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Mobile Applications for Personalized Mental Health Resiliency Training

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ABSTRACT

The Canadian Armed Forces (CAF) are conducting a major effort to expand and modernize the training and preparation provided to CAF members for mental health and resilience. The core of this effort is the Road to Mental Readiness (R2MR) training program. In support of this effort, we are developing and evaluating a series of mobile applications ("apps") designed to make this training available to CAF members when and how they need it. This paper presents the design, implementation and research issues involved in the development of the R2MR mobile apps. These apps are designed to help CAF members manage their stress responses, improve short-term performance and long-term mental health outcomes, as well as to reduce barriers and encourage early access to care. The mobile apps can also be used as an adjunct to mental health treatment as they are based on cognitive behavioural theory (CBT). Specifically, mobile apps for goal-setting, self-talk, mental rehearsal, tactical breathing, attention control and working memory will allow users to build CBT-based personal training scenarios to help them achieve mental health objectives. A mental health continuum app will allow individuals to self-monitor and will suggest when additional resources may be required. Integrated into existing mobile technology, these apps will enable users to set reminders and monitor their progress over time in a number of different mental health areas. In this paper, we discuss our investigations into the benefits of a number of opportunities afforded by mobile learning, namely: gamification, immersion, and the use of real-time biofeedback via wearable technologies (e.g., heart rate monitors) used with mobile devices. Finally, as previous program evaluation has suggested that repeated application and practice of the R2MR skills improves their retention and effectiveness, we discuss our evaluation of the instructional aspects of these apps.

ABOUT THE AUTHORS

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Jerzy Jarmasz is a Defence Scientist and the leader of the Learning & Training Group in the Human-Systems Integration Section at Defence Research and Development Canada Toronto Research Centre. With backgrounds in both electrical engineering and cognitive science, Dr. Jarmasz brings a multidisciplinary approach to all of his projects. His areas of expertise include simulation-based training, complex systems, training for cognitive skills (situation awareness, decision making) and small-team mission training (Close Air Support, Counter-IED). Dr. Jarmasz is currently leading research teams studying the effectiveness of high-fidelity patient simulators for combat medic training, and synthetic team mates in virtual reality for small-team Army training.

Hamid Boland is a Project Manager at the DRDC Toronto Research Center. Hamid graduated with a Bachelor of Applied Science degree in Communications Engineers, and completed a Masters of Engineering in Technology Innovation Management.

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Calgary in 1998. Kim began her career working with troubled and traumatized children and youth, and then, in 2000, accepted a position with the Department of National Defence working in the Operational Trauma and Stress Support Centre. There she worked exclusively with CAF members who had suffered an operational stress injury providing individual, group and family therapy. In 2009 Kim began to apply her clinical experience to develop mental health prevention and resilience curriculum for the Road to Mental Readiness Program.

LCol Suzanne Bailey has been a member of the Canadian Forces since 1986, serving as a social work officer since 1996. After a decade of clinical work, LCol Bailey has been involved in the standardization of Canadian Forces Mental Health and Leadership curriculum through the Road to Mental Readiness (R2MR) program since 2008.

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INTRODUCTION

The Canadian Armed Forces (CAF) recognizes that mental fitness and well-being are key contributors to operational readiness. As such, since 2008 the CAF has been developing the Road to Mental Readiness (R2MR) program, a comprehensive mental health training and education program designed to increase mental health literacy and enhance resilience and mental toughness, in order to ultimately improve short-term performance and long-term mental health outcomes. R2MR is a mental health education program that is currently being delivered throughout the CAF career cycle, beginning at the recruit level (Fikretoglu, Liu, & Blackler, 2016). The three key objectives of R2MR, as delivered to the recruits, are: 1) to teach recruits stress management skills they can use to minimize psychological distress, 2) to improve recruits' understanding of basic mental health literacy concepts, and 3) to change recruits' attitudes and intentions towards seeking help from a mental health professional (Fikretoglu et al., 2016).

Mental health resiliency can be regarded as mental strength built up to defend against adverse situations (Davydov, Stewart, Ritchie, & Chaudieu, 2010). R2MR training encompasses the entire package of resilience and mental health training that is embedded throughout CAF members' career, including the deployment cycle. R2MR is designed to ensure that the most appropriate training is provided when required to ensure CAF personnel are prepared mentally for the challenges they may encounter, both near-term to the soldier's current mission, and in the long-term throughout one's career. The training provided to the CAF members focuses on improving performance by managing physiological arousal levels. This is done through a series of techniques such as goal setting, visualization, self-talk, controlled breathing (referred to as "tactical breathing" in the R2MR curriculum) and attention control. When practiced, these skills can become automated and can be used effectively during stressful situations in order to improve performance (Bouchard, Bernier, Boivin, Morin, & Robillard, 2012).

Background

Mental resilience generally refers to an individual's capacity to return to baseline following exposure to an adverse event or circumstance. An individual's military readiness can be influenced by many factors such as organization structure, training and support from others (Blackburn, 2014). A related, although distinct, concept is that of mental toughness which can be defined as a personal capacity to deliver high performance on a regular basis despite varying degrees of situational demands (Gucciardi, Hanton, Gordon, Mallett, & Temby, 2015). Both concepts are crucial to improving performance and sustaining emotional and psychological well-being of military members and have been included into the R2MR training program.

The R2MR training provided to CAF members focuses on enhancing mental resilience and mental toughness by monitoring physiological arousal levels and decreasing them when they exceed healthy levels. R2MR program has incorporated detailed information about the stress response and its potential impact on performance and decision making. CAF members are provided detailed explanation of the types of stressors in a given environment and are taught a series of skills to manage such stressors.

The R2MR curriculum includes six basic mental health management skills. The first four are skills or countermeasures (goal setting, self-talk, mental rehearsal, and tactical breathing) that have been proven to be effective in managing physiological responses to stress and enhancing performance in a similar program implemented by the US Navy Seals. The two additional skills, attentional control and psychological self-monitoring, were added as a result of subsequent investigations and experiences by CAF personnel implementing the R2MR curriculum. Attention control is aimed at helping CAF members to effectively direct their attention to appropriate cues for the duration of a task while screening out irrelevant external and internal stimuli. When practiced, these skills can become automated and can be used effectively during stressful situations in order to improve performance (Bouchard et al., 2012). Psychological self-monitoring was introduced in order to provide CAF members with the skills to recognize symptoms of stress and distress in themselves and others, and is based on the Mental Health Continuum Model (MHCM), which was developed in collaboration with the United States Marine Corps. The decision to introduce this sixth skill was partly motivated by the finding that CAF members have a better chance of recovery from mental illness if the stigma commonly associated with mental health issues is reduced (Arrabito & Leung, 2014) . Reducing the stigma associated with seeking help for mental health-related issues involves, among other things, a better awareness of the signs and symptoms of mental distress, hence the addition of the sixth skill.

The MHCM is the conceptual core of the R2MR, and the skills taught in the R2MR curriculum are presented as tools to help CAF members identify where they are on the continuum and how to move themselves to healthier parts of it. One of the key messages of the MHCM is that mental health and mental illness are not merely two points in a binary "health space." Health, be it physical or mental, is a dynamic state that can deteriorate or improve through a range of intermediate states, according to circumstances. Many CAF members have physical and mental health concerns that, if identified and treated early, have the potential to be temporary and reversible. The mental health continuum provides insight into the varying levels of mental health issues and offers guidance on the appropriate support depending on the severity of the condition. Given the stated preference of many CAF personnel to manage their own mental health conditions, the MHCM helps to distinguish between early distress that can often be self-managed, and more persistent symptoms that would require professional assistance.

The Need for Mobile Apps in Mental Readiness Skills Development

Current classroom delivery of R2MR has been shown to improve CAF new recruits willingness to seek mental health care as compared to new recruits who did not receive R2MR training (Fikretoglu et al., 2016). Even slightly preventing the worsening of attitudes and intentions towards seeking mental health care may be additive throughout the exposure of R2MR training (Fikretoglu et al., 2016), which suggests that opportunities to increase exposure to and repetition of R2MR skills and concepts may be beneficial for improving mental health outcomes in the CAF.

While the R2MR in-class training has been effective in engaging the audience, increasing mental health knowledge, reducing stigma and changing attitudes towards care seeking, program evaluation has demonstrated that repetitive application and practice of the skills in the training environment is essential for retention and effectiveness (Fikretoglu, Beatty, & Aihua, 2014). Repetition of the skills reinforces learning while demonstrating that the skills can be applied to a wide range in situations in both military employment as well as day to day life. Furthermore, when learning a new skill, deliberate practice can improve retention, proficiency and performance in early learning (Driskell, Copper, & Moran, 1994) and can contribute to the development of more complex knowledge and skills (Gopher, Weil, & Siegel, 1989). Importantly, although assigning repeated practice of clinical skills based on cognitive behavioural therapy (CBT) such as cognitive restructuring can reduce symptoms during CBT (Kazantzis, Deane, & Ronan, 2000), the complementary homework has to be validated for proper efficiency (Fikretoglu et al., 2016). As such it is important to be involved in the design and the development stages of complementary applications for any curriculum.

The desire for providing more opportunities to access and rehearse the R2MR materials is one key motivation behind the creation of R2MR mobile apps. Furthermore, the CAF is in the midst of a major shift in its approach to delivering individual training and education, largely aiming to create an infrastructure where CAF members can tailor their training and learning to their individual needs and circumstances, leveraging the technological advances in recent years that now enable such individualized training (Canadian Defence Academy, 2013). The major enablers of this shift are electronic learning, and more specifically mobile learning (m-learning), that is, learning and training using internet-enabled mobile devices such as smartphones or tablets. Mobile learning can serve to deliver content and even support real-time communication with a health care professional such as a health coach (Wayne, Perez, Kaplan, & Ritvo, 2015), an important component of the MHCM (Thompson & McCreary, 2006).

The current development of the R2MR mobile app, comprised of a toolkit containing seven different modules, has been designed with the intention to be used to facilitate mental skill acquisition and use, as well as an adjunct to mental health treatment as it is based on cognitive behavioural theory (CBT). Although still undergoing usability testing and iterative feature development, the mobile app has the potential to deliver practical and effective on-the-go support for augmenting the delivery of R2MR training. Mobile learning in general offers the ability for individualized learning, which might improve learners' access to and motivation for learning, regardless of their proficiency level. With the R2MR apps integrated into existing mobile technology, users will be able to set reminders for each app and monitor their progress over time using their device's built-in services.

Biofeedback

One advanced feature of a mobile device which merits further examination is the ability to wirelessly connect with sensors for physiological data such as off-the shelf heart rate monitors (e.g., Mio Alpha; Physical Enterprises Inc.). Although, non-medical grade wearable devices are not controlled, the ability to wirelessly connect sensors to the Smartphone (e.g., via Bluetooth) opens up a new line of mobile research whereby biofeedback to the average user is possible. We would like to explore the possible benefits of providing biofeedback to enhance learning and training. Specifically, we will look at the effectiveness of real-time biofeedback of heart rate on techniques learned during the R2MR training to examine how this feature influences the ability of the user to reduce stress and optimize their performance. Biofeedback from wearable devices (e.g., heart rate monitors) can inform the user of physiological benefits from using the app. While commercial wearable monitors are not certified for monitoring biological data to medical standards, they have been shown to be adequately reliable in most use cases relevant to the R2MR apps (i.e., while the user is relatively stationary; Binsch, Wabeke & Valk, 2016). Heart rate biofeedback has been previously shown to be a useful complement to tactical breathing training during stressful virtual reality (VR) simulations in CAF soldiers (Bouchard et al., 2012). Specifically, CAF soldiers were able to attain an optimal heart rate and arousal state for improved stress management skills during stressful VR simulations (Bouchard et al., 2012). Achieving an optimal heart rate is crucial for improving performance (Karvonen & Vuorimaa, 1988) as well as improving mental health and resiliency (Oldehinkel, Verhulst, & Ormel, 2008).

In keeping with our approach of evaluating aspects during the design process, we conducted an experimental assessment of the value of biofeedback in improving the learning of specific R2MR skills. This assessment is summarized below in the Biofeedback Methods section.

METHODS

General App Design Approach

In order to meet the stated requirements of the R2MR program, the apps designed to support this curriculum need to present validated instructional content by means of an app design that suits the needs of their intended users in a range of different contexts, and in particular that encourages their users to make use of the apps' different functions at appropriate times, as per the R2MR program's recommendations on self-monitoring and help-seeking. The validation of the content (currently being performed for MHCM app) is proceeding in parallel to our efforts to direct all stages of the design of the apps according to a human-centred design approach (Maguire, 2001). We have adopted an "Agile" software development methodology, which allows stakeholders to provide feedback and alter a product's features in an iterative fashion at different stages of the life cycle (Pressman, 2009). The Agile Model is best for projects similar to the current mobile apps, which are dynamic and whose final state cannot be prescribed precisely by stakeholders at the project's outset (Pressman, 2009). Furthermore, previous work (Berge, 2011) has shown that it is important for apps designed to support mental health-related training to be comprehensive, integrated (in the sense of having all components fluidly integrated in one overall framework), have good user acceptance, and be evidence-based and validated. The apps also should have appropriate iconography (Archer and Roney, 2012) in order to be accessible and reduce cognitive load (Berge, 2011; Mariger, 2006), and should have personalization when relevant (Archer and Roney, 2012).

We have conducted various forms of usability and user acceptance evaluation during the course of the design process for the apps. These evaluations are summarized in the Evaluation section.

Usability Assessments

We assessed the usability of the R2MR app during the design process by both gathering feedback from users interacting with prototypes of the app and by submitting the app design to an analytic assessment by external design consultants.

The user feedback was conducted as pilot testing in preparation for a formal usability study which is yet to be performed. After briefly explaining the purpose of the apps, the primary investigator asked prospective users a series of exploratory questions about the app. The purpose of these questions was to understand and uncover the assumptions that we have made about how the users want to use the mobile apps (Hall, 2013). In addition, naïve users were asked to perform a so-called Concurrent Think Aloud (CTA) protocol, wherein they verbalized what they were thinking and doing as they used the mobile apps (e.g., they might say "I am setting a new goal on mental well-being" as they clicked on the "outcome goal" button, then might say "inputting Graduate Basic Military Training… wait … I'm stuck", and so on). CTA paradigms are based on previous work (Ericsson, 2006) and are commonly used in usability studies in order to understand participants' thoughts and elicit real-time feedback and emotional responses as they attempt to work through applications (Kjeldskov & Skov, 2003). Participants were also asked to provide answers in response to open-ended questions about a series of use case scenarios such as: "Where would you go if you wanted to find out about your support options?"

The analytic assessment of the apps was conducted by an external consultant (Pivot Design Group©) who rated the apps' various features and components against established interaction design principles (Tognazzini, 2003), usability heuristics (Nielsen, 1994), and mobile design guidelines (Hoober & Berkman, 2011), as informed by the consultants' previous experience and research on medical training apps. The outcome of this evaluation provided feedback on the usability of our apps and recommendations on improving the apps' design. Further formal usability studies are planned that will utilize the CTA method, use-case scenarios, as well as usability questionnaires including the System Usability Scale (SUS) (Brooke, 1996), a generic usability scale with validated psychometric properties (Bangor, Kortum, & Miller, 2008).

Making Use of Integrated Smartphone Features

The advanced technological features of the smartphone (e.g., real-time biofeedback from wearable devices via Bluetooth connections) can be leveraged to individualize the learning experience and putatively enhance user experience, thus increasing potential for learning.

Biofeedback Methods

We have incorporated heart rate biofeedback in the R2MR Tactical Breathing app. Available both pre/post and in near-real-time ("real-time"), the heart rate biofeedback option during the breathing training/exercise offers users the ability to be objectively aware of their current physiological state. This is important as many individuals are poor at accurately perceiving their physiological state such as heart rate (Whitehead, Drescher, Heiman, & Blackwell, 1977).

We conducted a study to test the effectiveness of different types of real-time biofeedback presented to users via mobile applications and wearable technologies while following an audio-recorded Tactical Breathing exercise. We tested 10 Search and Rescue Technicians (SAR Techs) undergoing R2MR training to see if the biofeedback thus provided could enhance the learning of self-regulation skills such as tactical breathing. Specifically, they were asked to use the feedback provided by a wearable monitoring device (the Hexoskin "smart shirt" from Carré Technologies Inc.) while they practiced bringing their vagal heart rate tone (Nolan et al., 2005) under control. Our hypothesis was that providing such feedback would improve the acquisition of self-regulation skills.

Following a briefing by the primary investigator on the purpose of the study, and having a chance to give their informed consent, participants were asked to perform certain experimental tasks in addition to the mandated R2MR training. Namely, they were provided with an audio recording of a script for tactical breathing in order to control their heart rate and to help them obtain an optimal level of arousal. While they applied the tactical breathing technique, they wore Hexoskin shirts and devices, which monitored their heart rate and breathing rate, and were required to rate their subjective stress level on a Likert-type scale. All participants performed this task both with and without real-time visual feedback of their physiological metrics (i.e., breathing and heart rates). Two types of visual feedback were provided, both via a proprietary app provided by Hexoskin. The first type consisted of numbers representing breathing and heart rates (i.e., a digital representation of their physiological state), while the second consisted of a visual animation depicting animated lungs and a graph trace of their heart rate (i.e., a graphical representation). In all three experimental conditions (i.e., the no-feedback condition and the two feedback ones), participants listened to an audio script designed to aid in breathing. In addition, resting breathing and heart rates were also recorded prior to each experimental condition (i.e., baseline condition) in order to control for the effect of tactical breathing with audio scripts).

Participants repeated the four (i.e., baseline and three experimental) conditions, three times a day, for four days. Importantly, task assignments were counterbalanced for each day of testing (i.e., participants repeated all conditions in a different order, each of the four days) in order to control for order effects. All participants then recorded their post-session subjective stress level on a Likert-type scale (post-stress level rating). In addition to a demographics questionnaire, participants completed two questionnaires on app usability. First, participants performed a custom questionnaire asking about the Hexoskin app (Hexoskin App Scale) and wearable device, and second, they completed the System Usability Scale (SUS) (Brooke, 1996), which is a generic usability scale with validated psychometric properties (Bangor et al., 2008).

Statistical analyses were conducted using repeated-measures one-way ANOVA with condition as the within-subject factor. To account for lack of sphericity Greenhouse-Geisser corrected p-values were reported (when appropriate). Post hoc contrasts were corrected for multiple comparisons (Bonferroni).

RESULTS

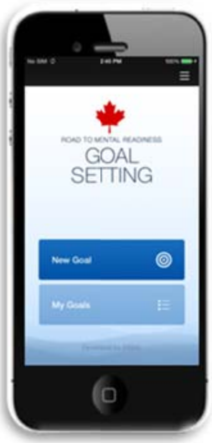
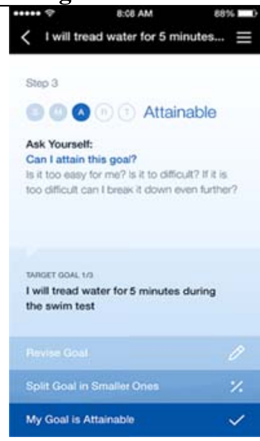
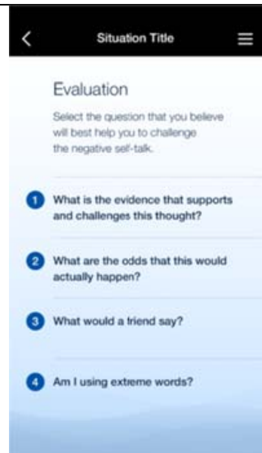
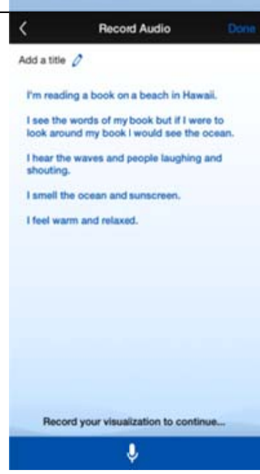
Design Process of the R2MR Mobile Apps

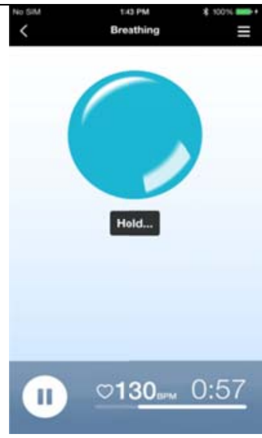
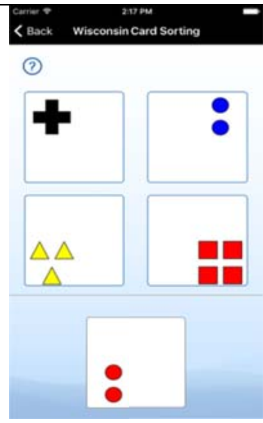
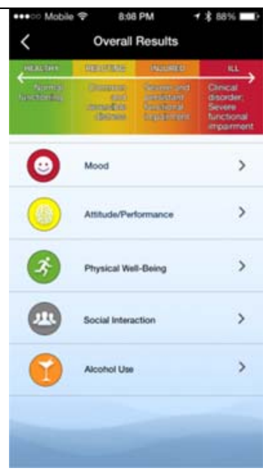
Within the R2MR mobile app, there are six distinct skills that are taught and applied, based on the in-classroom material. Specifically, the mobile app contains content that will help build and reinforce the skills of goal-setting, positive self-talk, imagery (visualization), tactical breathing, attention control, and psychological self-monitoring. We have added an additional skill based off of previous research on working memory with CAF members (Vartanian et al., 2013). Below is a brief summary of each of the skill components within the R2MR mobile app (see Table 1). These skills allow users to build CBT-based personal training scenarios to achieve mental health objectives, serve as training tools to reinforce mental health and resiliency and monitor their competency with the skill set over time.

Evaluation of the R2MR Apps

We have taken some initial steps towards evaluating the apps. As discussed above, iterative evaluation of the apps is an important aspect of the design process. It is also important for the success of the R2MR program as a whole for the apps' effectiveness as instructional complements to the in-class R2MR curriculum to be assessed. We are preparing for a randomized control group evaluation of the effects of the apps, used as supplements to the classroom lectures, on R2MR knowledge and skill retention and application by CAF personnel. In preparation for this study, however, we have undertaken usability testing of the apps, as well as an experimental evaluation of the usefulness of the biofeedback feature for supporting the learning of specific skills. Brief summaries of these assessments are highlighted in Tables 2 and 3.

Table 1. Details of the R2MR Mobile Apps

Skill	Design	Background	App Description
		Goal setting has been found to be extremely effective in improving performance when accompanied by individual goal monitoring strategies (Harkin et al., 2016).	The R2MR app allows learners to take the theory learned in the classroom and record their own individual goals, apply the SMART (Specific, Measureable, Achievable, Relevant, Time-bound) criteria through an interactive guided feature, monitor progress, and set reminders and target tasks for completion.
		Built upon the principles of Cognitive Behavioural theory, this skill focuses on the role of our internal dialog in our emotions and behaviour. Self-talk is purported to positive influence performance via cognitive, behavioral, motivational and affective pathways (Hardy, Oliver, & Tod, 2009).	This component of the app is an interactive guide intended to increase individual positive self-talk, guide the learner to stay in the moment, and challenge personal negative self-talk. Learners can record positive statements, record positive events that have occurred in their life.
		Imagery/visualization has been found to be very effective in enhancing performance when practiced (Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). In order for imagery to be effective it needs to be practiced with heightened attention to all senses, vividness, controllability, and perspective.	The R2MR app allows the learner to develop effective guided imagery scripts, record them, and play them back as required.

		Breathing is the primary means by which humans can exert control over stress and physiological activation (Philippot, Chapelle, & Blairy, 2002). As perceived stress increases, the natural tendency is to hold one's breath, which increases muscle tension and interferes with the coordinated movement necessary for maximum performance.	This breathing component of the app provides the learner an interactive guide for controlled, deep breathing. Learners are able to customize their technique in regards to the timing of inhalation and exhalation, and background music and scenery. Real-time heart rate biofeedback is also available for arousal training.
		The ability to maintain focus and to shift attention to relevant stimuli is crucial to improved performance based off of Nideffer's Attention Control Training principles (Nideffer & Sharpe, 1978), attention focus (Lichstein, Riedel, & Richman, 2000) and attention shifting (Soveri, Waris, & Laine, 2013).	Learners are provided a guide and training tool in order to enhance their individual selective attention to relevant cues, ability to remain present and focused, ability to shift attention quickly and effectively based upon changing demands.
		Self-monitoring is an extremely broad term which encompasses tracking nearly any pattern from which to move forward and assess your progress (or lack of progress) towards a goal. Within the R2MR material, learners are taught this skill in the context of attaining and/or maintaining psychological health.	This component of the app allows individuals to monitor their own health behaviours and helps them to determine when additional resources may be required. Learners are provided a self-screening measure, which walks them through different health assessment measures and provides customized suggestions for help and access to resources.

		Repeated training with the N-back paradigm has been shown to enhance working memory (Jaeggi, Buschkuehl, Perrig, & Meier, 2010) and generalize to other fluid intelligence tasks (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008), due to increased neural efficiency (Vartanian et al., 2013).	Learners perform the N-back task (either dual or single modalities). Learners are encouraged with gamification badges and reminders, as well as customizable icons to remember (e.g., shape, colour, picture, etc.).

Table 2. Summary of Recommendations from Expert Evaluation and User Feedback

1	Combine all apps into one R2MR app
2	Display all tools on home screen for easier access
3	Simplify navigation & user interface design
4	Create user login system for personalization
5	Contextual experience (i.e., provide information/instructions in context)
6	Design for accessibility

Biofeedback Results and Discussion

An analysis of the mean breathing rate at baseline and in the three experimental condition revealed a significant effect of condition (ANOVA $F_{2,127}$ = 59.7, $p<0.05$, see Figure 1A). Post hoc comparisons (Bonferroni corrected) revealed significant decreases ($p<0.05$) in breathing rate during the three experimental conditions (No feedback, numeric feedback, visual feedback) relative to the baseline condition, which confirms that participants were able to successfully perform the task (i.e., to follow paced breathing timing) in all three experimental conditions. However, no differences in heart rate (ANOVA $F_{3,171}$ = 2.2, $p>0.05$) or subjective stress levels (ANOVA $F_{2,112}$ = 1.3, $p>0.05$) were observed between experimental conditions and baseline conditions (Figures 1B & 1C, respectively).

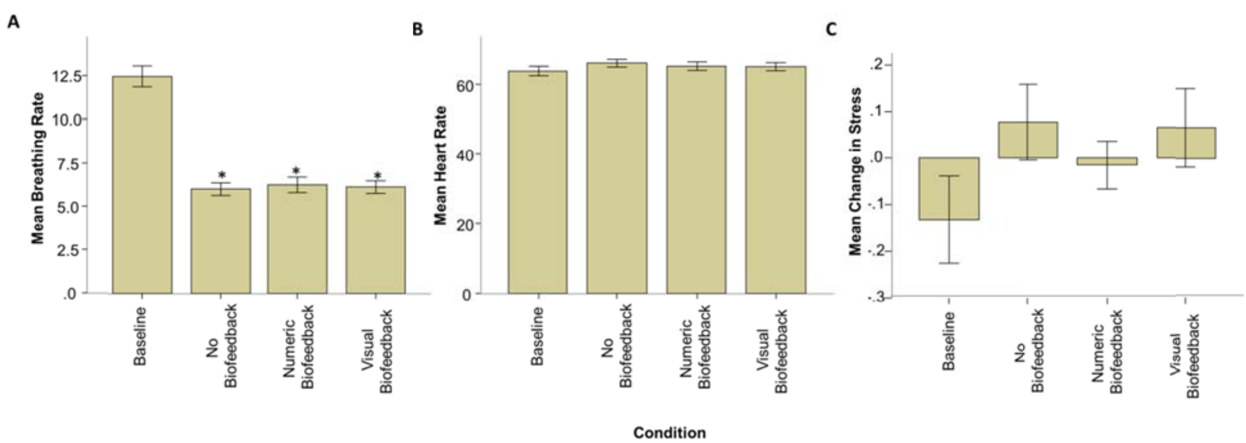


Figure 1. Mean Breathing Rate (A), Heart Rate (B) and Change in Stress for the Baseline and Experimental Conditions During Tactical Breathing; *Denotes p<0.05 (Bonferroni).

Responses from the usability questionnaire items that were reverse-coded were reversed again to match the direction of the other items, for ease of computation. Results from the Hexoskin App Scale indicated an average of 2.0±1.3

(out of a maximum of 5), while results from the SUS questionnaire indicated an average of 2.5±1.4 (out of a maximum of 5). Importantly, as the experimenters were not always able to enforce participation of all required trials, only 51% of all trials were performed by the participants. A summary of the user-feedback from the biofeedback study can be seen in Table 3.

Table 3. Main Lessons Learned from Biofeedback Usability

1	Biometric shirt is cumbersome, participants would prefer wrist-mounted heart rate monitor, or validated custom hardware similar to previous findings (Uddin et al., 2016)
2	Do not need elaborate animations as biofeedback, numbers are sufficient
3	Do not need breathing rate biofeedback for effective tactical breathing
4	Breathing timing can be recommended, but should be customizable to fit individual differences in breathing capacity and expertise

From the combined physiological and subjective ratings results, it would seem the real-time biofeedback as provided by this iteration of the Hexoskin monitoring shirts did not have a measurable influence on learning outcomes and were not perceived as useful by the participants. The reason for this seemingly lack of effectiveness of biofeedback is unclear. However, we surmise that the subjective ratings provide a clue, in particular the remarks suggesting that the biofeedback isn't necessary for this training. The participants in the study were elite CAF personnel whose training is on par with professional athletes. In particular, they already have extensive experience in managing their physiological arousal levels. Thus, it is quite likely that the results above are evidence of a performance ceiling, in that the participants were almost certainly already proficient at the skill we were training them in. Future investigations of the value of biofeedback for R2MR training, in addition to addressing the usability concerns of the monitoring shirt, should focus on the value of feedback for personnel who have not yet acquired advanced self-regulation skills.

DISCUSSION

Training mobile apps are a promising complement to lecture-based instruction for skills such as those in the R2MR curriculum. It is important, however, to keep in mind that the purpose of such apps is not just to provide declarative information. They must be developed so as to provide users opportunities to *contextualize* information (e.g., by relating it clearly to their own situation) and *apply* the skills procedurally in real life, thus allowing students (in our case, in R2MR courses) to reinforce lecture-based training. Related to this is the importance of designing training apps to allow for the customization of training to individual users. In addition, it is important to leverage the capabilities of the Smartphone in order to maximize the effectiveness of the apps. For instance, features such as personalized reminders integrated into users' calendars and notifications centre, a contacts directory directly integrated with the calling app, and accurate positioning sensing can allow apps to provide "get help" services similar to those described elsewhere (Price et al., 2014), thereby reducing the barriers to seeking help that can still remain despite in-class training.

The design process we used has striven to ensure the apps developed for the R2MR curriculum implement the user-centred characteristics described above. While our user testing to date suggests good acceptance overall for our apps, some features need to be further explored and refined. For instance, the results from the biofeedback study suggest that the potential benefits of real-time biofeedback may be restricted to situations which exceed users' proficiency in arousal control, either because they have not yet mastered the required skills or because the situation exceeds the parameters for which they have trained. In addition, some off-the-shelf biofeedback technologies may still be too cumbersome for the target user population. Therefore, similar to previous findings (Uddin et al., 2016) it may be useful to create customized hardware as well as software. Finally, similar to previous findings (Meuret, Wilhelm, & Roth, 2001), we found that users do not require respiratory biofeedback for successful arousal control. As such, our current Tactical Breathing app has been designed to only incorporate numeric heart rate biofeedback. The design process of this specific feature demonstrates the importance of an iterative process incorporating user feedback in developing the R2MR apps.

Future Directions

In general terms, we intend to continue work on two main fronts: validating the training value of the various features of the app, and increasing the app's appeal to users in order to ensure improved long-term outcomes. In terms of validating the app's training value, we have yet to commence work on evaluating effect of the app's user-driven modules (Goal Setting, Visualization, Self-Talk, and MHCM) and app-driven modules (Tactical Breathing, Attention Control and Memory) on actual learning outcomes. In addition to evaluating whether mobile apps can improve learning and skills retention, it is important to determine whether they support users in appropriately *applying* these skills in real life situations, both on-the-job and off. Further, can the location and direct dialling of resources for help in the MHCM module decrease the barriers to seeking care?

In terms of improving the app's appeal, one future direction is to continue exploring the appropriate use of biofeedback in the R2MR apps. The results from the pilot study on real-time biofeedback during tactical breathing indicate the importance of matching training intervention to students' skill levels and motivation for learning. Our results suggest that skilled users such as SAR Techs might exhibit performance ceiling for arousal control when at rest. A strongly motivated "mastery" group (Fenz & Epstein, 1967), such as SAR Techs, might have to be evaluated in more taxing situations in which they would struggle to control their arousal. Conversely, further testing on novice individuals using the Tactical Breathing module with a wrist-mounted heart rate monitor might provide clearer insight into the potential benefits of training and performing with real-time biofeedback. In addition, further evaluation of the app's modules should be performed during some scenario-based situations. Testing under conditions that are both more stressful and more contextualized could shed further light on the benefits of the app, but this must be accompanied by effective debriefing and explanations by the instructors (Thompson & McCreary, 2006) in order to be effective.

One important issue that needs to be addressed is whether users will actually use apps that have been developed from experimentally-validated paradigms rather than primarily to be "playable." While experimentally-validated task paradigms have the advantage of having been shown to improve some aspect of human performance, they are not always much fun to use. We are therefore conducting investigations into whether the R2MR app modules can to some extent be "gamified" (e.g., by using achievement badges), and also into whether the R2MR curriculum can be implemented as a "serious game". Serious games have been shown to have promise for increasing the efficiency of training complex cognitive skills and improving performance; for instance, in one study training with serious games was shown to increase usage by threefold as compared with traditional CBT (Mautone, Spiker, Karp, & Conkey, 2010). However, the game elements must be carefully adapted to the specific training environment (Mautone et al., 2010). One factor that has come up in our usability studies is that users wish to compete against other members and want to beat their "score". Thus, leveraging the natural competitiveness of many CAF members might be a more appropriate "gamification" intervention than simple badges.

Following testing, CAF Health Services intends to release the R2MR app on the iTunes and Google Play app stores. This widespread distribution is in line with the CAF's intent to improve the long-term well-being of all its members. In addition, it will help to enable further evaluations of the app's impact on learning and retention of the R2MR skills throughout CAF members' careers.

In summary, mobile apps for training must be developed *for* the users, regardless of the intent or design goals underpinning them, and all the more so for apps designed to provide users with skills for managing their mental health. This is why the implementation of human-centred design principles such as interaction principles (Tognazzini, 2003), usability heuristics (Nielsen, 1994), and mobile design guidelines (Hoober & Berkman, 2011) are crucial during the design and development phases of a training app. Even features that seem to be "obviously" useful, such as biofeedback, must be designed and tested carefully in order to avoid negative user experiences, as our experiences have shown. Validation of the content and assessment of the utility of advanced smartphone features, as well as the evaluation of the usability of the app's components will provide insight into which skills are used most frequently, which skills may be more challenging to learn and apply, and whether or not the ability to customize skill application leads to improvements in performance or well-being for users.

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