Autonomous, Computer-Based Behavioral Health Countermeasure Evaluation at HI-SEAS Mars Analog

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INTRODUCTION: Living in an isolated, confined environment (ICE) can induce conflict, stress, and depression. Computer-based behavioral health countermeasures are appealing for training and treatment in ICEs because they provide confidentiality and do not require communication with the outside environment. We evaluated the Virtual Space Station (VSS), a suite of interactive computer-delivered psychological training and treatment programs, at the Hawaii Space Exploration Analog and Simulation (HI-SEAS) III expedition.

METHODS: Six subjects (3 male, 3 female) spent 8 mo in group-isolation and used the Conflict, Stress, and Depression modules in the VSS. Survey evaluations, data collected within the program, and postdeployment interviews were collected.

RESULTS: This crew dealt with behavioral health issues common to ICEs. The VSS proved to be a valuable resource and was used both as intended, and in unanticipated ways, to help maintain behavioral health. The Conflict and Stress Modules were rated as highly acceptable (1.8 on a 7-point Likert scale). The crew identified a total of 13 stressors and worked on 9 problems through the VSS. Opinions about the modules were highly individualized. Crewmembers identified exercises in the VSS that were applicable and not applicable to their needs. Additional content to improve the program was identified.

DISCUSSION: Autonomous, confidential training and treatment for behavioral health issues will need to be a critical component of long duration spaceflight travel. This work provides an evaluation of such a tool in a relevant ICE.

KEYWORDS: Isolated confined environment, spaceflight analog, conflict, stress, depression.

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Living in an isolated, confined environment (ICE) can induce conflict, stress, and depression.[5,15] Case studies of teams in polar regions,[11,20] military vessels,[22] ground-based space analogs,[1] and on orbit in space[13] show behavioral health issues are exacerbated by isolation and confinement. The operational demands of living in these extreme environments, such as in space or on submarines, elevates stress.[4,21] To improve behavioral health outcomes, active training, treatment, and monitoring are needed.[14] Autonomous and confidential behavioral health countermeasures are important in ICEs where crewmembers may not be able to communicate easily or confidentially with others outside their environment. Computer-based approaches are appealing for psychosocial training and treatment in ICEs for this reason.[15] Many computer-based treatments, however, show low compliance and acceptability.[9] Further, not many computer-based training and treatment programs have been developed specifically for ICEs, where the demands and stressors are different from those in the general population.

The Virtual Space Station (VSS) is a suite of interactive-media-based, computer-delivered psychological training and treatment programs designed for use on long-duration spaceflights. **Fig. 1** shows representative images of the VSS computer interface. There are three primary modules: Conflict Management, Stress Management, and Depression Treatment. The programs within the modules are based on cognitive behavioral therapy, a treatment technique that focuses on helping patients restructure their thoughts and change their behaviors to achieve better outcomes.[10] The VSS was developed using the 'virtual practicum' model to improve the interactive nature of the

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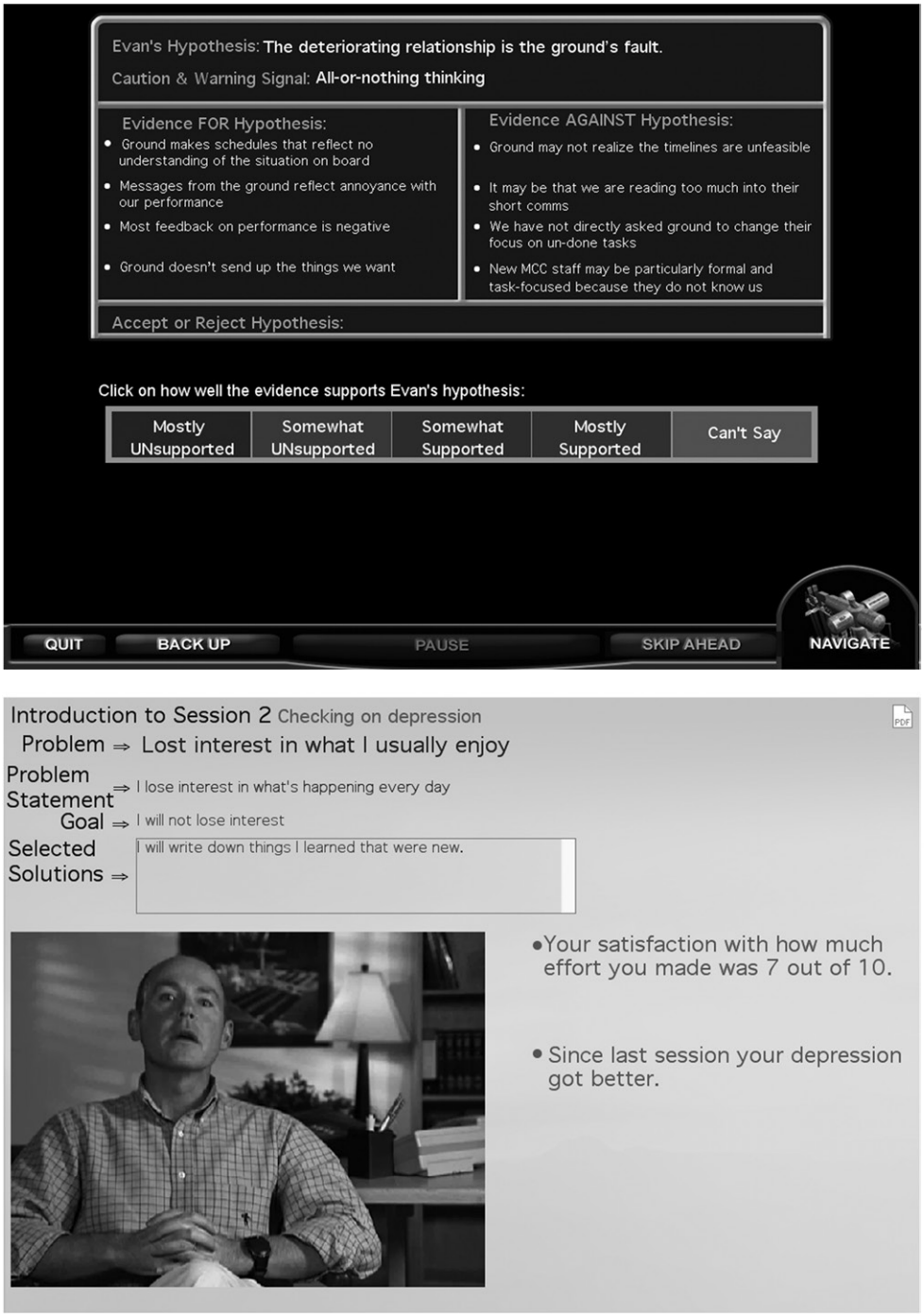

Fig. 1. Virtual Space Station computer interface for Hypothesis Testing in the Conflict module (top) and the 2nd session of the Depression module (bottom).

program and improve learning outcomes.[12] The programs were developed as a self-guided psychosocial training and treatment resource for NASA as part of projects by the National Space Biomedical Research Institute (NSBRI)[6] for use by astronauts on long duration missions.

The Conflict module uses cognitive behavioral therapy to train subjects in how to think about conflict to reach effective solutions. The module includes a conflict briefing, an interactive conflict simulation, a conflict assessment tool, and a cognitive restructuring exercise. The programs were evaluated with an astronaut population to measure usability and gauge the content acceptability. Users approved of the content (75%, 8 of 11 users) and all felt they learned either a moderate or large amount from the module. Overall, the results indicated that the interactive-media-based psychological training was accepted as a valid and engaging tool by the astronauts.[8]

The Stress module also uses cognitive behavioral therapy and helps users identify and improve their individual response to stress. The module consists of six approximately one-hour sessions implemented over the course of six weeks. Each session trains users on different methods to deal with thoughts, feelings, and actions associated with stress. In a randomized controlled trial, a version of the stress content significantly decreased perceived stress and increased perceived control over stress.[18]

The Depression module uses problem solving treatment (PST) to activate subjects with low mood.[17] It consists of six 30- to 60-min sessions implemented over the course of 6 wk. The subject works with a virtual therapist who provides tailored feedback based on the subject's input through branching algorithms. The feedback is based on their level of depression, problem-solving strategies, and perception of success using the program. Studies have shown it is credible, acceptable, and usable for those with mild depression[7] and for moderate to severe major depressive disorder.[2] In a randomized clinical trial, users treated with the computer-delivered depression program showed significantly improved depression outcomes compared to a no treatment control group.[19]

We evaluated the VSS in the 8-mo Hawaii Space Exploration Analog and Simulation (HI-SEAS) III expedition. Our objectives were to: 1) assess the acceptability of the VSS content in an ICE and determine whether it would be used and retained; and 2) customize the VSS for use by astronauts based on the

evaluation of the VSS with subjects living in an ICE. We collected data from within the programs (i.e., how and when they were used) as well as survey questionnaires. Structured interviews at the end of the isolation period provided information on what aspects the users liked most and least about the program. This evaluation in the isolated and confined HI-SEAS environment provided a unique opportunity to assess the acceptability of validated computer-based behavioral health training and treatment in an environment relevant to spaceflight.

METHODS

Environment

The HI-SEAS habitat is a 135.8 m^2 dome on the volcanic slopes of Mauna Loa on the big island of Hawaii. The private sleeping quarters for each person is limited to approximately 4.2 m^2. The crewmembers (CM) were confined to the habitat for 8 mo and only left the habitat if performing a simulated extravehicular activity (EVA) in a mock EVA suit. A 20-min time delay each way was imposed on all communication outside of the habitat to simulate Mars transmission delay. All food and life support systems were designed to simulate the extreme conditions astronauts might encounter on Mars.[3]

Subjects

The protocol was approved by the Dartmouth College Committee for the Protection of Human Subjects, the University of Hawai'i Internal Review Board, and the NASA Institutional Review Board. All subjects consented to participate in the study. Six participants (3 male, 3 female) spent 8 mo in group isolation. CMs in HI-SEAS were volunteers, selected based on criteria similar to that of realistic astronaut selection. Participants must have had an undergraduate degree in engineering or science along with either 3 yr of experience or completion/enrollment in graduate education. CMs were selected to ensure diverse backgrounds and skill sets. Potential subjects were screened using standard measures of cognitive resources and personality, then interviewed. Prior to entering the habitat crews engaged in a cohesion exercise with the National Outdoor Leadership School.[3]

Procedures

The subjects were asked to complete all the content in the Conflict and Stress modules. They were also asked to complete the first two sessions in the Depression module. Subjects completed the Conflict content within 2 mo of entering the habitat. The Stress module was completed over 6 wk within the first 4 mo of deployment. Subjects completed the first two Depression sessions beginning 4 mo into the mission. All modules were made freely available to CMs after the initial exposure so they could return to the content as desired.

Subjects completed "Acceptability of Content Questionnaires" for both the Conflict and Stress modules. The questionnaires consisted of six questions rated on a 7-point Likert scale with 1 being "Strongly Agree" and 7 "Strongly Disagree." An additional questionnaire was administered for the Conflict module to assess content scope and value. The 9-question Patient Health Questionnaire (PHQ-9)[16] measures depressive symptoms and was embedded in the Depression program. The VSS also saved the users' work, including metrics on program use as well as problems, stressors, behavioral action plans, and resilience plans.

Semistructured exit interviews were conducted to provide additional information on the utility of the program and identify ways the program could be better adapted for use in ICEs. Each individual interview lasted approximately 30 min per person. The questions focused on perceived value, content retention, implementation, and acceptability. The CMs were also asked if they returned to use the programs outside of the scheduled usage on their own. The group interview with all six CMs lasted approximately 60 min and focused on identifying technical issues with the program.

Interviews were coded, as shown in **Table I**. There were 10 primary groupings of codes. "Conflict," "Stress," and "Depression" codes captured specific information about each of the major components within the VSS. "Usage," "Value," "Group Perception," and "Alternative Uses" codes focused on how subjects implemented the content and strategies learned in the VSS in subsequent behavioral health outcomes. "Technical Issues," "Comparison to Other Tools," and "Content Changes" codes focused on areas of development for future deployments.

RESULTS

Conflict Module

All CMs completed the Conflict program, and indicated during interviews the program was liked (five CMs with nine incidences) more than disliked (two CMs with four incidences). From the Acceptability Questionnaire (**Fig. 2**), CMs felt comfortable using the Conflict module (1.6) and rated it highly acceptable (1.8). The CMs somewhat agreed the program improved their conflict management skills (3.2). They were neutral on preference for in-person delivery of conflict training (4.0). CMs agreed the Conflict module has value for others (1.9) and would recommend it to a friend (2.2).

The module began with a 10-min instructional briefing on how conflicts develop and progress. The Conflict Content questionnaire indicated all CMs found the Conflict introduction valuable and interesting. Some felt the module could be improved by text recognition software, for example when the user inputs how he or she would respond in a conflict scenario. More real life examples were requested. In interviews, three CMs indicated the framework presented in the briefing for thinking about conflict was useful in their subsequent interactions with others.

The module also has a Conflict Simulation, where subjects were engaged in a virtual conflict and choose the response of one of the characters to progress through the simulation. From the Conflict questionnaire, CMs found value in the Conflict Simulation, and three people cited it positively in interviews conducted 4 mo after CMs used the module. Four CMs ran

Table I. Code Categories and Examples for HI-SEAS III Qualitative Interviews.

CODE CATEGORY	DESCRIPTION	EXAMPLE QUOTE
Conflict	Relates to the Conflict program	"The hypothesis testing is good practice for just sort of calming myself down and actually thinking about the problems…"
Stress	Relates to the Stress program	"There were a couple things in the stress management. One in particular that I actually did use."
Depression	Relates to the Depression program	"I think that [Depression] was my least favorite one."
Usage	Describes how or when the VSS or VSS techniques were used	"Actually I use that [Guided Muscle Relaxation] to put myself to bed all the time."
Value	Describes the usefulness of VSS or VSS techniques	"I found that part useful [Hypothesis Testing], and I think hadn't – if it hadn't been for that, probably could have a few more tiffs and I'm glad I avoided that."
Group Perception	Conveys the individuals perception of the group perception	"That was really split. Some people really liked it, and some people were like, "Oh, my God, no!""
Alternative Uses	Identifies novel uses for the VSS content	"I found it useful as a tool for helping others rather than myself."
Technical Issues	Identifies barriers to the functionality or user interface	"It would just freeze up in the window and you click as many times as you want and it wouldn't let you do anything."
Comparison to Other Tools	Indicates the level of content the VSS achieves	"It's one of the best, probably the best, conflict management training thing that I've gone through."
Content Changes	Identifies new content that is desirable or old content to be modified	"I think if we had more videos like that – and more examples of real life problems… that would be helpful, in my opinion."

through the simulation more than once, taking different paths through the simulation to reach different outcomes. The crew felt this exercise was useful, but two CMs felt the situation was too unrealistic. Two others suggested incorporating conflicts related to gender differences as a topic to be addressed.

The last component of the Conflict program was Hypothesis Testing, shown in Fig. 1. This was a cognitive restructuring exercise that guided subjects through evaluating their interpretation of a conflict based on evidence they assess from a written scenario. In interviews, CMs said they used the Hypothesis Testing exercise in their interactions with others. This exercise was similar in design and delivery to the Weighing Evidence exercises in the Stress program. Together, this approach to cognitive restructuring was cited positively six times in interviews. CMs felt increasing the number of examples provided and using text recognition software to interpret typed responses could improve the exercise.

Stress Module

All CMs completed all exercises in the Stress program across each of the six sessions. Interviews indicated some aspects of the Stress program were well liked (4 CMs, 11 incidences) and some were disliked (4 CMs, 12 incidences). From the Acceptability Questionnaire (Fig. 2), CMs felt comfortable using the Stress modules (1.9) and it was rated highly acceptable (1.8). They somewhat agreed that the programs improved their stress management skills (2.5). CMs somewhat preferred in-person delivery of stress content over computer based delivery (3.3). CMs agreed the Stress module has value for others (2.1) and would recommend it to a friend (2.2). Four of the CMs used the Stress program as suggested in the training, separating their sessions by approximately a week, while the remaining two completed some sessions on the same day.

The Stress program asked subjects to view stress and their responses to stress as a pyramid, with stress triggers at the apex, and their thoughts, feelings, and actions in response to these triggers as the base. To build their stress pyramid, users would identify triggers causing stress in their lives (e.g., workload), their physical and emotional feelings in response to the triggers (e.g., tension, frustration), their thoughts associated with these triggers (e.g., I can't do this anymore), and the actions they perform as a result of these triggers (e.g., eating poorly). Subjects also listed the resilience tools they use to counteract stress (e.g., exercise). One CM noted in the post-mission interview that creating his or her stress pyramid was a useful activity. Taking the components of the stress pyramid and forming a ratio of each individual's stressors and the thoughts, feelings, and actions they have in response to stress, divided by their resilience tools to deal with stress gives a possible indicator of an individual's ability to cope with stress. A smaller ratio may suggest better coping since the participant listed more mechanisms to deal with stress than stressors. **Fig. 3** shows the stress ratios for each CM.

In postinterviews, the two most commonly cited exercises in the VSS were within the Stress module: Guided Muscle Relaxation with seven incidences and Focused Breathing with six incidences. These exercises address the body's response to stress and were effective with this cohort of subjects. **Fig. 4** shows the initial stress state of the CMs before beginning the exercise compared to the final state after completing the exercise. CMs reported decreased stress 83% of times using focused breathing (10 of 12 sessions) and 61% using guided muscle relaxation (11 of 18 sessions).

Strategic Problem Solving was an exercise in the Stress module that used a shortened version of the Problem Solving Treatment technique implemented in the Depression program.

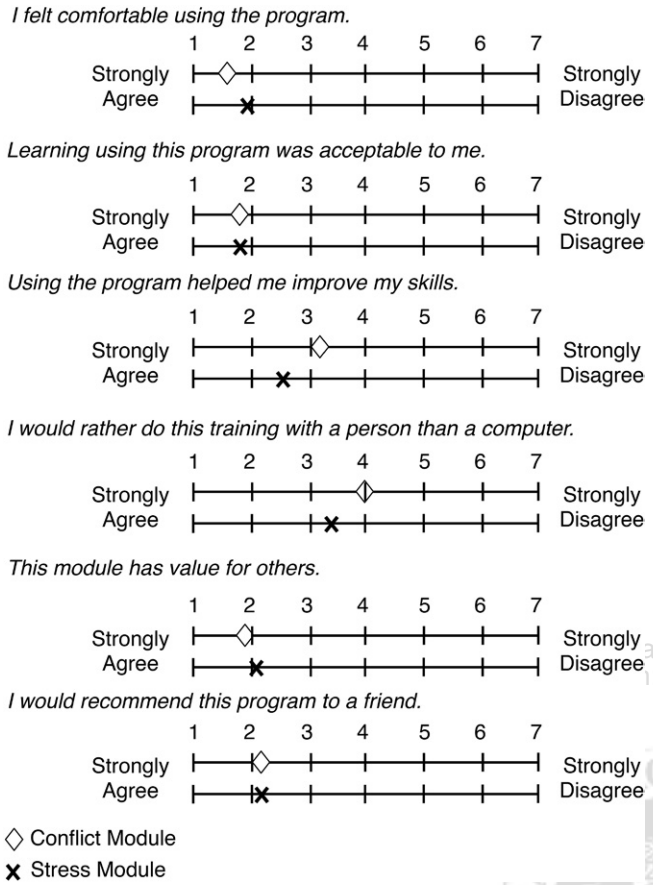

Fig. 2. Summary of Acceptability Survey data for both the Conflict and Stress Modules.

Strategic Problem Solving, however, did not focus solely on addressing depression. One CM noted the exercise was useful for working through issues he or she was having. One CM repeated this exercise voluntarily over the course of the mission. CMs worked on a total of 13 stressors. Of those, four were related to stressors outside of the habitat, while the remaining nine were all related to problems inside the habitat.

There were several additional exercises in the Stress module CMs noted in the postmission interviews. Three CMs felt that Resilience through Writing was a helpful tool. This was a journaling activity and CMs felt it helped them organize their thoughts. One CM enjoyed the real life examples in the Stress program and cited them positively two times. The crew had

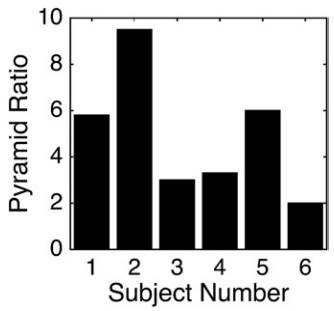

Fig. 3. Ratio of stress responses to resilience tools identified in each individual's stress pyramid. Smaller ratios may indicate improved coping with stress.

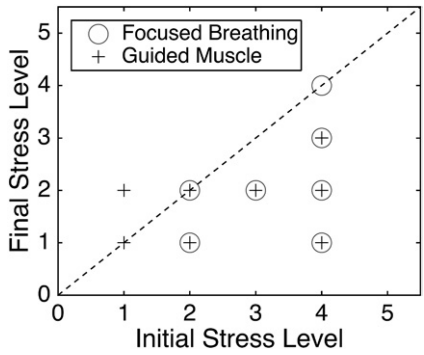

Fig. 4. Stress levels before and after performing Focused Breathing and Guided Muscle Relaxation within the Stress program. The diagonal line indicates stress levels did not change, points below the line indicate stress decreased, and data above the line indicate stress increased.

mixed feelings about Compartmentalization, which was a tool designed to help the user put aside stress triggers and focus on immediate needs. Some felt it was useful to use this concept when interacting with others, while others felt it was poorly implemented in the program or could lead to denial. One participant repeated this exercise voluntarily. The VSS also had supplemental materials for each module. One participant felt the supplemental Stress texts were useful to read. One CM noted that the Stress Trivia Challenge was unhelpful and frustrating because the trivia questions were not covered previously in the module. A different CM repeated this exercise to improve his or her score.

Depression Module

Four CMs completed the first two sessions of the Depression program as requested in the study. One CM, however, completed only one session of the program while another CM completed all six sessions voluntarily. Three CMs reported feeling depressed during the mission, one of whom scored in the mild depression range (PHQ-9 = 8), another of whom indicated he or she was clinically depressed and also had a history of depression. The three remaining CMs did not report depression. Two CMs noted the PHQ-9 imbedded in the program was unhelpful because the questions were not appropriately scoped to how they felt. Overall, the Depression program was the least accepted and CMs noted more frequently they disliked working with it (6 CMs with 20 incidences) than they liked working with it (5 CMs with 11 incidences).

The PST technique used in the Depression program began by "Identifying a Problem" and developing a problem statement. CMs used PST within the program and identified a total of 63 unique problems. In the sessions, CMs chose to work on a total of 9 problems. Of these, four were external to the habitat, and the remaining five were internal to the habitat. CMs noted three incidents when the Identifying the Problem step was helpful, because they had difficulty framing their problems. The next step in PST is to "Set a Goal" to work toward. One CM noted the Set a Goal exercise was helpful. Subjects then brainstormed solutions to the problem. CMs noted four incidents where this step was helpful in thinking of solutions they might not have otherwise identified. In the PST method, subjects then develop a structured "Action Plan" to work on their problem.

Four CMs noted six incidences in which they used the Action Plan, likely because it was a tangible item subjects could refer to. The final step in PST was to "Schedule Enjoyable Activities" over the course of the next week. The crew had mixed feelings about this because some felt it was difficult to plan fun things they enjoyed doing. The average number of enjoyable activities planned was 8.5 ± 4 activities per person per week. When returning to the program after 1 wk of working on the problem with the Action Plan, users could "Revise a Problem" if they were unsuccessful. Four CMs revised their problems to identify better solutions.

Two CMs indicated they solved a problem while working through the program. CMs rated their progress on solving their problems with an average score of 1.3, between "Good" and "Mixed" results. One CM felt strongly that the real life examples in the depression program were very helpful, and cited this four times.

Overall Impressions of the Programs

Table II shows the frequency of each code within the coding categories indicating the general opinion CMs had of the VSS: Value, Usage, Group Perception, and Alternative Uses. All CMs noted that they used the program when it was scheduled, but five CMs also indicated they used the VSS or the techniques in the program on their own. These five CMs noted a total of 21 incidences when they used the content independently of what was scheduled. CMs used the program most often for personal development (e.g., reframing how they think about someone's actions or using the Action Plan), but four CMs noted they used the content in the program to deal directly with fellow crewmates. Four CMs indicated they adopted the techniques learned in the VSS into their normal behavior. All CMs said they felt some aspect of the content was not relevant to them. This was due either to lack of personal need or a mismatch in the timing of when they were exposed to the content versus when they needed the content to deal with conflict, stress, or depression. Five CMs felt the program required too much effort, and this sentiment was generally directed toward the Depression program. Three CMs noted they forgot to use the content, again highlighting issues with timing exposure to the content during deployments.

All CMs identified content in the VSS they found valuable and content they did not find valuable. CMs identified ways using the program produced better outcomes or changed their perspective. Five of the CMs noted they used their own techniques not found in the VSS for dealing with conflict, stress, and depression. Four CMs felt the program could have value for others, both in an ICE and outside. Three CMs felt the problems they faced were not covered in the VSS. Two CMs felt like the program focused too much on negative feelings.

When individuals explained their perception of the group's opinion of the VSS, they cited the group having a negative opinion six times and a positive opinion two times. Only one person noted the group felt positively about the VSS content. Negative group opinions were generally about the Depression program.

Three different people identified three alternative uses for the program: One CM felt the program could alleviate loneliness on long duration space missions. One felt it was useful as an academic resource. One used it to help other crewmates deal with conflict, stress, and depression.

Program Improvements

Four CMs suggested new content that could be added to the VSS. Suggested content included adding more videos and testimonials showing real life examples, putting the program on a smart tablet device (e.g., as an app), and adding a feature to facilitate group discussion of the content. One CM felt that since the program would be used in small isolated environments, providing training on how to ask other people to modify their behavior within the group would be useful. Four CMs felt the Depression program should be modified to add feedback from a live clinician on the participant's information. Additionally, some noted the depression questionnaire should be changed to capture smaller levels of changes in mood. Adding live clinician feedback was the most commonly cited content change and was referred to several times (eight incidents). If this is

Table II. Codes Regarding the General Opinions CMs Had When Interacting with the Virtual Space Station Content.*

CATEGORY	CODE	COUNT	% CODES	# OF CMS CITED
Value	Content was valuable	48	10%	6
	Content was not valuable	20	4%	6
	Content led to better outcomes	18	4%	5
	Content changed my perspective	17	4%	5
	Implemented my own technique	11	2%	5
	Program would provide value for others	10	2%	4
	Isolation contributed to my needs	9	2%	5
	My problem was not covered	7	2%	3
	Content too focused on negatives	3	1%	2
Usage	Content not relevant for me	25	5%	6
	Used the program or tools on my own	21	4%	5
	Required too much effort	13	3%	5
	Used the program when scheduled	10	2%	6
	Adopted behavior learned in VSS	10	2%	4
	Forgot to use the content	8	2%	3
	Implemented when interacting with others	7	2%	4
Group Perception	Group dislike	6	1%	4
	Group like	2	0%	1
Alternative uses	Friendship/loneliness	5	1%	1
	Use to help others	5	1%	1
	Academic resource	2	0%	1

* Codes from each category related to general opinion (Value, Usage, Group Perception, Alternative Uses) are shown by count or number of times cited. The "% Codes" shows how heavily weighted the code is in comparison to other codes (i.e., the number of time the code was cited divided by the total number of codes). "# of CMs Cited" is the number of crewmembers citing that code.

unfeasible, additional training on how to use the program to help others was desirable. Two CMs felt the Conflict program should be expanded. CMs felt the Weighing Evidence exercise should include tips on how to implement the tools in real time and put them into practice. It could also include common pitfalls to avoid, ensuring the evidence is being weighed properly. One CM felt the Stress content should be changed to improve the Compartmentalization and Stress Trivia Challenge modules because they thought the questions were poorly chosen. Two CMs noted additional content should not be exercise based, but should be video based and interactive. CMs also felt gender differences should be better incorporated into the program.

Four of the CMs stated they had never been exposed to the kind of conflict, stress, and depression training the VSS offered. When CMs had been exposed to these kinds of tools previously, three felt certain aspects were better (three incidents), five felt it was comparable (eight incidents), and four felt it was worse (five incidents). Four of the cases when a CM felt the VSS was worse than previous exposure were in reference to the shortcomings of a computer replacing a live clinician in the Depression program.

Several technical issues were noted with the program, which caused frustration among the CMs. There were several incidences when a button or clickable component of the program would not appear or activate (this bug has been fixed in the most recent version of the program). CMs felt that the ability to skip ahead in videos would be valuable, particularly if they had used the module previously. Some noted incidences where they had difficulty scrolling through the content. Some found the interface confusing because there were alternative ways to access some content (for example, the Stress program could be accessed from two locations within the VSS) and the links were not labeled intuitively.

DISCUSSION

To function successfully over long durations in ICEs, crewmembers must be able to recognize the signs of psychological and interpersonal problems both in themselves and in others and to be able to deal with them autonomously and confidentially.[5] The data from this study showed there were problems with stress, interpersonal conflict, and mood common to ICEs during this HI-SEAS deployment. CMs interacted with the VSS as part of this research study, and then subsequently used these tools to address behavioral health issues. Overall, the data indicate that computer-based resources can provide a useful resource within an ICE. Subjects used the modules when not scheduled, and reported using the content from the programs in their interactions with others in the habitat. The responses to the content were highly individualized. Not all CMs liked or used all areas, but each CM found areas that provided either training or treatment they found useful. Often, when the participant noted an exercise they did not personally find valuable, they indicated it would likely be useful for others. This supports the need for a program like the VSS that encompasses several content areas and provides both training and treatment.

Conflict management is critical to repair relationships after a dispute where distance from the conflict cannot be achieved.[20] CMs felt the Conflict program was useful training and returned to the content voluntarily. Many CMs implemented the techniques in the program when interacting with others and indicated they felt it improved conflict outcomes. Many noted that the training was either new to them or better than other conflict training they had experienced. The conflict program had weaknesses, however. The content was not extensive, and some CMs asked for more examples and interactive scenarios.

Also, the timing of when the material was introduced seemed to be important. CMs used the module near the beginning of the deployment to HI-SEAS. Most behavioral health problems, however, occurred later in the mission. Although some CMs reported using conflict content, others stated they forgot about it and therefore did not use it. The possibility exists that the material might have been even more compelling and interesting if it had been introduced later in the mission, when issues with interpersonal conflict were more prevalent.

Crews in ICEs must find effective ways to relax, restore attention, and relieve stress.[15] Preferences for exercises within the Stress content were highly individualized, but every CM felt the training was valuable. Several CMs noted some techniques that were novel and highly useful. Although exercises were also identified as not useful, overall, the program was well received by the crew. The most common positively cited exercises were in the Stress module. The relaxation techniques (focused breathing and guided muscle relaxation) were the most popular, and noted by several as the most useful tool in the program. Several CMs noted these techniques helped improve relaxation and allowed them to sleep better at night.

The Depression program was not well received, but the techniques taught in PST were. For CMs who did indicate feeling depressed, one of the three noted how helpful the program content was, while the remaining two felt it was too cumbersome to engage in through the computer. CMs felt working through the program in conjunction with a clinician would be beneficial, which is consistent with findings in other studies where results from computer based depression treatments are improved when combined with a clinician.[9]

One possible reason for the response to the depression program was that, in contrast to the conflict and stress programs, it is a treatment program that assumes the user is having trouble with mood. When it has been used in clinical trials with depressed individuals, acceptability and usability are rated highly.[2,19] In a recent randomized controlled trial of the depression program, usability scores increased from the first to sixth session.[19] At HI-SEAS, however, CMs were asked to use the program whether or not they had a problem with mood, so those who were not depressed might have found the frequent mentions of depression within the program not relevant to them. In retrospect, having people use the depression program without a defined need for it may not have been a good study design.

Also, in this instance, the individual who arguably had the greatest need for the program did not want to use it. Working

through the exercises on the computer was seen as cumbersome and he or she lacked motivation to engage in the program unless prompted by another person. This did prompt another CM, however, to use the program as a training tool, looking for strategies and ideas to deal with depression in others. This suggests the depression program has relevance not just for treatment, but also as a training tool. Additionally, the CMs suggested the program could be used as a resource by the behavioral support teams. A ground-based physician or psychologist could recommend the use of the program to a depressed member of a crew, and then use the program as an adjunct to the therapy they are delivering from the ground.

This study provides an evaluation of acceptability and content utilization for a suite of computer-based behavioral health tools deployed to an ICE for 8 mo. Training on behavioral health issues can improve outcomes,[5,15] and this evaluation indicates that CMs felt they were able to use the information they received to improve outcomes, although this particular study was not powered to study this directly. Computer-based options are particularly attractive for space and isolated, confined, and extreme environments because they are confidential, easy to administer, can be used when communication options are limited, and allow users to engage in the program without worrying about the stigma associated with mental health.[5,6,15] Several CMs noted the confidential nature of the program was an advantage and the program data indicated CMs felt comfortable reporting their problems and stressors.

The VSS was acceptable and useful in an ICE setting, but there were some limitations to this study. Although the HI-SEAS habitat and study design simulates many of the aspects of a Mars mission, it is not known how well the attitudes and outlook of the HI-SEAS III crew match those of a Mars crew. Also, the sample size is small, and may not be generalizable to a larger astronaut population. Work on increased data collection in ICEs is ongoing.

For the HI-SEAS III expedition, the quantitative data showed the crew found the material in the Virtual Space Station valuable, and interview data showed the material was retained. Overall, the program was well accepted by most CMs, was felt to improve conflict/stress management skills, and was seen as a worthwhile resource for depression, stress and conflict. Opinions on the modules were highly individualized, with some crew feeling certain modules were not applicable to their needs, while others were. Additional content to improve the program was identified. The VSS proved to be a valuable resource and was used both as intended and in unanticipated ways to help achieve positive behavioral health outcomes. Training and treatment for behavioral health issues will need to be a critical component of long duration spaceflight travel. This work provides an evaluation of such a tool in a relevant ICE environment.

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