

Validated Development of Stress Inoculation through Cognitive and Biofeedback Training

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ABSTRACT

A key military priority is building resilience to stress, because of the near- and long-term effects of stress on mission performance, personal well-being, and relationships. Most stress treatment and prevention research focuses on the adverse effects of stress, neglecting to build on its potential positive effects on performance. The efforts discussed in this paper demonstrate that a software training app can provide an effective individualized method for mitigating the negative effects of stress while emphasizing its positive effects on performance. The Stress Resilience Training System (SRTS) iPad app blends cognitive training with advanced biofeedback to teach individuals to understand, regulate and exploit their stress responses, using a game-based learning framework. SRTS provides information on stress and its effects, techniques for self-regulation based on heart rate variability (HRV) biofeedback, HRV-controlled simulations, narrative self-tests, and adaptive coaching. The paper describes the SRTS methodology and positive results from multiple evaluations, including usability and efficacy studies on military, para-military and non-military samples. The usability study showed the app is intuitive and easy to use. The efficacy studies showed that participants improved in a number of key resilience-related measures including perceived PTSD symptoms, stress and depression, and also reported improvements in on-the-job performance, personal, and familial relations. The empirical results strongly support the ability of game/simulation-based biofeedback training to build stress resilience in a variety of different populations. Evaluation results suggest additional enhancements to the methodology including: a web-based version for multi-platform delivery; increased use of biometric data for better feedback of progress; incorporation of social networking for supportive interaction; and virtual mentoring to replicate the benefits of personal mentoring. The enhancements will make the capability a more valuable addition to initial and sustainment resilience training over a range of military and non-military applications.

ABOUT THE AUTHORS

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CDR Joseph Cohn, PhD is an Aerospace Experimental Psychologist in the U.S. Navy's Medical Service Corps, currently assigned as Associate Director to OUSD (AT&L)'s Human Performance Training and BioSystems Directorate (HPT&B). Dr. Cohn directed SRTS research and development during his previous tour in the Office of Naval Research's Human and Bioengineered Systems Division as a Military Deputy and Program Officer; and before that as a Program Manager at the Defense Advanced Research Projects Agency (DARPA).

Elizabeth O'Neill is a Program Analyst, providing scientific and technical expertise to ONR for the Warfighter Performance Department's Human and Bioengineered Systems Division and the Expeditionary Maneuver Warfare and Combating Terrorism Department. Ms. O'Neill also develops strategic guidance for the OSD Human System research portfolio, focusing on Adaptive Training technologies and Natural Human System Interfaces.

Gershon Weltman, PhD serves as Principal Scientist at Perceptronics Solutions and is the Principal Investigator on the SRTS project. Dr. Weltman's professional experience includes his long-term executive and technical management of predecessor Perceptronics, Inc., where he was responsible for directing the creative design, production and delivery of many innovative simulation and decision support systems.

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INTRODUCTION

Resilience under stress is a critical issue in today's military service. The negative effects of stress can include decrements in immediate performance, psychological injuries leading to high-risk behaviors such as alcohol and drug misuse; and in extreme cases PTSD and suicide (Hoge et al., 2004). Therefore, developing service members' resilience – their ability to withstand, recover, grow and adapt under stressful circumstances – is vital to protecting our military force's health. Without such resilience, service members' performance can suffer and their fitness and readiness for deployment may be adversely affected (Bates et al., 2010).

The need for stress resilience training extends to military populations other than those experiencing actual combat. For example, a 2009 research study of 368 guards and medical staff at Joint Task Force Guantanamo, conducted by the Naval Center for Combat and Operational Stress Control (NCCOSC) showed elevated levels of perceived stress, symptoms of PTSD and depression. The study concluded that because of the stressful nature of detainee operations, guards experience PTSD symptoms similar to, and depression higher than, combat-deployed service members and that those at risk are less likely to seek treatment (Webb-Murphy, 2011).

Non-military populations such as law enforcement personnel are also prime candidates for stress resilience training. In fact, police work and military service share many stress-related features: Psychological stressors connected with the mission, including extended duty cycles and exposure to horrific scenes of death and injury, are common to both cases (Balko, 2013). Anger management issues, family relationship issues and substance abuse, all resulting from stress, are again common to both military and police. And suicides in both the police and military now exceed deaths in the line of duty. Similar to military populations, a failure to get help is a major contributor to police suicide and other stress effects (Goldfarb, 2012).

There are also positive aspects to stress, as demonstrated by experienced warfighters and other extreme performers who are able to adapt to stress through self-awareness of their stress state and self-regulation of stress energy. The productive use of stress energy by parachutists was demonstrated in a pioneering set of studies by Fenz et al (1967 & 1972). Their work showed that expert parachutists experienced levels of stress similar to novices, but much earlier in the jump sequence than novices, whose stress peaked at the start of the jump. This suggests that experts, rather than failing to experience stress, do so at points where the resultant arousal is most likely to positively impact performance, while novices experience this arousal at points where it is most likely to negatively impact performance. Similar results were seen in an exceptionally realistic simulated stress study conducted by the Army Research Institute (Berkun, 1964), in which experienced personnel apparently used stress energy to perform better in threatening situations, while novices performed worse under the same conditions.

Our main objective in designing and developing the Stress Resilience Training System (SRTS) was to demonstrate that a software training app can provide an effective individualized method for mitigating the negative effects of situational and mission related stress while at the same time emphasizing its potential positive effects on performance. The SRTS app itself is described in the following section. This objective is in line with a congressionally mandated Institute of Medicine report which recommended that the Department of Defense (DOD) employ only evidence-based resilience and prevention programs, and that it eliminate non-evidence-based

programming (Institute of Medicine, 2014). Accordingly, the prime goal of this paper is to present in one place all of the empirical evidence to date for the usability and efficacy of the SRTS approach. The results of that empirical work – six successful studies concluded in 2013 – by independent university, military and paramilitary organizations are described below. The empirical results support the use of game/simulation based biofeedback training, as demonstrated by SRTS, to build stress resilience in a variety of different populations.

STRESS RESILIENCE TRAINING SYSTEM DESCRIPTION

Overview

The SRTS is a self-contained, mobile training course presently available as an iPad app. Its design concept combines: (1) information about the physiology of stress and resilience; (2) engaging training in a series of evidence-based energy self-regulation techniques; and (3) the use of heart rate variability coherence biofeedback to control a series of progressively more challenging games that are designed to increase the utilization and sustainment of the resilience-building skills (Cohn et al., 2010). The fully implemented SRTS app as described here has a Navy orientation, because the Navy's Operational Stress Control (OSC) Program has been a major transition and evaluation partner; but the program's approach is equally applicable to any highly stressed persons, including law enforcement and security personnel, and individuals working in institutional and corporate environments.

Unique Features

The key features that differentiate the SRTS program from other resilience building and stress control approaches are:

- Adopting portable technology in a scientifically validated stress resilience training approach that incorporates *both* cognitive learning and HRV coherence biofeedback;
- Minimizing the adverse effects of stress *and enhancing its productive effects* to help improve immediate performance as well as prevent the occurrence of psychological injuries;
- Using a state-of-the art mobile device such as the iPad or other tablet to greatly enhance training effectiveness by enabling refreshment training and practice during and after deployment; and
- Embedding the training methods in a set of Casual and Serious Games to provide a framework for learning to control and use stress productively in a form acceptable to today's young military population (Fletcher & Tobias, 2006), and other age groups as well.

Contents

The SRTS iPad app provides access to four main components:

- **KNOW HOW.** Teaches the user about stress and its effects in the form of narrated video modules on such topics as Resilience, Stress, Putting Stress in Perspective and Preparing for, Performing in and Recovering from Operations and the role of Spirituality.
- **TECHNIQUES.** Teaches a science-based biofeedback technique for energy management based on self-regulation of Heart Rate Variability (HRV) and shifts from negative to positive emotions.
- **GAMES.** Provides a set of HRV-controlled games and simulations used to encourage practice of the biofeedback stress control techniques in a series of engaging and progressively more challenging environments. The initial game is Basic Training, which introduces the user to the graphical and numerical feedback components. Subsequent games and simulations use the Basic Training elements as feedback, and the users perform better in the game by raising their HRV Coherence score. Figure 1 shows the



Figure 1. Asteroid Defense Game

Asteroid Defense game in which users defend their city against in-coming asteroids, and higher HRV Coherence gives them more ammunition. A high-speed space driving game is even more difficult.

- **REVIEW.** Allows the user to review his or her progress in learning and HRV Coherence skills through the use of story-based self tests and graphical visualizations of time based performance measures.

Each component has been designed with human factors considerations to support ease of use and produced to high iPad app standards.

HRV Coherence Biofeedback

An essential part of the SRTS app is HRV Coherence training using techniques and processes developed and validated by the Institute of Heartmath and others (McCraty et al., 2001; Kageyama, 1998). McCraty et al (2006) demonstrated that the pattern of beat-to-beat heart activity, or the heart rhythm, was correlated with emotions and neurocognitive function. They developed the HRV Coherence method of Heart Rate Variability (HRV) biofeedback to facilitate acquisition of self-regulation techniques that allow users to recognize and shift the mental and emotional responses associated with counter-productive stress reactions. Whereas basic HRV biofeedback encompasses the *amount* of beat-to-beat variability, HRV Coherence focuses on the *time-pattern* of variability.

The top graph of Figure 2 shows the edgy, jerky HRV pattern associated with *incoherence*. Incoherence means that activity in higher brain systems and the sympathetic and parasympathetic nervous systems are out of synch; it represents the neurophysiology of poor mental and physical performance. The bottom graph shows the more even HRV pattern associated with *HRV Coherence*, when the sympathetic and parasympathetic nervous systems are in synch. It represents the neurophysiology of optimal function, when everything seems easy and cognitive performance is enhanced. Overall, low HRV indicates a more depleted state of psycho-physiological functioning, which can result from an accumulation of operational stress (Dishman et al., 2000).

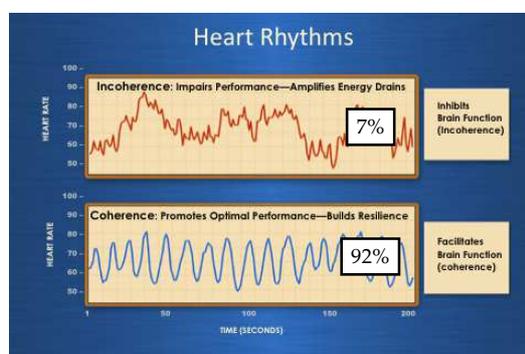


Figure 2. HRV Coherence and Incoherence

The iPad SRTS employs a specially designed ear sensor to detect the pulse, which is used to measure the basic heart rate, and Heartmath algorithms using power spectral analysis to determine a numerical HRV Coherence score as a percentage between 0 and 100. The Coherence score is calculated by analyzing the Power Spectral Density (PSD) of the Heart Rate Variability (HRV) data, which indicates the power of the HRV pattern at various frequencies. The PSD is computed on the basis of a Fast Fourier Transform which performs a frequency domain analysis of the HRV data. The Coherence score is created by quantifying the extent to which the power of the signal is spread across the range of frequencies. High coherence will have the HRV signal clustered around a small band of frequencies; in contrast, low coherence will have a wide spread of peaks and valleys across the range of frequencies. The SRTS goal is to allow the user both to increase the absolute amount of HRV and to reach high levels of HRV Coherence.

EMPIRICAL VALIDATION

While the SRTS app is still under development, it has been possible to perform a series of user evaluations. These assessments range from demonstrating user acceptance to characterizing the impact of the SRTS app on reducing stress and improving performance. The following summarizes the set of assessments completed in 2013.

GMU Usability Study

A comprehensive usability study of the SRTS iPad version, focusing on its interface features, was conducted by researchers from the George Mason University (GMU) Department of Psychology's Arch Lab. Fifteen male and female participants (mean age 21.4 years) were recruited through a voluntary university research database and were compensated with partial course credit. Participants were representative of the target user age for SRTS. Each participant session lasted one hour. The study is fully described in Smith et al (2013).

The study used two main data collection methods. In *Guided-Exploration* the participants were directed through a guided-exploration of the SRTS app. The guided-exploration path was selected by the researchers to ensure that all participants encountered each section of SRTS at least once for a more thorough experience with the program. In *Questionnaires* a 5-point Likert-scale SRTS Questionnaire covered specific aspects of the SRTS interface, and a Response to Stressful Experiences Scale (RSES) gave a subjective resilience score (Johnson et al, 2008). Figure 3 shows the mean ratings from the SRTS Questionnaire. According to the SRTS questionnaire results, participants agreed that SRTS was useful, SRTS was easy to use, SRTS was well integrated, SRTS was quick to learn, and they felt confident using SRTS. Users were overall positive about the system, with user quotes including, “[SRTS] is simple, the visuals are clean and coherent,” and, “I find the concept to be intriguing and I enjoyed how user-friendly the system was.”

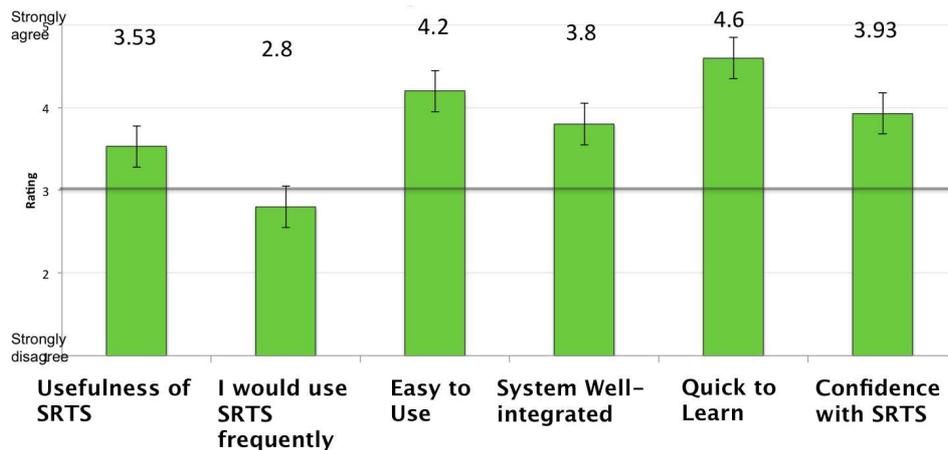


Figure 3. Mean Ratings from SRTS Questionnaire

Eleven (11) participants completed the RSES and their sum RSES scores were correlated with responses to the questions “I believe that when used regularly the SRTS system is useful in helping people to manage and deal with stress,” and “I think that I would like to use this system frequently.” One positive correlation indicated that participants with higher subjective stress resilience also felt that SRTS would help them in the future to manage stress ($r = .72, p < .05$). A second positive correlation indicated that participants with higher subjective stress resilience scores also thought that they would use the system more frequently ($r = .75, p < .01$).

Afghanistan Clinical Field Trial

CDR Randy Reese, Ph.D., then a Clinical Neuropsychologist and Assistant Director for Medical Services at the Warrior Recovery Center, Kandahar Air Field, conducted an informal clinical field trial. CDR Reese learned about the SRTS from an Office of Naval Research (ONR) press release; he wanted to try using SRTS as part of his work in preventing PTSD and other psychological injuries, and asked for support. The SRTS team sent him five SRTS units, began his experience with a teleconference training session, and also put in place means of continually monitoring and supporting his work. The team has continued to communicate with and support CDR Reese in his work after he rotated from Afghanistan

CDR Reese's clinical focus is the relationship between traumatic brain injury (TBI) and stress self-regulation. At his regular duty station at Camp Lejeune he has observed that the vast majority of Marines with persisting cognitive complaints experience difficulty as a result of PTSD or variants of combat stress, and not so much because of a history of concussion. In theater, CDR Reese did not perform comprehensive neuropsychological assessments, and he saw his primary role as working to prevent PTSD and post-concussive syndrome. He believed that helping soldiers learn to self-regulate hyperarousal is a key objective and saw SRTS as an important new tool toward achieving that goal. Since his patients were with him for only a week or two before they either rotate back to duty or move somewhere else for more rigorous medical therapy than he can provide, he asked for recommendations regarding a "curriculum" for SRTS when time is limited. He was provided with an overview that showed how to get

the most from the SRTS within those constraints, and also a written short-term curriculum. CDR Reese's experience with SRTS as a therapeutic tool was very positive; he reported:

"I'd say it was a hugely successful field trial. The (SRTS) devices and software were very well received, and I think were a great clinical tool. I have also learned about more effective ways to use the features over time."...One soldier with previous deployments and history of chronic PTSD and sleep issues and headaches said, "I have made more progress in the past week and a half (while at the WRC) than in five years of appointments at TBI clinics at home." This was attributed primarily to education (about hyperarousal arising from repeated combat experiences and impact of hyperarousal on multiple areas of functioning) and development of skills to reduce sympathetic hyperarousal, primarily using biofeedback and other cognitive/relaxation skills" (Reese, 2013).

Air Force Evaluation Study

The Air Force Research Laboratory (AFRL) conducted an evaluation study using Air Force personnel available at Peterson AFB, Colorado Springs, CO, and the study results were reported in an AFRL briefing (Christensen, 2013). The study participants were 20 personnel from 50th Security Forces who volunteered to participate and completed initial paper surveys on occupational stress, health, mental health, and burnout. The participants received an 8-week SRTS intervention including weekly 1-hour mentoring sessions by phone from mentors trained by Institute of Heartmath, and the initial surveys were repeated at end of the 8 weeks. Recruitment for the evaluation was challenging because highly stressed individuals were less willing to commit additional time to study participation. Also, iPad usage was moderate overall at 25 min/week, which was lower than requested usage of ~ 75 min/week. Finally, the Air Force users were working with an iPad app oriented toward Navy personnel – not an optimum match with the security forces.

Despite the challenges, the overall results were quite positive. Figure 4 shows the statistically significant ($P < .05$) negative correlation between reported stress level and SRTS iPad usage; 92% of SRTS users scores indicated same or better overall stress levels, while only 50% of control group scores indicated same or better overall stress. The strong correlation between usage and decline in stress may reflect strong motivation and/or the contribution of good mentoring. Trends in the results also suggested positive effect on overload (unable to keep up with work demands) and negative interpersonal functioning. Likewise, the percent of SRTS users reporting high emotional exhaustion decreased following the SRTS intervention, and the same was true for the percent reporting to be at high risk for clinical distress. The small N meant only a few users were affected, but the trend again was positive.

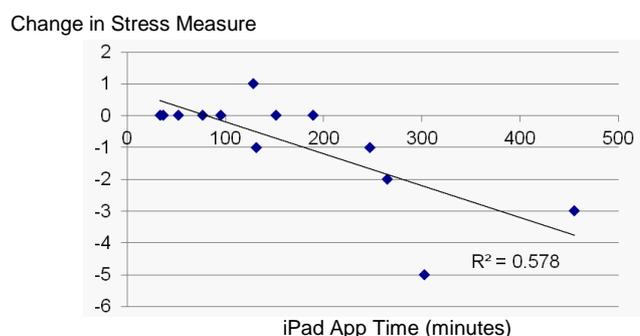


Figure 4. Change in reported stress as a function of SRTS usage time

In addition, verbal feedback from the SRTS users was very positive, including such reports as: "sleeping better" "calmer and more focused" "enjoy time with family more." Typical comments were:

"With all my challenges the past few weeks...I used every tool and technique you taught me and I got the highest PT score I have ever received."

"My mentor helped me see the progress I was making that I didn't realize I was making."

Military Operational Medicine Research Program Evaluation Study

Dr. Jeffrey Pyne of the Central Arkansas Veterans Healthcare System directed a SRTS evaluation as part of a larger study sponsored by the Military Operational Medicine Research Program (MOMRP). A main objective of this study

was to determine whether pre-deployment level of HRV had an effect on post-deployment PTSD symptoms. Assessment measures were: (1) Pre-deployment SDNN (a measure of Heart Rate Variability); and (2) pre- and post-deployment PTSD Checklist (PCL, a measure of symptom severity). Subjects were from the Virginia Army National Guard Cavalry and Aviation groups; 427 soldiers completed pre-deployment assessment, 308 completed post-deployment, and 247 had usable HRV data. The results were reported in Pyne (2013).

The statistically significant results ($P < .05$) of the study were: For the entire subject group, higher pre-deployment HRV correlated with less severe post-deployment PTSD symptoms; for the subjects 26 years old and older, SRTS intervention resulted in less severe post-deployment PTSD symptoms. The experimental results indicates that personnel who show higher HRV pre-deployment are likely to report less severe post-deployment PTSD symptoms; and even short SRTS intervention can decrease post-deployment PTSD symptoms. Since the SRTS app is designed to increase HRV, the overall conclusion is that SRTS usage before, during and after deployment can prevent and/or alleviate PTSD symptoms -- as originally hypothesized at the beginning of the SRTS program.

Naval Center for Combat and Operational Stress Control (NCCOSC) Evaluation Study

The Navy Center for Combat and Operational Stress Control (NCCOSC) was originally designated as a SME for the SRTS project. It assumed the lead in organizing a military efficacy evaluation, formed a SRTS Study Team to develop the protocols, obtained the required IRB approval, and has worked with the support of Perceptronics Solutions and its subcontractors to conduct the study. The key NCCOSC members of the study group include CAPT Scott Johnston, NCCOSC Director and Principal Investigator, and Dr. Ted Morrison, SRTS study team coordinator.

The NCCOSC study is designed to evaluate the effectiveness of the SRTS program at reducing perceived stress, PTSD symptoms, depression, anxiety, sleep quality, attrition and class/operational performance among Navy service members. The 71 initial participants were recruited from the San Diego based Coastal and Riverine Expeditionary Group and Squadron (which includes Explosive Ordinance Disposal). Service members were randomly assigned to one of three conditions: the SRTS iPad app condition; an iPad-based Progressive Muscle Relaxation (PMR) condition (PMR is a stress control app previously applied by NCCOSC, which was used here for comparison and as an iPad-use control); and a no-intervention control group. SRTS participants were given a 2-hour training session, and 8 weeks of iPad SRTS personal training at home.

Preliminary results from the iPad SRTS evaluation study were reported by Dr. Morrison at the 2013 International Society for Traumatic Stress Studies (Morrison et al, 2013) and they were highly positive. The most important results from the NCCOSC viewpoint were those on app usage. This is because there remains a serious stigma attached to seeking psychological help in military populations, and a key objective of SRTS was to overcome this stigma by providing a personal alternative or adjunct tool. As shown in Figure 5, questions on applying the app before and during perceived stressful events all provided statistically significant positive differences ($P < .02$) between users of SRTS and those of the Progressive Muscle Relaxation (PMR) app. And overall, SRTS was opened 250% more (2.5x) than the PMR app as determined by usage capture software embedded in the two apps.

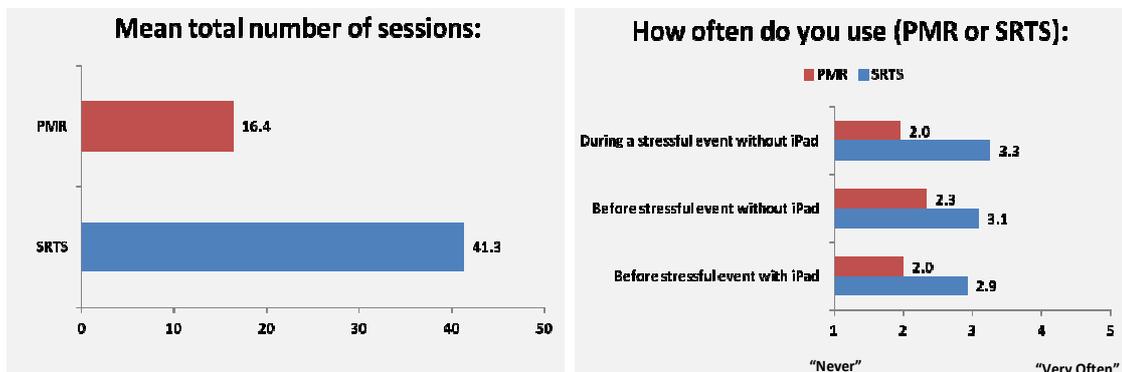


Figure 5. Comparison of SRTS and PMR app usage

The study also achieved statistical significance ($P < .05$) on its two most important scales: PSS-10 (Perceived Stress Scale) dealing with perceived stress, and PHQ-9 (Patient Health Questionnaire) dealing with depression, which is

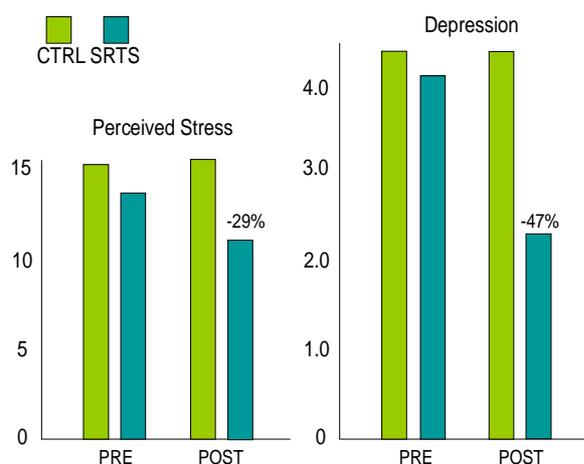


Figure 6. NCCOSC PSS-10 and PHQ-9 results

dispatchers. As reported in Weltman et al (2014) we delivered an initial training session including resilience background and SRTS iPad operation. The participants then used the SRTS units on their own time for 6 weeks, and Institute of Heartmath provided 4 weeks of 1-hour personal telephone mentoring to each participant. SDPD participants completed the Personal and Organizational Quality Assessment (POQA) during the initial training session and at the end of the intervention. The POQA has four primary scales – Emotional Vitality, Organizational Stress, Emotional Stress and Physical Stress – and nine subscales, including such factors as Emotional Buoyancy, Anxiety and Depression, Anger and Resentment, Fatigue, etc. POQA has been previously used by Institute of Heartmath in its research studies and practice, and individual scores are compared to norms from a sample of 5,971 working adults. In addition, the mentors submitted reports of the participants’ comments and their observations.

The results of the study were positive: As shown in Figure 7, all four main scales within the POQA instrument showed improvement; Emotional Vitality improved by 25% ($p < 0.05$) and Physical Stress improved by 24% ($p < 0.01$). Eight of the nine subscales showed improvement, with the Stress subscale, perhaps the key measure of the study, improving approximately 40% ($p < 0.06$). All participants said that the mentoring helped to deepen their understanding of how to use the SRTS skills in everyday situations. In addition, the participant comments as reported by the mentors were universally positive. Participants reported that they were able to learn the Coherence Advantage technique and to progress in the games from the simpler to the more challenging. More important, they were able to apply the technique in real-life situations, including one actual confrontation with a suspect. Participants related improvements in both on-the-job performance and personal and familial situations. They enthusiastically praised the program and recommended it for wide application in law enforcement training.

closely related to PTSD. As shown in Figure 6, the pre-intervention levels of Perceived Stress and Depression of the SRTS group were nearly the same as those of the no-intervention control group, while post-intervention the SRTS group showed much lower levels of Perceived Stress (-29%) and Depression (-47%) when compared to the control group ($P < 0.05$). We would have expected the SRTS and the control group to have had similar life experiences during the intervention period, so this is strong evidence for the positive effect of the SRTS app during the intervention.

San Diego Police Department (SDPD) Study

The Chief of Police approved an evaluation study as a result of strong interest by the head of the newly formed SDPD Wellness Program. The department recruited 14 highly motivated participants: 12 sworn officers and 2

dispatchers. As reported in Weltman et al (2014) we delivered an initial training session including resilience background and SRTS iPad operation. The participants then used the SRTS units on their own time for 6 weeks, and Institute of Heartmath provided 4 weeks of 1-hour personal telephone mentoring to each participant. SDPD participants completed the Personal and Organizational Quality Assessment (POQA) during the initial training session and at the end of the intervention. The POQA has four primary scales – Emotional Vitality, Organizational Stress, Emotional Stress and Physical Stress – and nine subscales, including such factors as Emotional Buoyancy, Anxiety and Depression, Anger and Resentment, Fatigue, etc. POQA has been previously used by Institute of Heartmath in its research studies and practice, and individual scores are compared to norms from a sample of 5,971 working adults. In addition, the mentors submitted reports of the participants’ comments and their observations.

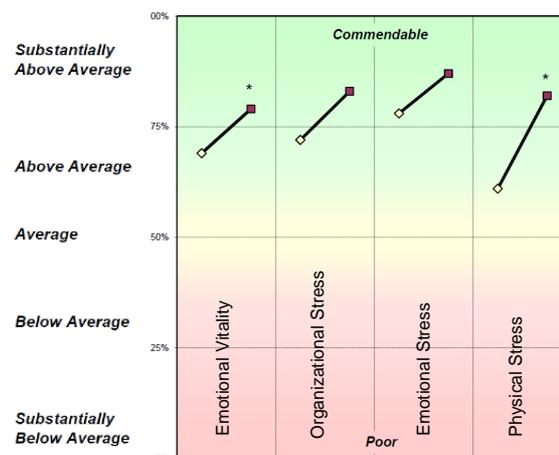


Figure 7. SDPD POQA primary scale results

DISCUSSION

We are extremely fortunate that six independent organizations to date have conducted empirical evaluations of the SRTS app. The study results show:

- The SRTS app and mentoring can have a substantial positive effect on resilience related factors and on-the-job performance even during a relatively short intervention. This is shown by the results of the Air Force study, the NCCOSC study and the SDPD study, and particularly by the user comments.

- The SRTS app can be much more engaging than other "softer" apps. This is shown by the NCCOSC study in which SRTS was compared to the Progressive Muscle Relaxation app.
- Users apply the SRTS techniques to real-life situations, and continue to apply the learned SRTS techniques even when they are away from the iPad app, which is exactly what we want them to do. This is clearly shown by the user comments in the Air Force study, the NCCOSC study and the SDPD study.
- Personal mentoring has a significant potential for increasing the sustainability of the techniques taught in the SRTS app. This is shown by user comments in the Air Force and SDPD studies.
- The SRTS app also has great promise for inoculation against PTSD and its symptoms, which was also a key original objective of SRTS development. This is shown by the MOMRP study and by the results of the Kandahar field trial.

Overall, these results are highly encouraging and confirm our original assumptions that the SRTS approach will help not only to build resilience to stressful events, but help in recovering from them.

The results of the empirical studies, and our interactions with the organizations performing them, indicated several new requirements for the SRTS app; these included a web based version to extend use to devices and situations other than personal iPads, enhanced feedback to the SRTS user, and means for interactions with leaders as well as with other SRTS users. In addition, since mentoring had proved beneficial in several studies, it appeared worthwhile to try and provide mentoring, or its equivalent, within the app itself. As a result, we have created a new service-oriented architecture (SOA) for SRTS that makes use of cloud technology, and have used it to implement an initial web based version that builds directly on the iPad app and supports the newly desired features.

Figure 8 shows two screens from the web based version, which maintains the look and feel of the iPad version without duplicating it exactly. Its design is based on our favorable user experience with the iPad version, but it adds new functionality and flow that strengthens the inherent SRTS features.

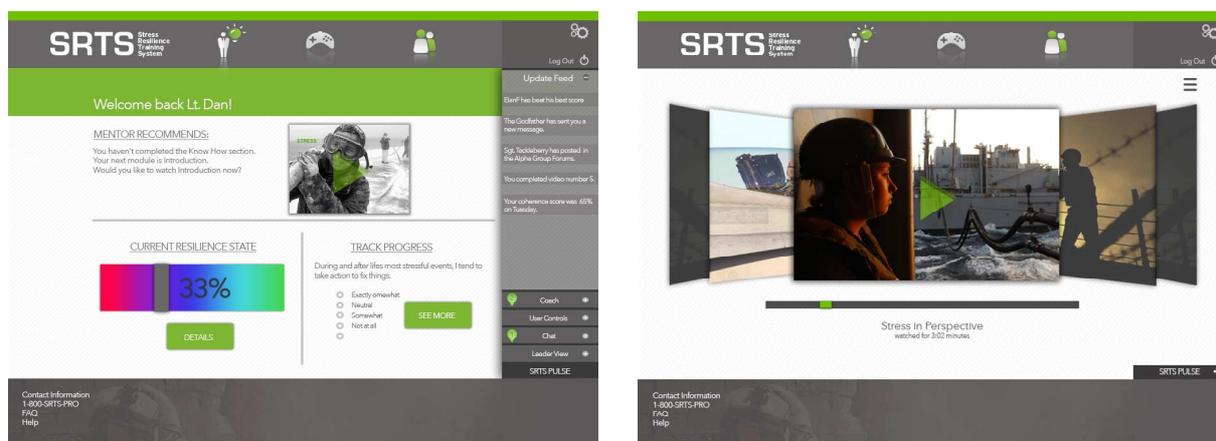


Figure 8. Web based version of SRTS program

The advantages of this technical approach are that it: (1) Provides a common backend infrastructure to support multiple devices such as iPad/iPhone, Web, Android, etc; (2) Facilitates customizable layouts and workflows using on-line publishing tools; (3) Permits dynamic publishing of content to users; (3) Allows ready integration with Social Media platforms for messaging, authentication and collaboration; (4) Supports the planned development of an enhanced and customizable Coaching/Mentoring capability involving two reasoning mechanisms – a deterministic Rule Based/Finite State Machine as in the current iPad app, and a Bayesian Inference Machine that is capable of more intelligent and nuanced training recommendations based on user population statistics as well as on individual user history and performance; and (5) Enables lower costs for distribution, technical support and updates.

Subsequent to the empirical studies described above, SRTS was selected for inclusion in the successful June 2014 Squad Overmatch demonstration of Stress Exposure Training (SET) technology sponsored by the US Army's Study Program Office (Johnston et al, 2014). The demonstration results indicated that SRTS could potentially serve as a

stress management skills component of a Squad Training Continuum covering basic training, advanced individual training, unit training, and deployment.

CONCLUSIONS

Overall, we conclude that the empirical results strongly support the ability of game/simulation-based biofeedback training to build stress resilience in a variety of different populations, and that the enhancements will make the capability a more valuable addition to initial and sustainment resilience training over a range of military and non-military applications. A particularly important outcome is the results from the MOMRP study with Army personnel which indicate that SRTS usage before, during and after deployment can prevent and/or alleviate PTSD symptoms -- as was originally hypothesized at the beginning of the SRTS program. Encouraged by these findings, this research team is pursuing several avenues to build on the evidence supporting the adoption of HRV-based resilience training for military personnel and veterans.

It is important to note that the improved measures of stress, depression, PTSD symptoms and resilience observed in this set of empirical studies, as well as the reports of improved on-the-job performance and familial relationships, were achieved despite the facts that: (1) the SRTS app was oriented to the Navy environment in its look and feel, and in the content of its learning modules and self tests, while many of the users were Air Force, Army, police and civilians; (2) many of the volunteer participants were likely also at an above average level of psychological and emotional health to begin with; and (3) the typical exposure to the SRTS app was relatively short. The results of the trials indicate that the SRTS approach to building stress resilience is suitable not only for military personnel, its original target, but also for other stressed populations, and in particular for law enforcement personnel.

The Air Force and SDPD case study results underscored the importance of mentor support and group interactions. The mentor interactions personalized the training to each participant, focusing on the issues that cause the most distress in each individual's life and applying the resilience-building techniques to those issues. This approach minimizes the negative effects of professional disturbances on the home, and the negative effects of domestic disturbances on the job. Mentors also build on a foundation of issues that rejuvenate and build energy, which leads to improved communication and performance. Likewise, an environment in which discussing the techniques and their application are both acceptable and encouraged is critical to improving the resilience of a unit or a department. These aspects of resilience training are so significant that have adjusted the new Web-based iteration of SRTS to emphasize the personalizing role of the mentor and the supportive impact of the group. We are confident that these adjustments and technical improvements will result in an SRTS resilience training program that is highly suitable for all military populations, for general law enforcement, and for numerous other civilian applications as well.

Our current aim is to build on the success of the evaluation studies to bring the SRTS stress inoculation and performance enhancement technology into widespread use in both military and civilian environments. The SRTS team, including our DoD sponsors, is working to create pilot projects that would help integrate SRTS as a skills building component within existing resilience programs in the Navy, Army, Air Force and Special Operating Forces. At the same time, we are seeking to expand SRTS use in paramilitary environments such as law enforcement and security, and in the equally high stressed working environment of humanitarian aid workers. We are also looking toward applications such as sports, where performance under stress is essential, and, of course, to the large market of corporate and personal well being. The transition and commercialization phase of SBIR programs is often the most difficult, but we are confident that the proven benefits of the SRTS software will allow us to bridge the gap.

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