychologically demanding tasks offered foundations from which to start. This thesis proposes a framework for an MST curriculum for urban firefighters by correlating the combined expertise from military, medical, law enforcement, and athletic programs with a relevant structural firefighting subtask. Like MST programs in other fields, this firefighter-specific MST curriculum focuses on the four pillars of arousal control, visualization, goal setting, and self-talk.

This MST curriculum leverages supplemental teaching methods shown to improve student performance. Both students and educators respond positively to video-supported instruction, rating it as more enjoyable than standard teaching methods.³⁴ Thus, the MST presentation incorporates short video clips to introduce the pillars in a digestible, entertaining way. The video clips also provide instructors with a touchstone to reinforce previously identified concepts. Moreover, active learning in small groups can augment traditional lecture-based instruction and result in better information retention and mastery.³⁵ For this reason, the participants are divided into three groups after the lecture and rotated through moderated stations, one each for arousal control and visualization and another for goal setting and self-talk combined. At each station, instructors facilitate an active discussion of the respective MST pillar and lead the participants in a group exercise.

³⁴ J. Dequeker and R. Jaspert, "Teaching Problem-Solving and Clinical Reasoning: 20 Years Experience with Video-Supported Small-Group Learning," *Medical Education* 32, no. 4 (July 1998): 384–89, <https://doi.org/10.1046/j.1365-2923.1998.00219.x>.

³⁵ Kristi J. Ferguson, "Facilitating Student Learning," in *An Introduction to Medical Teaching*, ed. William B. Jeffries and Kathryn N. Huggett (Dordrecht: Springer Netherlands, 2010), 1–10, https://doi.org/10.1007/978-90-481-3641-4_1.

A combination of video clips and small-group learning has been shown to produce significantly better results than teaching with individual activities.³⁶

Using proven teaching techniques and established psychological concepts, this MST program offers a training template for the needs and challenges of the fire department. The following sections describe in greater detail the content and delivery of this novel, firefighter-specific MST curriculum. An outline of the presentation is provided in Appendix A, and the material is available upon request from the author.

A. INTRODUCTION

To introduce the concepts covered in this MST program and engage learners, this program begins with a five-and-a-half-minute video excerpt of Captain Charles “Sully” Sullenberger’s first-hand account of his successful landing of an airliner suddenly crippled by dual engine failure.³⁷ While seemingly unrelated to the fire service, this account vividly describes several physiological stress responses and mitigation techniques that overlap with this program. Studies demonstrate that videos can be effective teaching tools and enhance students’ ability to visualize challenging biological concepts.³⁸ For maximum efficacy, classroom videos should be six minutes or less and combined with active learning.³⁹ The lead instructor refers to this introductory video throughout the training, guiding trainees to identify the MST concepts presented in Captain Sullenberger’s narrative to emphasize the real-world applicability of these techniques. An additional one-and-a-

³⁶ Muslem Asnawi et al., “The Application of Video Clips with Small Group and Individual Activities to Improve Young Learners’ Speaking Performance,” *Teaching English with Technology* 17, no. 4 (2017): 25–37, <https://www.ceeol.com/search/article-detail?id=579130>.

³⁷ Inc., “Captain Sully’s Minute-by-Minute Description of the Miracle on the Hudson,” video, 12:22, YouTube, March 6, 2019, <https://www.youtube.com/watch?v=w6EblErBJqw>.

³⁸ Barbara Means et al., *Evaluation of Evidence-Based Practices in Online Learning: A Meta-analysis and Review of Online Learning Studies* (Washington, DC: Department of Education, Office of Planning, Evaluation, and Policy Development, 2009), <https://repository.alt.ac.uk/629/>; Sambit Dash et al., “Audio-Visual Aid in Teaching ‘Fatty Liver,’” *Biochemistry and Molecular Biology Education* 44, no. 3 (2016): 241–45, <https://doi.org/10.1002/bmb.20935>.

³⁹ Asnawi et al., “The Application of Video Clips”; Cynthia J. Brame, “Effective Educational Videos: Principles and Guidelines for Maximizing Student Learning from Video Content,” *CBE—Life Sciences Education* 15, no. 4 (December 2016): 1–6, <https://doi.org/10.1187/cbe.16-03-0125>.

half-minute movie scene depicting a fighter’s mental simulation before executing rapid-fire actions in a fistfight later illustrates the pillar of visualization.⁴⁰

Before delving into the four pillars of MST techniques presented in this program, participants receive a brief introduction to the physiology of stress and a history of MST to establish its legitimacy as an evidence-based practice in the scientific community. The instructor summarizes the function of the ANS using relatable metaphors and avoiding overly technical explanations. The fight-or-flight response of the SNS acts as the brain’s gas pedal whereas the PSNS’s rest-and-relax signal serves as the brake pedal. The interplay of the “brake” and “gas” response systems and their role in regulating various physiological responses encompasses the body’s stress response. A color-coded graphical representation of the Yerkes–Dodson curve provides the backdrop for a discussion of the relationship between pressure and performance (see Figure 2).

⁴⁰ Fahad Rather, “*Sherlock Holmes* 2009—Fight Scene 1080p HD,” video, 3:49, YouTube, October 10, 2013, <https://www.youtube.com/watch?v=ILuhWLNqpiA>.



Figure 2. Simplified Yerkes–Dodson Curve Showing Zone of Optimal Performance.⁴¹

As shown in Figure 2, when stress increases from a resting state, there is a direct positive correlation with performance, but this zone of optimal performance has its limit. Beyond the high pressure threshold, additional stress has adverse physiological effects and degrades performance. Instructors refer to the area of peak performance as the “ideal zone” throughout the training, with the goal of MST being to present a set of techniques that enable participants to reach this ideal zone and keep them from sliding beyond it, down the backside of the curve.

After this preface, the program introduces the four pillars of the training regimen. The instructor reiterates these pillars when teaching associated techniques and strategies throughout the hour-long presentation, as repetition reinforces concepts in the participants’

⁴¹ Source: Ian Martin, “Pressure, Performance and Stress Curve,” Delphis, July 23, 2020, <https://delphis.org.uk/peak-performance/stress-and-the-pressure-performance-curve/>.

memory.⁴² In total, eight techniques are presented. In arousal control, trainees learn how and when to use box breathing and prolonged exhalation. In visualization, the instructor presents the benefits of simulated mental practice and leads students through an example. Under goal setting, participants learn the key components of high-quality goals and how setting interim and outcome goals can help them successfully complete complex tasks during high-stress emergency response. Finally, within self-talk, the strategies of instructional self-talk, motivational self-talk, and preparatory arousal are taught. After the completion of this presentation, participants are divided into small groups and given opportunities to practice each technique in a series of breakout sessions.

B. TRAINING SECTION ONE: AROUSAL CONTROL

Arousal control is the use of deliberate techniques to modulate the biometric manifestations of the body's normal stress response. While it may be possible to control the physiological responses produced by the ANS, doing so generally requires years of training. Buddhist monks, for example, have demonstrated the ability to significantly alter levels of serum cortisol and proteins in their bloodstream, systolic and diastolic blood pressure, pulse rate, and even reaction time through meditation.⁴³ Most people cannot achieve this level of expertise; however, breath control stands out as a strategy to mitigate the physiological response to stress without years of practice. As breath control can be taught with limited time, it has the potential to impact firefighters significantly.

Respiratory drive is controlled by chemoreceptors that detect the concentration of CO₂ in the bloodstream and is usually unconscious and automatic.⁴⁴ Voluntary control signals sent by the cortex can override and replace the involuntary signals from the

⁴² N. Ofen-Noy, Y. Dudai, and A. Karni, "Skill Learning in Mirror Reading: How Repetition Determines Acquisition," *Cognitive Brain Research* 17, no. 2 (2003): 507–21, [https://doi.org/10.1016/S0926-6410\(03\)00166-6](https://doi.org/10.1016/S0926-6410(03)00166-6).

⁴³ Ratree Sudsuang, Vilai Chentanez, and Kongdej Veluvan, "Effect of Buddhist Meditation on Serum Cortisol and Total Protein Levels, Blood Pressure, Pulse Rate, Lung Volume and Reaction Time," *Physiology & Behavior* 50, no. 3 (September 1991): 543–48, [https://doi.org/10.1016/0031-9384\(91\)90543-W](https://doi.org/10.1016/0031-9384(91)90543-W).

⁴⁴ Diethelm W. Richter and Jeffrey C. Smith, "Respiratory Rhythm Generation in Vivo," *Physiology* 29, no. 1 (January 2014): 58–71, <https://doi.org/10.1152/physiol.00035.2013>.

brainstem, activating the muscles used for inhalation or exhalation.⁴⁵ Controlling respiratory rate and depth can be tremendously beneficial in stressful situations. For this reason, disciplines from martial arts to the military have incorporated some form of breath control into their training for centuries. Respiratory strategies have been investigated in the firefighting profession but primarily with a focus on conserving air through techniques like skip breathing.⁴⁶

This MST program presents two breath control techniques, the first of which is box breathing or square breathing. It involves engaging the diaphragm to inhale deeply through the nose for four seconds, holding the breath for four seconds, exhaling completely over four seconds, and pausing for four seconds before beginning again. Mindfulness training and meditation use box breathing to reduce anxiety, improve lung function, reduce blood pressure, and help with pain management.⁴⁷ Popularized by Grossman and Christensen in their book *On Combat: The Psychology and Physiology of Deadly Conflict in War and in Peace*, “tactical breathing” was widely adopted by North American military and law enforcement communities for stress management.⁴⁸ Recently, the technique has gained traction in fire service industry publications as a method for reducing claustrophobia in new recruits during initial training with breathing apparatus.⁴⁹

⁴⁵ Billy L. Luu et al., “TMS-Evoked Silent Periods in Scalene and Parasternal Intercostal Muscles during Voluntary Breathing,” *Respiratory Physiology & Neurobiology* 216 (2015): 15–22, <https://doi.org/10.1016/j.resp.2015.05.010>.

⁴⁶ M. Napier et al., “Breathing Techniques Used to Conserve Air in a Self-Contained Breathing Apparatus,” *International Journal of Exercise Science: Conference Proceedings* 8, no. 5 (2017): 41, <https://digitalcommons.wku.edu/ijesab/vol8/iss5/41>.

⁴⁷ Anjana Iyer, Suroshree Mitra, and Rachana Dabadghav, “The Effect of Rhythmic Deep Breathing on Pain and Anxiety in Patients with Burns,” *Indian Journal of Burns* 28, no. 1 (2020): 74–78, https://doi.org/10.4103/ijb.ijb_5_20; Ashfaq Ahmed, R. Gayatri Devi, and A. Jothi Priya, “Effect of Box Breathing Technique on Lung Function Test,” *Journal of Pharmaceutical Research International* 33, no. 58A (2021): 25–31, <http://www.apsciencelibrary.com/handle/123456789/9178>; Amit Rosenberg and Daniel Hamiel, “Reducing Test Anxiety and Related Symptoms Using a Biofeedback Respiratory Practice Device: A Randomized Control Trial,” *Applied Psychophysiology and Biofeedback* 46, no. 1 (2021): 69–82, <https://doi.org/10.1007/s10484-020-09494-9>.

⁴⁸ Dave Grossman and Loren W. Christensen, *On Combat: The Psychology and Physiology of Deadly Conflict in War and in Peace*, 2nd ed. (Columbia, IL: PPCT Research Publications, 2007).

⁴⁹ Kenneth Stepien, “SCBA Claustrophobia,” *Firehouse*, May 5, 2022, <https://www.firehouse.com/safety-health/scba-accessories/article/21265972/scba-claustrophobia>.

The curriculum introduces box breathing as a strategy to use during periods of rest or in the preparatory phase of an emergency exercise and acknowledges its limitations. The effectiveness of box breathing in high-intensity situations where active coping is required has recently been called into question by German researchers because box breathing requires the subject to focus attention on the action of breathing and the associated counts.⁵⁰ This concentration could lessen working memory and inhibit the ability to perform cognitive and operational tasks because it uses up the added mental resources required for those operations. For this reason, detaching briefly to count breaths may not be practical for firefighters in emergency response. Furthermore, under increased physiological load, maintaining the periods of breath retention between inspiratory and expiratory phases may be difficult or impossible. Therefore, box breathing is best used as firefighters are enroute to an emergency but should not be maintained once they have arrived on scene and have begun engaging in emergency response activities.

To counter this problem, instructors suggest an alternative technique for periods of high activity or cardiovascular load associated with emergency response activities. Research suggests that prolonged exhalation can improve performance in conditions of increased cognitive load.⁵¹ With the prolonged exhalation breathing method, participants do not hold their breath but inhale for two to four seconds and exhale over a prolonged four to eight seconds.⁵² During inhalation, the SNS sends a signal via a network of nerves in the thoracic spinal column that quickens the HR through norepinephrine release. During exhalation, the PSNS sends a signal via the vagus nerve, releasing acetylcholine and triggering a decrease in beat-to-beat intervals.⁵³ As a result of these signals, one's HR slightly declines during exhalation and increases during inhalation. Breathing techniques

⁵⁰ Stefan Röttger et al., "The Effectiveness of Combat Tactical Breathing as Compared with Prolonged Exhalation," *Applied Psychophysiology and Biofeedback* 46, no. 1 (2020): 19–28, <https://doi.org/10.1007/s10484-020-09485-w>.

⁵¹ Röttger et al.

⁵² Roderik J. S. Gerritsen and Guido P. H. Band, "Breath of Life: The Respiratory Vagal Stimulation Model of Contemplative Activity," *Frontiers in Human Neuroscience* 12 (October 2018): 1–25, <https://doi.org/10.3389/fnhum.2018.00397>.

⁵³ Marc A. Russo, Danielle M. Santarelli, and Dean O'Rourke, "The Physiological Effects of Slow Breathing in the Healthy Human," *Breathe* 13, no. 4 (December 2017): 298–309, <https://doi.org/10.1183/20734735.009817>.

focused on the exhalation portion of the respiratory cycle exploit this phenomenon, known as respiratory sinus arrhythmia. A recent study of the effects of two vagal breathing patterns with prolonged exhalation has shown that even a brief application of these techniques can decrease stress, increase HRV, and improve decision-making.⁵⁴

Participants receive instruction during the lecture portion on how to perform prolonged exhalation breathing as a respiratory and stress-management technique during periods of extreme exertion. In the small-group breakout sessions following the lecture, a fitness trainer describes the diaphragmatic breathing strategies for students. Then, they practice both breathing techniques, individually and as a group, with the trainer's guidance.

C. TRAINING SECTION TWO: VISUALIZATION

The pillar of visualization using the technique of simulated mental practice is the next topic in the fire department (FD)'s MST program because it is a powerful performance-enhancing tool. Research has directly tied visualization to improved performance in multiple settings and among subjects with a range of expertise. The use of mental imagery is commonplace in athletics and is gaining acceptance outside of sports in fields such as aviation and surgery.⁵⁵ Mental imagery has been shown to increase strength and balance in recreational athletes.⁵⁶ Motor imagery, a technique in which a person imagines performing a movement without tensing any muscles, can increase muscle activation and isometric force development when used during or even before physical

⁵⁴ Marijke De Couck et al., "How Breathing Can Help You Make Better Decisions: Two Studies on the Effects of Breathing Patterns on Heart Rate Variability and Decision-Making in Business Cases," *International Journal of Psychophysiology* 139 (2019): 1–9, <https://doi.org/10.1016/j.ijpsycho.2019.02.011>.

⁵⁵ Christopher Clarey, "Olympians Use Imagery as Mental Training," *New York Times*, February 22, 2014, <https://www.nytimes.com/2014/02/23/sports/olympics/olympians-use-imagery-as-mental-training.html>; Florian Jentsch, Clint Bowers, and Eduardo Salas, "Could Mental Practice and Imagery Be Techniques for Enhancing Aviation Performance?," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 41, no. 2 (October 1997): 1172–75, <https://doi.org/10.1177/1071181397041002100>; Edward F. Ibrahim, Martin D. Richardson, and Debra Nestel, "Mental Imagery and Learning: A Qualitative Study in Orthopaedic Trauma Surgery," *Medical Education* 49, no. 9 (2015): 888–900, <https://doi.org/10.1111/medu.12759>; F. Jungmann et al., "Impact of Perceptual Ability and Mental Imagery Training on Simulated Laparoscopic Knot-Tying in Surgical Novices Using a Nissen Fundoplication Model," *Scandinavian Journal of Surgery* 100, no. 2 (2011): 78–85, <https://doi.org/10.1177/14574969110000203>.

⁵⁶ Vasundhra Nagar and Majumi M. Noohu, "The Effect of Mental Imagery on Muscle Strength and Balance Performance in Recreational Basketball Players," *Medicina Sportiva* 10, no. 3 (2014): 2387–93.

activity.⁵⁷ In one striking example of the power of visualization, researchers tested its effectiveness at improving free-throw shooting percentages in a cohort of skilled basketball players.⁵⁸ After a period of daily practice, the physical practice group and the simulated mental practice group both showed an equal and statistically significant improvement over the control group.

The instructor uses the free-throw experiment to introduce visualization during the MST, illustrating that simulated mental practice is an easy-to-use tool at any time or place and, when used consistently, has tangible impacts on real-world performance. After this introduction, the participants watch a one-and-a-half-minute video depicting a scene from the 2009 film *Sherlock Holmes* in which the lead character conducts a mental simulation before executing a rapid-fire series of actions in a fistfight.⁵⁹ The series of strikes through the mind's eye of the fighter provides a concrete and relatable example of visualization for the participants. The video smoothly transitions into a discussion of tasks that lend themselves to simulated mental practice, as well as the importance of vividness in visualization.

During the lecture, the instructor provides participants with examples of simple and complicated tasks that can be practiced mentally, both before and during execution. Simple tasks may include donning a breathing apparatus mask while complex tasks may encompass locating, packaging, and rescuing a downed firefighter. There is a direct relationship between the vividness of the mental simulation and performance on physical activity tasks; for this reason, participants are instructed to add as much detail as possible to their visualizations when putting this technique into practice in the field.⁶⁰ Later, in the

⁵⁷ F. Di Rienzo et al., "Short-Term Effects of Integrated Motor Imagery Practice on Muscle Activation and Force Performance," *Neuroscience* 305 (2015): 146–56, <https://doi.org/10.1016/j.neuroscience.2015.07.080>.

⁵⁸ George Grouios et al., "The Effect of a Simulated Mental Practice Technique on Free Throw Shooting Accuracy of Highly Skilled Basketball Players," *Journal of Human Movement Studies* 33 (1997): 119–38.

⁵⁹ Rather, "*Sherlock Holmes* 2009."

⁶⁰ Nichola Callow, Ross Roberts, and Joanna Z. Fawkes, "Effects of Dynamic and Static Imagery on Vividness of Imagery, Skiing Performance, and Confidence," *Journal of Imagery Research in Sport and Physical Activity* 1, no. 1 (February 2006), <https://doi.org/10.2202/1932-0191.1001>.

visualization breakout session, an instructor guides participants through creating a rich, multi-sensory mental simulation of a complex firefighting task. The instructor includes information from multiple senses—such as the light and vibration from alarms, the weight and texture of tools and appliances, and the heat and noise of the environment—which are crucial in maximizing the effectiveness of this technique.⁶¹

D. TRAINING SECTION THREE: GOAL SETTING

The third pillar of the MST program, goal setting, is frequently used by athletes, both in training and during competition, and has been positively correlated to enhanced performance.⁶² High-performing athletes who employ goal-setting strategies often set intermediate process goals that ultimately lead to the completion of outcome goals.⁶³ Goal-setting theory (GST) is a theoretical framework initially developed by Edwin Locke and Gary Latham in 1990 to describe goal-setting interventions.⁶⁴ Key insights from GST reveal that goal setting can help individuals focus their efforts and ignore distraction, increase their persistence, and improve task completion.⁶⁵ Locke and Latham also offer guidance for setting effective goals by combining both proximal (short-term) and distal (long-term) goals and show that more-challenging goals lead to higher performance.⁶⁶ Therefore, the MST program instructs participants on the technique of setting interim and

⁶¹ Daniel Gould et al., “Imagery Training for Peak Performance,” in *Exploring Sport and Exercise Psychology*, ed. Judy L. Van Raalte and Britton W. Brewer, 3rd ed. (Washington, DC: American Psychological Association, 2014), 55–82, <https://doi.org/10.1037/14251-004>.

⁶² Laura Healy, Alison Tincknell-Smith, and Nikos Ntoumanis, “Goal Setting in Sport and Performance,” in *Oxford Research Encyclopedia of Psychology* (Oxford: Oxford University Press, 2018), <https://doi.org/10.1093/acrefore/9780190236557.013.152>.

⁶³ Michael O’Brien, Stephen Mellalieu, and Sheldon Hanton, “Goal-Setting Effects in Elite and Nonelite Boxers,” *Journal of Applied Sport Psychology* 21, no. 3 (2009): 293–306, <https://doi.org/10.1080/10413200903030894>; Sheldon Hanton and Graham Jones, “The Acquisition and Development of Cognitive Skills and Strategies: I. Making the Butterflies Fly in Formation,” *Sport Psychologist* 13, no. 1 (1999): 1–21, <https://doi.org/10.1123/tsp.13.1.1>.

⁶⁴ Edwin A. Locke and Gary P. Latham, *A Theory of Goal Setting & Task Performance* (Englewood Cliffs, NJ: Prentice-Hall, 1990).

⁶⁵ Edwin A. Locke and Gary P. Latham, “Building a Practically Useful Theory of Goal Setting and Task Motivation: A 35-Year Odyssey,” *American Psychologist* 57, no. 9 (2002): 705–17, <https://doi.org/10.1037/0003-066X.57.9.705>.

⁶⁶ Gary P. Latham and Edwin A. Locke, “New Developments in and Directions for Goal-Setting Research,” *European Psychologist* 12, no. 4 (2007): 290–300, <https://doi.org/10.1027/1016-9040.12.4.290>.

outcome goals in emergency response. The instructor identifies a common outcome goal in emergency response: locate and rescue an incapacitated colleague. This outcome goal is then broken down into multiple smaller interim goals—stepwise goals that must be met to achieve the outcome. In the example of the firefighter rescue, the interim goals include locating the victim, applying a rescue intervention device to supplement the victim’s air supply, packaging the victim for removal, and working with other rescuers to carry the victim to an exit. Each of these steps is further subdivided into interim process goals, such as identifying the correct fittings on the rescue device, locating the corresponding component on the victim’s breathing apparatus, and connecting the rescue device.

Another component of GST is the importance of setting high-quality goals. Specific goals are more effective than vague ones, and specificity may combine with the difficulty of a goal to further enhance its quality. Difficulty must be balanced with achievability. Provided the goal is plausible, however, research has shown that setting more difficult goals can lead to higher success rates than setting less-challenging goals.⁶⁷ Previous research on mental preparation strategies in the fire department has concluded that “both specific and realistic goals are key components to perform on a higher level and to solve critical situations in the context of firefighters.”⁶⁸ Thus, the presentation provides additional goal-setting guidance emphasizing these two characteristics. The lecture offers multiple examples of high-quality goals, as well as vague or unreasonable targets to avoid, and discusses the differences between them. Participants combine these goal-setting techniques and practice them during the small-group breakout sessions. They encounter a complex tactical scenario and identify incremental intermediate goals whose attainment is necessary for achieving the overall outcome goal. When setting these intermediate goals, participants have to break up challenging tasks into achievable, specific pieces.

⁶⁷ Edwin A. Locke and Gary P. Latham, “The Development of Goal Setting Theory: A Half Century Retrospective,” *Motivation Science* 5, no. 2 (2019): 93–105, <https://doi.org/10.1037/mot0000127>.

⁶⁸ Marquardt, Krämer, and Schürmann, “Mental Preparation Strategies,” 333.

E. TRAINING SECTION FOUR: SELF-TALK

The final pillar of the MST program is self-talk, another set of mental skills techniques shown to improve athletic performance.⁶⁹ Using self-talk can boost attention and confidence, increase effort, and improve anxiety control.⁷⁰ However, self-talk appears to be more effective for novel tasks rather than well-learned ones, which may be explained by its effect on attention. Two distinct types of self-talk cues exist, and the instructor presents both as strategies to the participants in this program. Motivational self-talk, such as positive self-affirmation and encouragement, seeks to improve confidence, increase effort and energy expenditure, and boost mood.⁷¹ On the other hand, instructional self-talk, such as athletes reminding themselves to bend their knees, is intended to improve performance through increased attentional focus and technique and tends to be more effective in tasks that require fine motor demands. Both instructional and motivational self-talk cues are effective in tasks that require strength and endurance.⁷²

The instructor asks participants to avoid negative self-talk, such as statements of self-doubt or predictions of an unsuccessful outcome, for its deleterious effect on both cognitive and physical performance.⁷³ In small-group sessions after the lecture, participants generate examples of negative self-talk cues to avoid.

Preparatory arousal, or “psyching up,” is another tool that can be used to improve performance. Athletes who practice preparatory arousal strategies before an event have

⁶⁹ Lisa J. Rogerson and Dennis W. Hrycaiko, “Enhancing Competitive Performance of Ice Hockey Goaltenders Using Centering and Self-Talk,” *Journal of Applied Sport Psychology* 14, no. 1 (2002): 14–26, <https://doi.org/10.1080/10413200209339008>.

⁷⁰ Antonis Hatzigeorgiadis, “Instructional and Motivational Self-Talk: An Investigation on Perceived Self-Talk Functions,” *Hellenic Journal of Psychology* 3 (2006): 164–75.

⁷¹ Yannis Theodorakis et al., “The Effects of Motivational versus Instructional Self-Talk on Improving Motor Performance,” *Sport Psychologist* 14, no. 3 (2000): 253–71, <https://doi.org/10.1123/tsp.14.3.253>.

⁷² Theodorakis et al.

⁷³ Junhyung Kim et al., “The Effects of Positive or Negative Self-Talk on the Alteration of Brain Functional Connectivity by Performing Cognitive Tasks,” *Scientific Reports* 11, no. 1 (2021): 14873, <https://doi.org/10.1038/s41598-021-94328-9>; Judy L. Van Raalte et al., “Cork! The Effects of Positive and Negative Self-Talk on Dart Throwing Performance,” *Journal of Sport Behavior* 18, no. 1 (1995): 50–57.

improved their performance significantly.⁷⁴ Techniques for preparatory arousal are incorporated into the self-talk portion of the training regimen.

To demonstrate instructional self-talk during the small-group sessions, instructors ask the participants to recall examples of abbreviations and mnemonics taught throughout the firefighting curriculum to recall the order of operations of technical tasks. These include “gap-set-force,” the steps for using a tool called a Halligan bar to break down an inward opening door, and LUNAR, the vital information—location, unit, name, air supply, and resources needed for rescue—to be relayed in a mayday radio message. As a demonstration of motivational self-talk, each student then supplies self-motivating statements that encourage success or increase effort, such as “I can do this” or “Dig deep, and just push a little bit harder.” Participants are then asked to combine the skills learned in the other sections of the training to generate increased arousal through positive motivational self-talk, an increased breathing rate, and the visualization of a rousing motivational speech from popular media or a prior personal experience.

F. REVIEW OF CONCEPTS

Following a review of the inverted-U hypothesis, participants are reminded of the goal of maintaining their position in the ideal zone of the stress–performance curve through the techniques learned in this program. The total duration of MST delivery—the combined evidenced-based teaching strategies including video, lecture, and small-group breakout sessions—is approximately 60 minutes. During the multi-modal training program, participants develop skills in the four pillars of MST: arousal control, visualization, goal setting, and self-talk, so the instructor reviews all four pillars, as well as the eight individual techniques covered through lecture. Finally, the instructor emphasizes the importance of continued practice. As with many skills taught during the basic firefighter course, the newly learned stress-control strategies will be perishable skills that require reinforcement and integration into daily operational routines to become habits for firefighters.

⁷⁴ Sarra Hammoudi-Nassib et al., “Effects of Psyching-Up on Sprint Performance,” *Journal of Strength & Conditioning Research* 31, no. 8 (August 2017): 2066–74, <https://doi.org/10.1519/JSC.0000000000000373>.

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III. RESEARCH DESIGN

This study followed the experimental research design model to evaluate the effectiveness of MST in a controlled environment. All experimental protocols were approved by the Naval Postgraduate School's Institutional Review Board (IRB) before their implementation.

A. PARTICIPANTS

Participants were recruited from new-hire firefighter training classes delivered by the Washington, DC, Fire & EMS Department's Training Academy. Such firefighter recruit academies provide an excellent source of experimental participants. The recruits have already passed a medical screening, and the exercise in the experimental scenario is like ones they have practiced throughout their training. By conducting the experiment near the end of the course of study, recruits are likely to be at peak proficiency with the tactical skills necessary to navigate the scenario.

During the previous week, recruits completed "Saving Our Own" training, specifically aimed at mitigating firefighter emergencies. While the training has exposed them to stressful, challenging, and realistic practical scenarios, stress-management techniques are not explicitly a part of the curriculum. A range of experience levels was noted in this recruit class. Some of the participants had prior firefighting experience from other agencies while others were completing their first recruit academy. Several of the recruits reported having 10 or more years of prior experience in other departments. The range of experience levels included in this cohort might lend insight into the potential benefits of MST for veteran versus novice firefighters.

B. DESIGN

Participants were randomly assigned identification numbers and split into two groups: an experimental group that would be given an MST curriculum lecture and a control group that would receive an unrelated lecture. Group assignments were blocked to ensure even distribution of demographics that might impact outcomes between the two

groups, particularly of participants with prior firefighting experience. Participants were also equalized among the intervention and control group by gender and level of medical training. The two groups were placed in different classrooms and remained separated for the duration of the experiment. Researchers collecting data on the day of the experiments and assessors of the quality of the recorded distress calls were blind to the group status of each participant.

C. PROCEDURE

Before the start of the experiment, all participants were given an IRB-approved recruitment speech and an informed consent form to sign. All the firefighter recruits were required to complete the practical exercise as it was a portion of the department's regular safety and survival training program. However, the informed consent paperwork allowed them to opt out of data collection. The first phase of the experiment was a classroom lecture. In the morning, a 60- to 90-minute lecture was delivered to each group. While the experimental group received instruction on the firefighting-specific MST curriculum described in the previous chapter, the control group attended a lecture about cardiovascular health, diet, and the heart disease risks associated with the profession. Both groups remained separated throughout the experiment.

Recruits were brought individually from their respective rooms to the experiment staging area according to a randomized list and paired with an instructor, who was not told their group status. Before the start of the exercise, each recruit who consented to participate was fitted with an HR device and monitored for at least five minutes at rest to establish baseline measurements for data collection. HR data were collected throughout the exercise and for a post-experimental recovery period. The data were downloaded onto the experimenters' computer, deidentified, categorized by the participants' randomly assigned identification numbers, and stored.

After a five-minute resting period, participants donned a portable radio with a shoulder strap, structural firefighting gear (coat, pants, boots, hood, gloves, and helmet), and a self-contained breathing apparatus (SCBA). Each participant was positioned approximately 100 feet away from the training building at a fire engine. The exercise began

when the actor playing the officer called the participant on the radio to join the crew. The participant followed a hose from the fire engine to the exterior entrance of the training building. At the front door, an instructor positioned next to a loop of hose in the line told the participant, “Put your mask on and go meet up with your crew. Leave this extra hose here for now.” The participant then followed the hose inside the first floor of the training building to the top of the stairs leading down to the basement, where two more instructors playing the parts of the participant’s crewmembers were waiting. The officer then said to the participant, “The fire is in the basement! Go back to the front door, feed us some more hose, then follow us down!” and advanced with the nozzle firefighter into the basement.

While the participant advanced the remaining hose down the stairs and descended, the two role players laid the nozzle down next to two training dummies, which had been placed under a 1,000 lb. concrete slab to simulate a partial building collapse. Firefighters’ SCBA are equipped with an integrated alarm, known as a personal alert safety system (PASS), which produces an increasingly loud set of warning tones if no motion is detected for 30 seconds; after 30 seconds of pre-alarm with no intervention, the PASS begins to sound a continual alarm tone and flash a series of LED warning lights. The alarm can also be manually activated by a firefighter in distress with the press of a button. In either situation, the alarm can be reset only by a double press of a button on the air pack’s shoulder-mounted console. When the participant reached the bottom of the stairs, this audible emergency alarm was activated by the instructors, indicating that there was a downed firefighter in distress. The correct procedure in this scenario would be to locate the source of the alarm, verify that it was sounding because of a true emergency (and not because the firefighter wearing it had remained motionless for over 60 seconds and had failed to reset the alarm), and transmit a distress call by radio to the incident commander requesting assistance. The duration from alarm activation to the participant’s reaching the dummies was recorded. Likewise, the duration from the participant’s reaching the dummies under the concrete to issuing a mayday distress call on a handheld radio was recorded. If the duration from the initial alarm to locating the simulated victims exceeded two minutes, an instructor would direct the participant, “This block is too heavy for you to move. You need to call a mayday.”

After completing the mayday transmission, the participant was escorted out the rear of the training building for a recovery period during which vital signs continued to be monitored and where a brief questionnaire was administered. The hose was repositioned back at the top of the stairs, and the slack loop was pulled back into place by the front door. The exercise was repeated in the same way with each successive participant until every recruit had participated. Biometric data, task times, survey responses, and mayday messages were recorded for post-experiment analysis.

D. MATERIALS

1. Heart Rate Monitor

A Polar H10 chest strap-mounted heart rate monitor was used on each participant to record HR and HRV. Multiple H10 monitors were used concurrently to allow overlap between participants. At the conclusion of each round, the participant's monitor was removed, the data were downloaded and cataloged, and the device was cleaned and made ready for the next participant. All heart rate monitors were labeled with unique serial numbers to assist in accurate data collection and prevent misidentification of monitors or participants.

2. Questionnaire

A post-experiment questionnaire was administered to participants. The questionnaire consisted of demographic questions as well as subjective assessments of perceived stress, self-assessed performance, any stress-management skills used, and participant estimates of the time to victim location and the time to distress call (see Appendix B).

3. Audio and Video Recording

Participants were videotaped by a shadowing instructor through the entire evolution. This video served as a backup for verifying task timing benchmarks manually recorded by the facilitators. Distress calls were made using a Motorola APX7000 radio and recorded at the agency's communications center. Digital time-stamped copies of the radio transmissions were provided to the investigators by the agency and used in the mayday

grading portion of the study. Experienced officers in the agency were given randomized audio files of the distress calls and asked to grade them on several performance factors using a scale developed for this study.

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IV. RESULTS

This chapter details findings from the experiments conducted at the DC Fire Training Academy. Where applicable, incomplete data sets resulting from collection equipment malfunctions were omitted, so sample sizes reflect the number of usable data points.

A. DEMOGRAPHICS

Forty-six firefighter recruits participated in the study. Twenty-six of them reported some previous firefighting experience from another department. The average age of the participants was 28.7 years old ($SD = 5.41$; see Table 1).

Table 1. Demographic Characteristics of Participants

	Control	Intervention
Sample size	$n = 20$	$n = 26$
Mean age	27.4, $SD = 4.25$	29.69, $SD = 6.05$
Gender	16 males, 4 females	23 males, 3 females
Experience	9 none, 11 some experience	11 none, 15 some experience

Note. Participants were randomly assigned to control and intervention groups. Experience level (novice versus experienced candidates) and gender were distributed between groups as evenly as possible.

B. TASK TIMES

Times were recorded for Task A (locating the source of the alarm) and Task B (recognizing the only possible course of action was to call a mayday and initiate a radio transmission), and participants were asked to estimate how long they believed each task took. The recorded task times did not show any statistically significant trends between groups nor did the relationship between actual and perceived task times (see Tables 2–4).

Table 2. Descriptive Statistics for Time to Locate Source of Alarm in Seconds (Task A)

	<i>n</i>	Mean	<i>SD</i>	Lower Bound	Upper Bound
Control	16	42.5	15.9	34.7	50.3
Intervention	22	53.5	24.4	43.3	63.7
Total	38	48.8	21.7	41.9	55.7

Note. 95% confidence interval for mean. $F(1,36) = 2.456, p = .126, \eta^2 = .064$.

Table 3. Descriptive Statistics for Time to Initiate Distress Call in Seconds (Task B)

	<i>n</i>	Mean	<i>SD</i>	Lower Bound	Lower Bound
Control	16	25.0	17.6	16.4	33.6
Intervention	22	30.7	18.8	22.8	38.6
Total	38	28.3	18.3	22.5	34.1

Note. 95% confidence interval for mean. $F(1,36) = .891, p = .352, \eta^2 = .024$.

Table 4. Descriptive Statistics for Total Time to Locate Source of Alarm and Initiate Distress Call in Seconds (Task A + Task B)

	<i>n</i>	Mean	<i>SD</i>	Lower Bound	Lower Bound
Control	16	67.5	28.4	53.6	81.4
Intervention	22	84.1	31.2	71.1	97.1
Total	38	77.1	30.8	67.3	86.9

Note. 95% confidence interval for mean. $F(1,36) = 2.833, p = .101, \eta^2 = .073$.

Participants' own estimates of the time it took to locate the victims after hearing a PASS device, as well as the time it took to call for help after identifying the victims were trapped under unmovable debris, were not significantly different between control and intervention groups. Participants could accurately judge the time it took them to locate the source of the alarm across both groups (see Table 5). Perceived task times for locating the victims had an almost 1:1 ratio with the actual task time, indicating that there was no

significant error in self-assessed estimates of the time elapsed. However, some participants from both groups misperceived the elapsed time during the second task. Participant estimates of the time it took to call a mayday after locating the victims were slightly longer than the actual time, indicating potential time distortion. The ratio of perceived time to actual time for both groups was greater than 1, though not significantly different between control and intervention groups (see Table 6).

Table 5. Descriptive Statistics for Ratio of Measured Task A Time to Self-Assessed Estimate of Task A Time (Task A : Task A Perceived)

	<i>n</i>	Mean	<i>SD</i>	Lower Bound	Lower Bound
Control	17	1.0	.57	.7	1.3
Intervention	22	1.15	.96	.7	1.6
Total	39	1.08	.81	.4	1.7

Note. 95% confidence interval for mean. $F(1,36) = .040, p = .842, \eta^2 = .058$.

Table 6. Descriptive Statistics for Ratio of Measured Task B Time to Self-Assessed Estimate of Task B Time (Task B : Task B Perceived)

	<i>n</i>	Mean	<i>SD</i>	Lower Bound	Lower Bound
Control	17	1.8	3.0	.4	3.2
Intervention	22	1.1	.86	.7	1.5
Total	39	1.4	2.08	.7	2.1

Note. 95% confidence interval for mean. $F(1,35) = 2.421, p = .129, \eta^2 = .024$.

C. MAYDAY MESSAGES

Emergency radio messages (maydays) were recorded and graded by independent fire academy instructors using a 14-point assessment rubric developed for this study (see Appendix C). For each of the attached mayday transmissions, instructors rated the audio recordings for comprehensibility and completeness on a scale from zero to four points.

Higher scores indicated better transmissions, with zero points awarded for being completely unintelligible or incorrect and four points for excellent. Additionally, evaluators awarded two points for each of the following conditions that was met: participant silenced the PASS device while making the mayday transmission, participant identified that there were two victims, and participant identified that there was debris trapping the victim. The host department did not have an established passing score for mayday transmissions on this kind of multipoint scale. Participants also rated their own performance on a scale of one (poor) to five (excellent). There was no relationship between self-assessed scores and instructor graded scores: $R = -.145$, $p = .353$. However, the intervention group did show a trend toward higher instructor-assigned grades that fell just shy of statistical significance.

Table 7. Descriptive Statistics for Instructor-Assessed Mayday Message Ratings

	<i>n</i>	Mean	<i>SD</i>	Lower Bound	Lower Bound
Control	19	5.63	2.52	4.42	6.85
Intervention	25	6.76	1.73	6.05	7.47
Total	44	6.28	2.16	5.62	6.93

Note. 95% confidence interval for mean. $F(1,42) = 3.101$, $p = .086$, $g = .53$.

D. USE OF AROUSAL CONTROL AND VISUALIZATION

Arousal control and visualization were the primary pillars of the MST curriculum, but participants in both groups could have been exposed to the concepts in previous experiences. The post-exercise survey gave all participants brief descriptions of these two methods. Then, participants were asked whether they used the described techniques during the exercise and whether they had found them helpful. The a priori hypothesis was that both techniques would be utilized by the intervention group more heavily, even after only one hour of instruction. Indeed, those in the intervention group were significantly more likely to report both instances of use and perceived helpfulness of each technique. On the post-exercise survey, participants selected from the following options on a numerical scale:

1 = *Did not use*, 2 = *Used, not helpful*, 3 = *Used, moderately helpful*, and 4 = *Used, extremely helpful*. Average scores for the intervention group were higher for arousal control ($M = 3.48, SD = .928$) and visualization ($M = 3.27, SD = .874$). Scores for the control group were lower for arousal control ($M = 2.61, SD = 1.243$) and visualization ($M = 2.59, SD = 1.278$; see Table 8).

Table 8. Use of Arousal Control and Visualization during Experiment

Use of Arousal Control	Use of Visualization
$F(1,31.096) = 4.046$	$F(1,25.75) = 6.983$
$p = .01$	$p = .03$
$g = .80$	$g = .65$

E. REALISM AND STRESSFULNESS

Participants were asked how stressful and how realistic they found the scenario on five-point scales. A score of 1 was *very low stress or not at all realistic* and 5 was *very high stress or very realistic*. There was no significant difference between control and intervention groups on either measure, with the overall cohort assessing the scenario as being low stress or moderate stress ($M = 2.57, SD = .83$) and moderately realistic ($M = 3.26, SD = 1.06$; see Table 9).

Table 9. Perceived Stressfulness and Realism of Scenario

Scenario Stressful?	Scenario Realistic?
$F(1,44) = .894$	$F(1,44) = 1.978$
$p = .126$	$p = .830$
$g = .46$	$g = .07$

F. SDNN, RMSSD, AND STRESS INDEX

Multivariate tests showed a significant difference in the standard deviation of the intervals of normal-normal sinus beats (SDNN) between rest and work measures. The main

effect SDNN was significant, so regardless of condition, there was a difference between rest and work SDNN measurements: $F(1,26) = 125.05, p < .01, \eta^2 = .828$. The interaction of SDNN by MST condition was also significant: $F(1,26) = 6.05, p = .02, \eta^2 = .189$. While the difference between both groups was not significant during rest ($p = .103$), the difference during the work period ($p = .079$) trended toward significance and warrants further research. A test for the contribution of experience found that it was not a significant variable; however, with the low n and unequal participants, this factor might emerge as more significant with additional research (see Table 10).

Table 10. Descriptive Statistics for SDNN during Rest and Work Periods

Element	Subgroup	<i>N</i>	<i>M</i>	<i>SD</i>	Lower Bound	Lower Bound
Rest SDNN	Overall	28	45.80	18.80	38.83	52.76
	Control	10	53.00	5.80	49.41	56.59
	Intervention	18	41.80	4.32	39.80	43.80
Work SDNN	Overall	31	12.19	10.37	8.54	15.84
	Control	12	8.87	5.40	5.81	11.93
	Intervention	19	14.29	12.21	8.80	19.78

Note. 95% confidence interval for mean. The difference in HRV as measured by SDNN between control and intervention groups approached significance during the work period only, with the intervention group showing higher HRV (lower state of arousal).

Multivariate tests showed a significant difference in the RMSSD between normal heartbeats between rest and work measures. The difference in HRV as measured by RMSSD between control and intervention groups was significant during the work period, with the intervention group displaying lower HRV (higher state of arousal) than the control group during rest (see Table 11). The main effect RMSSD was significant, so regardless of condition, there was a difference between rest and work RMSSD measurements: $F(1,26) = 80.545, p < .01, \eta^2 = .756$. The interaction of RMSSD by control and intervention group was also significant: $F(1,26) = 6.321, p = .02, \eta^2 = .196$. The difference was significant between both groups during rest ($p = .05$) but not during the work period

($p = .19$). A test for the contribution of experience found that it was not a significant variable.

Table 11. Descriptive Statistics for RMSSD during Rest and Work Periods

Element	Subgroup	<i>n</i>	<i>M</i>	<i>SD</i>	Lower Bound	Upper Bound
Rest RMSSD	Overall	28	35.49	20.75	27.80	43.18
	Control	10	45.19	25.30	29.51	60.87
	Intervention	18	30.11	16.08	22.68	37.54
Work RMSSD	Overall	31	11.13	9.36	7.84	14.42
	Control	12	8.77	7.58	4.48	13.06
	Intervention	19	12.62	10.25	8.01	17.23

Note. 95% confidence interval for mean.

Multivariate tests showed a significant difference in Baevsky’s stress index, a geometric measure of HRV reflecting cardiovascular system stress, between rest and work measures. During the rest period, the intervention group had a significantly higher stress index than the control group. However, during the working period, this relationship was inverted, with the intervention group showing a significantly lower stress index than the control group. The main effect of the stress index was significant, so regardless of condition, there was a difference between rest and work stress index measurements; $F(1,26) = 110.389, p < .01, \eta^2 = .809$. The interaction of the stress index by MST condition was also significant: $F(1,26) = 8.169, p = .01, \eta^2 = .239$. The difference in the stress index was significant for the rest period ($p = .04$) and approaching significance for the work period ($p = .065$), suggesting further research is needed. A test for the contribution of experience found that it was not a significant variable (see Table 12).

Table 12. Descriptive Statistics for Stress Index during Rest and Work Periods

Element	Subgroup	<i>n</i>	<i>M</i>	<i>SD</i>	Lower Bound	Upper Bound
Rest Stress Index	Overall	28	11.50	4.83	9.71	13.29
	Control	10	9.16	3.37	7.07	11.25
	Intervention	18	12.79	5.11	10.43	15.15
Work Stress Index	Overall	31	35.09	17.67	28.87	41.31
	Control	12	42.61	21.20	30.62	54.60
	Intervention	19	30.33	13.57	24.23	36.43

Note. 95% confidence interval for mean.

G. SDNN AND RMSSD RATIOS

The SDNN and RMSSD ratios were calculated by dividing the value during the rest period by that during the work period. Because measures of HRV decrease with stress, the ratio of rest to work was expected to be > 1. Higher values would indicate a greater magnitude of change from low to high stress. The control group had a greater magnitude of change from low stress to high stress, indicating that the MST curriculum was useful in helping firefighters in the intervention group control their stress response (see Tables 13–14). An analysis of variance (ANOVA) of SDNN and RMSSD ratios showed a statistically significant difference between control and intervention groups.

Table 13. SDNN and RMSSD Ratios

SDNN Ratio	RMSSD Ratio
$F(1,26) = 6.051$	$F(1,26) = 6.321$
$p = .021$	$p = .018$
$\eta^2 = .189$	$\eta^2 = .196$

Table 14. Descriptive Statistics for Ratio of Rest to Work, SDNN, and RMSSD

Element	Subgroup	<i>n</i>	<i>M</i>	<i>SD</i>	Lower Bound	Upper Bound
SDNN Ratio	Overall	28	5.65	3.90	4.21	7.09
	Control	10	8.11	4.55	5.29	10.93
	Intervention	18	4.28	2.76	3.00	5.56
RMSSD Ratio	Overall	28	5.51	4.87	3.71	7.31
	Control	10	8.46	6.41	4.49	12.43
	Intervention	18	3.87	2.83	2.56	5.18

Note. 95% confidence interval for mean.

The participants in the control group had a significantly higher ratio for both measures of HRV, representing a greater magnitude of change from low to high stress than for intervention group participants. These results suggest that MST was effective in promoting a more gradual physiological response when presented with a stressful scenario. Stress increased less quickly during the performance of the exercise in the MST participants than in the control group.

H. STRESS INDEX RATIOS

The stress index ratio was calculated by dividing the stress index during the rest period by the stress index during the work period. Because stress index values increase with stress, the ratio of rest to work was expected to be < 1. Lower values would indicate a greater magnitude of change from low to high stress. The control group had a greater magnitude of change from low stress to high stress, indicating that the MST curriculum was useful in helping firefighters in the intervention group control their stress response (see Table 15). The ANOVA of stress index ratios showed a statistically significant difference between control and intervention groups: $F(1,26) = 8.169, p = .008, \eta^2 = .239$

The participants in the control group had a significantly lower ratio, representing a greater magnitude of change from low to high stress than for their counterparts in the intervention group. These results suggest that MST was effective in dampening the body’s initial response when presented with a stressful scenario.

Table 15. Descriptive Statistics for Ratio of Rest to Work,
Stress Index

Element	Subgroup	<i>n</i>	<i>M</i>	<i>SD</i>	Lower Bound	Upper Bound
Stress Index Ratio	Overall	28	.41	.25	.32	.50
	Control	10	.26	.15	.17	.35
	Intervention	18	.49	.26	.37	.61

Note. 95% confidence interval for mean.

V. DISCUSSION

Forty-six firefighter recruits in a large metropolitan fire department participated in the study. Recruits in the intervention group were given a brief MST curriculum of approximately 60 minutes while their peers in the control group received an unrelated training course about the effects of nutrition and cardiovascular disease on performance. Participants completed a firefighting exercise with live actors during which they discovered their simulated crew replaced with training mannequins trapped under a large piece of concrete. Participants sounded a mayday emergency radio transmission, which concluded the exercise, and after exiting the building, they completed a post-exercise survey. Data collected by a Polar H10 monitor worn by each participant were analyzed to compare the difference in stress markers between the two groups. As hypothesized, MST was shown to be effective at reducing the effects of stress across several physiological indicators, despite the short duration of the applied intervention.

A. TASK PERFORMANCE

Task times were recorded to gauge how long it took to locate the victim and how long it took to transmit a distress signal, but the times did not differ significantly between control and intervention groups. This outcome was likely due to the low level of difficulty associated with both tasks in this experimental set up, in which the participants' visibility was not limited by smoke, and the training building was relatively uncluttered by debris. Yerkes and Dodson argued that more-challenging tasks require a different optimal level of arousal, so if conditions in future experiments are modified to increase the difficulty of the tested tasks, a difference might be expected between participants who use MST to modulate their arousal and those who do not.⁷⁵

It is difficult to produce those levels of stress in a training environment, so it might not be possible to simulate the extreme level of pressure facing a firefighter in a real-life

⁷⁵ Robert G. Mair, Kristen D. Onos, and Jacqueline R. Hembrook, "Cognitive Activation by Central Thalamic Stimulation: The Yerkes–Dodson Law Revisited," *Dose-Response* 9, no. 3 (July 2011): 313–31, <https://doi.org/10.2203/dose-response.10-017.Mair>.

emergency. When asked how stressful and how realistic the scenario in this study was, the participants described it as inducing “low stress” or “moderate stress” and being “moderately realistic.” Repeating the study in the presence of live fire conditions would certainly be one way to increase the stress and realism, but doing so would be time and resource intensive. Live fire training exercises require the use of additional certified trainers, access to a specialized burn building, and the purchase of consumable materials. However, departments could inject stress into their scenarios in other ways to produce a similar physiological result. Conducting training in unfamiliar surroundings or limiting participants’ sensory input using training smoke or obscured SCBA masks are some possible options for increasing the level of difficulty. Additionally, instructors could borrow from the methodology developed in the Trier social stress test, in which facilitators induce stress by having participants perform an oral presentation in front of an interview-style panel.⁷⁶ Firefighting instructors could subject participants to significant additional stress without increasing the difficulty of facilitating the exercises by creating a panel of observers to monitor the training. Furthermore, the panel might create higher levels of stress if the panelists were identified ahead of time as high-ranking members of the department or if the study participants were told their score on the exercise would be affected by the panel’s observations.

Based on their prior training, participants were expected to know that if they found a trapped firefighter whom they could not quickly extricate, they needed to make a mayday radio distress call. If the duration from the initial alarm to the participant’s locating the simulated victims exceeded two minutes, an instructor prompted the participant: “This block is too heavy for you to move. You need to call a mayday.” It is worth noting that not a single participant required this prompt, and most completed this task in less than 30 seconds.

Across both groups, participants’ estimates of the time it took to locate the victims after hearing a PASS device were almost identical to the actual times. However, during the second task of identifying that the victims were under an immovable object and the only

⁷⁶ Andrew P. Allen et al., “The Trier Social Stress Test: Principles and Practice,” *Neurobiology of Stress* 6 (2017): 113–26, <https://doi.org/10.1016/j.ynstr.2016.11.001>.

recourse was to call for help, the ratio of the perceived time to actual time for both groups was less accurate, with both groups overestimating how long the task took. As the level of stress of the scenario increased, participants might have been feeling the effects of time distortion. Alternatively, their chronological memories of the event might have been affected by the additional stress, causing them to remember it as taking longer than it did. Additional studies should focus on this effect and determine whether MST or other factors have any function on memory accuracy or the ability to accurately gauge the passing of time during high-pressure situations.

The mayday messages transmitted by the participants were recorded on the department's radio system and later graded by a panel of senior fire officers. While the finding was not statistically significant, the intervention group did show a trend toward higher instructor-assigned grades. Future MST experiments might reveal that for this variable, the difference between control and intervention groups becomes more pronounced with increased stress, changes in delivery, or larger enrollment numbers.

B. SDNN, RMSSD, AND STRESS INDEX

Even a short MST session appears to impact the physiological stress response. While the difference between the SDNN intervals in both groups was not significant during rest, the difference during the work period trended toward significance and warrants further exploration. The participants in the intervention group had lower HRV according to this metric, indicating that the MST skill may have resulted in a lower level of arousal when they were exposed to stress. The RMSSD between normal heartbeats, on the other hand, showed a significant difference between both groups during the rest period but not during the work period. The lower level of HRV displayed by the intervention group may have been a result of the successful use of preparatory arousal techniques discussed in the self-talk portion of the curriculum. Because human performance improves as pressure mounts, participants learned the value of moving to the right of the Yerkes–Dodson curve to approach the ideal range of performance. This strategy can be particularly helpful in combating fatigue or under-arousal in preparation for stressful activity. The stress index findings were promising during both periods, with a significant difference during the rest

period between intervention and control, and a difference and approaching significance during the work period. The higher stress index scores of the intervention group during rest may also point to the effectiveness of the preparatory arousal techniques. During the working period, the intervention group showed a significantly lower stress index than the control group, indicating that the MST techniques were effective in helping dampen the stress response when faced with a simulated firefighter emergency. The stress index findings during both periods suggest that further research is needed to confirm these effects. As noted earlier, increasing the stress level in the scenario may produce a more distinct difference between the two groups.

One of the physiological markers of interest was the magnitude of change between the available stress markers measured during the experiment. Here, the present study produced the most significant findings and pointed to an effective intervention. Across all three measures, the intervention group had a lower magnitude of change in its physiological stress response than its counterparts in the control group, meaning the change from rest to work was less dramatic and more gradual for those exposed to the MST lecture. This promising finding indicates that MST can be a useful tool in dampening the body's initial fight-or-flight response, allowing firefighters to stay cooler and calmer for longer. The differences noted in physiological stress between the two groups would likely result in improved performance for MST practitioners on the highly demanding tasks firefighters can expect to encounter in the real world. Further research should investigate other techniques for implementation of MST in the firefighter population, as well as methods for retaining skills gained through repetition and reinforcement.

C. COMPARISON OF RESULTS TO EXISTING LITERATURE

Research on the effectiveness of MST in the firefighter population is extremely limited. At the time of this publication, Marquardt's study was the only effort to examine mental training in this professional arena. In that study, a survey of 68 firefighters examined the relationship between various mental strategies and firefighters' assessment of how they affect performance, success, and perceived stress.⁷⁷ The findings of the present

⁷⁷ Marquardt, Krämer, and Schürmann, "Mental Preparation Strategies."

study correlate with Marquardt’s determination that firefighters believe they would benefit from the use of mental preparedness strategies. The present study further supports this finding across multiple measures of physiological stress, as measured by HR before and during stressful work periods. Both the findings of the present study and those of Marquardt align with other research of subjects ranging from police officers to soldiers.⁷⁸

D. LIMITATIONS

Of the 60 firefighter recruits selected for the study, 14 opted out of having their data collected. The remaining 46 recruits participated in all phases of the experiment. However, due to difficulties with data collection during the experiment, some data sets were partially incomplete and were, therefore, omitted from certain calculations. The resulting sample sizes made it difficult in several cases to draw conclusions, and results often trended in a direction but fell short of statistical significance. As this area of research expands, additional analyses should seek to overcome the limitations of small sample sizes by conducting longitudinal studies in the host department or running multiple studies in parallel with successive recruit classes, assuming their demographics are similar. Partnering with the country’s largest municipal departments such as the Fire Department of the City of New York would allow researchers to conduct training with higher participant counts, as those organizations typically field recruit classes of over 100 students.

1. Intervention Time and Lack of Repetition

To keep the intervention group from sharing the MST techniques with their classmates, the groups were physically separated at the beginning of the day and did not interact with each other until the conclusion of the experiment. This constraint meant that both training delivery and assessment of its effect had to be conducted on the same day. The resulting time constraints limited the delivery of the MST curriculum to approximately

⁷⁸ Page et al., “Brief Mental Skills Training Improves Memory”; James Peter J. Fitzwater, Calum Alexander Arthur, and Lew Hardy, “‘The Tough Get Tougher’: Mental Skills Training with Elite Military Recruits,” *Sport, Exercise, and Performance Psychology* 7, no. 1 (February 2018): 93–107, <https://doi.org/10.1037/spy0000101>.

one hour to leave enough time to cycle each participant through the experiment. Other MST programs, such as those in the military or in medical education, deliver information to students over the course of weeks or months, through multiple sessions, with ample opportunity for practice and reinforcement. Although previous research has shown that even an extremely brief intervention can have a profound impact on performance under stress, it remains unclear how long this effect lasts.⁷⁹ The author of the 2016 brief MST intervention study was particularly concerned that there was no follow-up to determine whether participants retained the information or the ability to bring it to bear during similar stressful events later in their careers.⁸⁰ Revisiting the recipients of single-session MST deliveries may reveal that without reinforcement and repetition, the benefits on stress level and performance erode over time. Such follow-up studies would help shape the delivery modality of future MST programs in the fire department.

2. Sampling Error with Devices

The Polar H10 devices were worn underneath standard firefighting protective gear and SCBA. The Polar H10 is an appealing collection device for these types of studies because of its durability, water resistance, and relatively low cost. The devices can store one data collection session in local memory or transmit results in real time to an iOS device paired by Bluetooth. During the present study, each participant was paired with an evaluator, who had to stay close to the recruit throughout the exercise to allow the collecting iOS device to maintain a Bluetooth connection to the monitor. However, the evaluators could not tell when poor connectivity occurred, so many data sets were corrupted and unusable for the study. Factors impacting connectivity in the training building included the physical proximity between the monitor and the collecting device and concrete or metal building components between the two that shielded signals. Adding live fire training to increase the level of stress and realism poses a particular challenge with the tenuous connectivity of these devices. Future studies using these devices could overcome connectivity issues by physically pairing the collecting device with the

⁷⁹ Page et al., “Brief Mental Skills Training Improves Memory.”

⁸⁰ J. Page, email to author, January 26, 2022.

participant by placing it in a container within the firefighting gear or by taking advantage of the local memory storage option and downloading each device individually after every round of data collection.

E. CONCLUSION AND RECOMMENDATIONS

This study set out to determine whether brief MST could influence firefighters' ability to complete their work under stress. Other professions have been using similar techniques to improve human performance in a variety of high-stress fields, from surgery to military special operations, but the fire service has been slow to formally adopt such measures. A fire department-tailored curriculum, focused on the four pillars of arousal control, visualization, goal setting, and self-talk, was tested in a cohort of firefighter recruits in an urban American fire department. The participants completed a realistic training scenario in which they had to mitigate a simulated firefighter emergency, and those who had received MST showed a markedly different stress response from the control group. Using HRV as a measure of stress, the results of the experiment showed that MST produced a higher state of physiological arousal during the preparatory phase, indicating that participants were closer to their optimal zone of performance before initiating the task. Additionally, HRV values indicated lower states of arousal during the working period for the intervention group, suggesting they were less negatively affected by their SNS response. Furthermore, changes in the stress response appeared to occur more gradually and with a lower magnitude for those who had implemented MST tools.

If a brief MST intervention could impact firefighter performance, a longer intervention or one administered over multiple sessions could have an even more profound effect. Other professions that use these kinds of curricula often integrate them into weeks- or months-long training programs. Future research is needed to determine whether the effects observed in this study could be magnified with repetition. Further research is also needed to examine the longevity of the positive effects of MST observed with this cohort of firefighters. The ability to induce realistic levels of stress was a limiting factor in the experiment, so it would be useful to repeat this study with higher-fidelity simulations by adding live fire conditions or other stressors.

The promising findings of this study indicate that MST can be a useful tool both in preparing firefighters to tackle stressful situations and for controlling their autonomic responses once the stressors are presented. Given the dangerous nature of the job and the grave consequences of failure, any technique that can reduce the negative effects of stress to improve tactical performance has the real potential to save lives. The effects produced by the pilot MST curriculum developed for this thesis suggest that departments should consider adding this kind of instruction to both recruit classes and in-service training for tenured members.

APPENDIX A. PRESENTATION OUTLINE

- Presenter Background
- Introduction
- Sullenberger Interview Video
- What is Mental Skills Training?
- History of Mental Skills Training
- Physiology of Stress
- Pressure/Performance Relationship (Yerkes–Dodson Curve)
- The “Big 4” Mental Skills
 - MST Pillar 1—Arousal Control
 - Skill 1—Box Breathing
 - Skill 2—Prolonged Exhalation
 - MST Pillar 2—Visualization
 - Skill 3—Simulated Mental Practice
 - MST Pillar 3—Goal Setting
 - Skill 4—Interim Goals
 - Skill 5—Outcome Goals
 - MST Pillar 4—Self-Talk
 - Skill 6—Instructional Self-Talk
 - Skill 7—Motivational Self-Talk
 - Skill 8—Preparatory Arousal
- Review of Concepts
- Practical Skills Breakout Session

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APPENDIX B. EFFECT OF MENTAL SKILLS ON FIREFIGHTER PERFORMANCE UNDER STRESS: POST-EXERCISE QUESTIONNAIRE

Participant ID number: _____

Age: _____

Gender: _____

1. Do you have previous experience as a firefighter prior to entering the DC Fire Academy? If yes, how many years? Yes/No
2. From the time that the victims' PASS alarm sounded, how long do you think it took you to reach them? (mm:ss)
3. From the time that you reached the victims, how long do you think it took you to transmit a MAYDAY message? (mm:ss)
4. From start to finish, how long do you think the exercise lasted? (mm:ss)
5. How helpful was the training you received this morning to your performance in this exercise?

1–5 scale with the following labels:

1. Not at all helpful
 2. Slightly helpful
 3. Helpful
 4. Very helpful
 5. Extremely helpful
6. Rate the quality, clarity, and accuracy of the MAYDAY message you transmitted on a scale from 1 to 5.
 1. Very bad—Information was inaccurate or missing entirely / transmission unintelligible / had to be prompted to transmit mayday.

2. Poor—Key information missing or inaccurate / difficult to hear or understand
 3. Average—Some information missing / mostly understandable / appropriate volume
 4. Good—Most relevant information relayed in a readily understandable voice and tone
 5. Excellent—Message was clear and concise, delivered in a calm and clear voice, easily understood by Command. All information was accurate and complete.
7. Visualization is the process of picturing yourself successfully completing a task in your “mind’s eye” which in turn can improve real-world performance. Did you use this technique during the exercise? If so, do you feel like it helped improve your overall performance?
- A. Did not use
 - B. Used, not helpful
 - C. Used, moderately helpful
 - D. Used, extremely helpful
 - E. Don’t know
8. Moderating physical and psychological activation (Arousal Control) can help ensure you are in an ideal performance state. Did you use any techniques like breath control or meditation to bring yourself into “the zone”? If so, do you feel like it helped improve your overall performance?
- A. Did not use
 - B. Used, not helpful
 - C. Used, moderately helpful
 - D. Used, extremely helpful
 - E. Don’t know

9. Did you employ any other mental skills or stress-management techniques during this exercise? If so, what were they?
10. During this exercise, you were presented with a difficult scenario under challenging conditions. On the scale below, please rate the highest level of stress you felt during the scenario (for this question, we are asking about mental stress, not physical exertion).

1–5 scale with the following labels:

1. Very low stress
2. Low stress
3. Moderate stress
4. High stress
5. Very high stress

11. Training exercises like the one in this study are designed to simulate a real-world environment. On the scale below, please rate how realistic you felt the scenario was (i.e., how real did it feel while you were doing it?).

1–5 scale with the following labels:

1. Not at all realistic
2. Somewhat realistic
3. Moderately realistic
4. Realistic
5. Very realistic

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APPENDIX C. MAYDAY RATING SCALE

Participant ID: _____

For each of the attached Mayday transmissions, please rate the following:

1. Comprehensibility – How clearly were you able to make out what the participant was saying?

0 – Completely unintelligible

1 – Mostly unintelligible

2 – Hard to understand, but relevant information intelligible

3 – Some words hard to understand but most information clear

4 – Extremely clear
2. Completeness – How much of the relevant Who/What/Where information was included in the transmission?

0 – No LUNAR information transmitted or information completely incorrect

1 – Minimal information transmitted or most information incorrect

2 – Some information transmitted but key points missing or some info incorrect

3 – Most relevant information included, minor points missing

4 – All relevant information relayed
3. Did the participant silence the PASS device while making their Mayday transmission(s)?

Yes (2) / No (0)
4. Did the participant identify that there were two victims?

Yes (2) / No (0)
5. Did the participant identify that there was debris trapping the victim?

Yes (2) / No (0)

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