



# Strengthening Health and Improving Emotional Defenses (SHIELD)

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**Abstract.** Relaxation techniques such as deep breathing, and meditation can be used to gain more control of how individuals respond to stressful situations. While these techniques are becoming increasingly mainstream, there is still a stigma that can deter some users. Unfortunately, these populations stand to gain the most from developing these psychological tools. We set out to develop a mobile application to make relaxation training more appealing and approachable for the targeted population, which we believe is critical in order to gain wide scale usage. The Department of Defense has devoted substantial resources to developing stress prevention and resilience programs to combat the effects of stress; however, there is limited evidence to justify the cost and scope of current programs. We aimed to develop a low-cost, evidence-based mobile application tailored for the Marine Corps. Our solution, Strengthening Health and Improving Emotional Defenses (SHIELD), is designed to be a comprehensive approach based on the latest evidence-based strategies to train Marines to develop psychological resilience and promote healthy responses to adverse and stressful events. The overall SHIELD program is designed to promote gradual, self-paced practice, allowing Marines to complete training on a schedule that works for them.

**Keywords:** Resiliency · Psychological health · Psychological flexibility  
Mindfulness · Self-regulation · Self-awareness

## 1 Objective and Significance

### 1.1 Problem Description

The psychological stress experienced by Marines can have negative consequences that reach beyond the individual; it affects job performance, personal relationships, and families. While most individuals can successfully respond to adverse situations, some may need help developing these essential skills at some point during their military tenure and when returning to civilian life. The inability to cope with chronic and acute day-to-day stressors, such as separation from loved ones or adjusting to the physical and mental demands of the Marine Corps, can leave individuals vulnerable to the harmful effects of stress, such as substance abuse or behavioral misconduct [1]. Teaching evidence-based strategies to promote psychological resilience—that is, the ability to adapt to stressful situations [2]—before exposure to stress can mitigate its costly and often harmful long-term effects [3, 4]. A number of programs have been

developed to strengthen psychological resilience, including BattleMind [5] (now known as Resilience Training), the Army's Comprehensive Soldier Fitness (CSF) program [6], and the Marine Corps' Combat Operational Stress Control [7]. However, these programs are costly, time consuming, and resource intensive [8]. The limited body of empirical evidence within military populations and the lack of a standard definition of effectiveness makes comparing programs difficult [9], and the inability to identify the effective components of a given program limits the overall utility of any concerted effort designed to develop psychological flexibility. If empirical evidence about independent components is readily available, users can focus on only the most effective components while ignoring those that are less effective, thereby optimizing the program for all individuals. Low-cost physiological sensors can also be used to provide objective feedback to further optimize and tailor any training program.

The Marine Corps requires a cost-effective, evidence-based psychological flexibility program that can be adaptively integrated into a variety of training approaches. This program must produce behavioral and physiological data to verify both short- and long-term effectiveness. A successful curriculum for training psychological flexibility to mitigate stress effects on Marines must meet three primary requirements:

1. The training program must be **driven by evidence and well-grounded scientific theory, while minimizing costly resource requirements**. The inclusion of evidence-based approaches increases the likelihood that the program will be effective. Current programs used by the armed forces often require a large staff of program managers and subject matter experts [9]; to reduce costs, the Marine Corps needs a program with inherently low operating costs and minimal resource requirements.
2. The program must **collect and record stress levels using available sensor technologies to demonstrate efficacy**. Sensor technologies are continually being improved and developed, and are rapidly proliferating, making it difficult to know what equipment will be available. A successful approach should make opportunistic use of sensors that are available in given environments (including the sensors on a Marine's personal equipment).
3. The program must **flexibly integrate into existing Marine Corps training and exercise regimes**. A low-cost, flexible curriculum is critical to meet this final challenge. A Marine's day-to-day activities are highly scheduled and constrained; with a flexible curriculum, Marines can independently practice resilience training without requiring instructor guidance or external resources.

## 1.2 Technical Approach

To meet these three requirements, we aimed to design and demonstrate a psychological flexibility program for Strengthening Health and Improving Emotional Defenses (SHIELD). SHIELD is a comprehensive approach based on the latest evidence-based strategies to train psychological flexibility and promote healthy responses to adverse and stressful events. To illustrate the technical merit, innovation, and soundness of our approach, we developed a prototype mobile application that delivers curriculum

modules, measures trainee progress, and interfaces with commercially available activity trackers to access physiological data.

Our technical approach addressed the three requirements defined above. First, the SHIELD training program must be driven by evidence and well-grounded scientific theory, while minimizing costly resource requirements. A successful approach should be evidence-based, highly adaptive, and accessible. We outlined a training and education-based curriculum to increase psychological flexibility using components from multiple evidence-based approaches (e.g., Mindfulness Based Stress Reduction (MBSR), relaxation response training, education about the physiology of stress, and yoga). These and other similar techniques emphasize mind-body awareness; they target and reduce stress with demonstrated efficacy in a diverse array of populations [10–15]. Our curriculum design includes techniques that minimize the amount of training and external resources required. We employed evidence-based practices from several existing stress reduction programs so that SHIELD is effective, low-cost, and requires little to no additional resources beyond those items typically available to Marines.

Second, to collect and record stress levels using available sensor technologies to demonstrate efficacy, we combined behavioral measures and body sensors that are already built into or easily integrated with personal mobile smartphone devices. This approach leverages the recently adopted Marine Corps Commercial Mobile Device Strategy, which allows Marines to carry personal mobile devices, a policy otherwise known as “Bring Your Own Device” (BYOD). Consumer-grade sensors that Marines are likely to carry provide high quality data that are comparable to more expensive technologies [16, 17]. In addition to the cost benefits of relying on BYOD sensors, Marines may be more likely to use wearable sensors in combination with the SHIELD intervention because they are more comfortable with wearable sensors they select as opposed to wearing a piece of required issued equipment. We developed a process to gather objective measures of efficacy that include the frequency and severity of disciplinary infractions, patterns of misconduct, and self-reported measures combined with low-cost embedded sensors to continuously track and model levels of stress using classification algorithms.

Third, to develop a curriculum that flexibly integrates into existing Marine Corps training and exercise regimes, our training program is delivered within a mobile smartphone application designed to motivate Marines to set and meet their own goals (without significant external oversight), and provide a fast and easy mechanism for Marines, instructors, and commanding officers to monitor program participation and progress. We focused on activity-based stress-reduction and stress coping training exercises delivered via a mobile platform to ensure flexible integration into the Marine Corps schedule. We developed and integrated a complete training module into the prototype mobile application and implemented user input and behavior logging capabilities. Additional modules focus on breathing exercises, mindfulness meditation, yoga, relaxation exercises, and awareness of the impact of stress on the mind and body. This focus will ensure a balance between effectiveness and usability.

## 2 Methods and Results

Our approach addresses three primary challenges. First, to develop a program that is driven by evidence and grounded scientific theory, while minimizing costly resource requirements. We define a training and education-based curriculum to increase psychological flexibility using components from multiple evidence-based approaches. Selected techniques emphasize mind-body awareness and target and reduce stress with demonstrated efficacy in a diverse array of populations [10]. Second, to collect and record stress levels using available sensor technologies to demonstrate feasibility, we combine behavioral measures and body sensors that are already built into or easily integrated with personal mobile smartphone devices. This approach leverages the recently adopted Marine Corps policy that allows Marines to carry personal mobile devices, an initiative otherwise known as “Bring Your Own Device”. This is particularly useful because consumer-grade sensors that Marines carry provide high quality data that are comparable to more expensive technologies. Lastly, to develop a curriculum that flexibly integrates into existing Marine Corps training and exercise regimes, our training program is delivered by a mobile smartphone application designed to motivate Marines to set and meet their own goals (without significant external oversight), and provide a fast and easy mechanism for Marines, instructors, and commanding officers to monitor program participation and progress. Our approach focuses on activity-based stress-reduction and stress coping training exercises delivered via a mobile platform to ensure flexible integration into the Marine Corps schedule. Modules under development focus on breathing exercises, mindfulness meditation, relaxation exercises, and awareness of the impact of stress on the mind and body.

### 2.1 Results

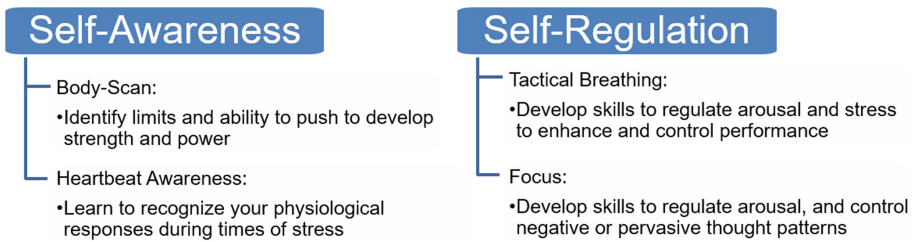
We evaluated components of the SHIELD program (e.g., curriculum modules, user interfaces (UIs), descriptive language, assessment measures, and wearable sensor integration). Components were evaluated on a weekly basis as part of our internal review meetings, which were attended by Charles River and all subject matter experts. The validation and review process was driven by three primary concerns: (1) modifying content to be in line with the Marine Corps milieu; (2) modifying and optimizing content to be delivered via a mobile application; and (3) ensuring the effectiveness and reliability of the SHIELD program.

**Curriculum Design and Requirements Analysis.** Our goal was to define and analyze the core components of the SHIELD curriculum. Our aim was to (1) identify the limitations of current training programs; (2) analyze relevant Marine training environments; and (3) identify actionable items to design and optimize the effectiveness of the SHIELD program. We worked internally with subject matter experts to identify specific requirements for training psychological flexibility. Following a review of relevant Marine training environments (e.g., physical training, recreation and class-room instruction), we learned that the curriculum and content must be comprehensive and self-contained, as well as remaining consistent across language,

readability, accessibility, organization, and assessment within all aspects of the SHIELD program.

We reviewed current prevention and stress resilience training programs available to civilian and military populations. Some of these programs are widely applied, such as the Operational Stress Control and Readiness (OSCAR) program, others are narrowly focused, such as the Mindfulness-Based Mind Fitness Training (MMFT) program. Lessons from these and other programs [9] helped to shape and guide the overall design of the SHIELD program. For example, we learned that programs with large time commitments or required classroom training were less well-tolerated than programs that were less structured [9]. We also learned that a program must be evaluated over time. For these reasons, we designed SHIELD so it does not need classroom or in-person instructional training, but does include the ability to quantify and track progress over time.

Practices include exercises to develop self-awareness, such as simple breath practices (tactical breathing) and mindfulness (focus) exercises, as well as self-regulation practices, including body-scan, and heartbeat awareness (see Fig. 1). The included exercises were selected to due to their simplicity and effectiveness, even when self-guided.



**Fig. 1.** The SHIELD curriculum includes exercises to train self-awareness and self-regulation

While the design can be highly structured based on individual need, we understand the need to develop a solution that is flexible enough to meet individual needs or to integrate into large-scale programs. Therefore, we designed the curriculum content to be selected à la carte to build customized programs or to be completed in full.

**Mobile Application Development.** We designed a mobile application to integrate sensor technologies, evaluate stress levels, deliver curriculum content, and provide an intuitive feedback and evaluation mechanism. The mobile application allows Marines to interact with the SHIELD program through a mobile application that guides them through each exercise and training modules (see Fig. 2). The mobile application also introduces the Marine to the SHIELD program, providing both a general overview and detailed instructions, as well as an interface to administer pre- and post-assessment measures.

The SHIELD mobile application design integrates sensor technologies, evaluates stress levels, delivers curriculum content, and provides an intuitive feedback and evaluation mechanism for Marines (see Fig. 3).

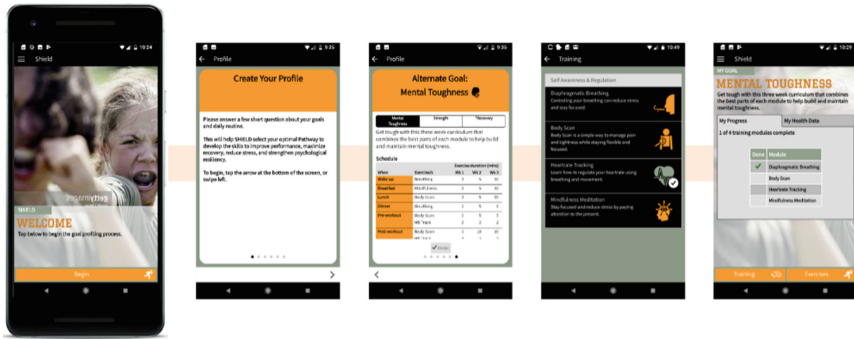


Fig. 2. SHIELD mobile application

Overview	Tutorial	Recap	Practice(s)
Brief overview of the practice and general goals	Guided instructions how to perform the skill	Review of skills and suggested times to practice	Self-guided sessions for daily practice

Fig. 3. Example of overview and guided training for breathing exercise

A key challenge and development risk for any remote application is connectivity with a central server so that information can be downloaded, uploaded, and communicated across the system in a reliable manner. To support this effort, we rely on a robust, cross-platform, mobile application communication framework to support essential types of communications on a back-end cloud server with intermittent connectivity. The framework is designed to maintain privacy and security of user data, both at rest and in transit. Besides the use of standard SSL for data encryption between the mobile application and back-end server, it requires mobile apps to be authorized and authenticated to connect to the server end point for communication. This HIPAA-compliant framework ensures only authorized mobile applications can communicate and push user data (so fake data cannot be added or overwrite other application data), and only authenticated mobile applications pull user data (so a user cannot see another user’s data). All this is done without the user needing to remember user IDs that they can potentially share (the application is uniquely authorized and is not tied to

user ID). The user needs to remember only a PIN that opens the encrypted application. Sharing the pin will not allow another app to get the user's data.

The three types of communication supported by the framework include:

- **Mobile application pulls information from a website:** Whenever an application is opened by the user, or when a specific widget or UI element is enabled by the user, the pull functions that must be performed by the applications are registered with the framework. Each pull function essentially maps to a server-side end point that returns data in an open data-interchange format. Since the framework knows the encrypted authorization code, it uses the authorization to pull the response from the server end point and push the data to the application layer. The framework can also execute scripts (that change the state of UI elements) based on the statistics returned by the server (e.g., count or value of a data element). The framework can be configured to respond with appropriate messages upon communication failure, including connection failure. The framework includes a handshake mechanism to ensure reliability of message receipt, delivery guarantees, and to avoid message duplication.
- **Mobile application pushes information to a website:** This is similar to the first type of communication, except the request to push data includes authorization as well as the payload. However, associated with push activity is a network-aware message queue framework that ensures that a message created for an end point successfully reaches the endpoint, even though there may not be network connectivity at the time the message was created. The framework achieves eventual consistency and works fine with intermittent connectivity.
- **The mobile device receives a push or remote notification:** In many mobile applications, a server-side cloud generates data targeted for a mobile application. The mobile OS allows apps to pull the data only when they are opened. One example is email and social media apps. Leveraging on push notification systems provided by Apple and Google, the mobile communication framework allows the server to send mobile-device-targeted custom notifications, which when opened, execute appropriate pulls and calls appropriate application layer hooks or listeners to return the required data.

### 3 Discussion

Charles River Analytics set out to demonstrate the feasibility of a portable psychological flexibility program. Our approach was motivated by three primary goals: (1) develop a program that is driven by evidence and well-grounded in scientific theory, while minimizing costly resource requirements; (2) support capabilities to collect and record stress levels using COTS sensor technologies; and (3) design a program that can flexibly integrate into existing Marine Corps training and exercise regimes. We demonstrate an approach to develop a platform for introducing and teaching relaxation techniques that support psychological resilience to audiences that may otherwise be reluctant to engage in such practices. While relaxation techniques such as meditation and mindfulness training are becoming increasingly popular amongst the general

population, we recognize that previously existing biases may deter its usage in certain audiences. Our initial evaluation provides a methodology for delivering relaxation techniques in a manner that is more approachable to groups who may otherwise be resistant, such as the Marines.

The operational Navy concept of the SHIELD system is that Marines will access the SHIELD application by downloading the app from Government app stores or Google Play. Marines can then engage with the application and individual modules whenever their schedule permits. No module is designed to require more than 5 or 10 min to complete. The entire curriculum can be completed in as little as six weeks, or Marines can choose to focus only on specific modules that suit their needs. Each week of modules focuses on a specific topic (e.g., Yoga, breathing exercises). While each week contains a number of specific modules, there are also companion tools that the Marine can select to help practice specific skills (e.g., Three Part Breath). Other operational uses include officers ensuring their Marines are fit for duty. For example, officers overseeing several Marines can use the data analysis and prediction capabilities within SHIELD to leverage physiological data gathered during normal daily activities, which are automatically inserted into SHIELD's stress classification models. These models can be used to make mission-critical activity or return-to-duty assessments on each Marine, and ensure the Marine has access to the support they require.

The *future naval relevance* of the SHIELD system is to provide the Navy with a low-cost, non-invasive sensing, assessment, and treatment option for training psychological flexibility and enhancing the resilience and performance of Marines. SHIELD accomplishes this in several ways: (1) the design of appropriate curriculum material; (2) the integration and capitalization on features of commercially available, ubiquitous sensor platforms; (3) the analysis of sensor data to enable prediction of stress; (4) the unobtrusive delivery of these capabilities through a mobile application.

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