# TOWARD DEVELOPMENT OF A TACTICAL DECISION MAKING UNDER STRESS INTEGRATED TRAINER

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## ABSTRACT

Incidents involving the USS Vincennes and the USS Starke have focused attention on the complexity of performing in high-stress conditions, such as those that characterize air warfare. As a result of these incidents, the Tactical Decision Making Under Stress (TADMUS) program sponsored by the Office of Naval Research was initiated. In recent years budget reductions, reduced manning, and increased overseas operations have shifted the emphasis on increasing shipboard training. The Tactical Decision Making Under Stress (TADMUS) Integrated Trainer is an interactive, self-paced training system designed to develop both declarative and procedural knowledge skills for effective tactical decision making. Training content is based on empirical findings from research conducted under the TADMUS program sponsored by the Office of Naval Research. A primary goal in developing the trainer is enhanced flexibility and consistency in implementation, minimized instructor involvement, and reduced training time. Therefore, we describe the instructional basis for integrating training to enhance stress, team, and decision skills, and present a description and example of the training strategy. Finally, we research plans and implications for application to other stressful task environments

## ABOUT THE AUTHORS

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## INTRODUCTION

Incidents involving the USS Vincennes and the USS Starke have focused attention on the complexity of performing in high-stress conditions, such as those that characterize air warfare. As a result of these incidents, the Tactical Decision Making Under Stress (TADMUS) program sponsored by the Office of Naval Research was initiated. The goal of TADMUS was to develop and apply human performance and training principles that could be used to mitigate decision errors (Cannon-Bowers et al., 1991). A number of training interventions were empirically demonstrated to improve performance of individuals and teams with respect to stress, team, and decision skills (i.e., stress exposure training, team leader training, critical thinking training) (Cohen et al., 1996; Johnston & Cannon-Bowers, 1996; Salas et al., 1997; Smith-Jentsch et al., 1996). In recent years budget reductions, reduced manning, and increased overseas operations have shifted the emphasis on increasing shipboard training (Oser et al., 1997; Phillips et al., 1997; Zachary et al.,1997). Consequently, demand has increased for automated training tools and instruction that will support rapid skill acquisition. Therefore, recent advanced research and development efforts have begun focusing on producing performance assessment and diagnosis tools, authoring tools, and training delivery methods that will enhance shipboard combat team training (Bailey et al., 1995; Naval Air Warfare Center Training Systems Division, 1997; Zachary et al., 1997). The purpose of this paper is to describe how the TADMUS training interventions are being integrated and streamlined using a computer based training environment to enhance transition to schoolhouse *and* shipboard implementation; with the expected result being reduced training time, increased consistency in training delivery, and reduced instructor involvement. The next section provides a brief overview of the major TADMUS training strategies involved in building stress skills, team skills, and decision skills. Then, we describe how theoretically and empirically grounded instructional strategies are being applied to ensure that team training instructional requirements (i.e., presentation, demonstration, practice, and feedback) are supported. In the third section we provide an example of lesson four from the stress training module to illustrate the instructional approach. The last section describes research plans and discusses potential applications to other task environments.

## BACKGROUND

Tactical teams often must function in highly stressful environments (e.g., environments that are characterized by high workload, time pressure, situational ambiguity, and various types of threats) (Orasanu & Salas, 1993). The TADMUS training research empirically demonstrated that sailors can maintain performance under stress by exercising skills in stress management, team coordination, and critical thinking. In addition, the research showed that event-based training in a combat simulation environment is crucial to enabling individuals to learn and apply these skills (Oser et al., 1997; Johnston et al., 1997). In particular, combat scenario events must be designed so that students can apply and acquire needed skills under *gradual* exposure to common task stressors (Hall et al., 1992; Saunders et al., 1996). Furthermore, the team training research demonstrated that instructor facilitation using performance processes feedback and encouraging team self-correction is a key factor in

learning teamwork skills (Cannon-Bowers et al., 1998). Taken together, these findings indicate that incorporating the declarative knowledge portion of TADMUS training in a PC-based system could refocus instructor involvement where it is really needed, as a facilitator in combat team training exercises. Therefore, the TADMUS Integrated Trainer was designed to incorporate combat scenario vignettes that would provide the necessary realistic cues to facilitate acquisition of general knowledge, as well as specific knowledge about procedures for implementing the three types of skills. The three skill areas are divided into separate modules so that individual skills training could take place prior to combat team simulation exercises designed to support acquisition of each skill. It is expected that the TADMUS Integrated Trainer will decrease the workload on schoolhouse and shipboard instructors, while improving the training effectiveness of combat team simulation exercises.

The stress skills portion of the curriculum familiarizes the students with the definition of stress, how stress can affect performance, and the steps that can be taken to maintain performance in stressful conditions (Hall et al., 1992; Saunders et al., 1996). One major effect of stress is to erode team skills (Serfaty et al., 1993), therefore, the team skills portion of the curriculum is designed to help students learn what it means to have good team skills, and how the presence or absence of good team skills can affect performance (Johnston et al., 1997; Smith-Jentsch et al., 1996). Moreover, the team skills lessons demonstrate to the students how to facilitate team skill acquisition (Smith-Jentsch et al., 1996). Stress can also affect one's ability to make accurate decisions. Working within a naturalistic decision making framework (Cohen et al., 1996; Klein & Hoffman, 1993), the decision skills portion discusses the effect decisions have on performance and provides opportunities to develop metacognitive strategies to addressing decision making in stressful environments where determining tactical plans relies on incomplete information.

Having identified the instructional objectives, we next turn our attention to the instructional strategy. A primary challenge to integrating the individual interventions was reducing training time and ensuring consistency in delivery while remaining true to the original curriculum that was proven to improve individual and/or team performance. Therefore, the following sections describe how the instruction was ordered for each skill area, what methods of instruction should be applied, including how to motivate students to invest the mental energy needed for high-performance learning, and how the sequence and methods for the training should be structured.

## INSTRUCTIONAL SEQUENCE AND METHODS

To develop courseware instructional sequence we drew from Elaboration Theory; a framework advanced by Reigeluth and Stein (1983). Elaboration Theory holds that instruction should begin with the most central, fundamental, or basic idea in a curriculum. Instruction then "elaborates" on this central theme to progressively discuss more detailed aspects of the domain. In this way, early lessons establish an advanced organizer or mental model with which the content of later lessons could be associated. Examination of content sequencing resulted in a fairly detailed ordering of lessons that would be presented within a course and the order in which topics would be presented within a lesson.

Next, Merrill's (1983) Component Display Theory (CDT) offered an approach to organizing the methods used to teach each of the ideas in the curriculum. CDT is a two-dimensional taxonomy of learning objectives in which a given "bit" of knowledge is defined as a fact, concept, procedure, or principle and the goal of instruction is defined as recall, application, or discovery. For each cell in this 4-by-3 matrix, Merrill gives an instructional prescription. For example, if the goal of instruction is teach the student to use a given procedure, Merrill suggests that instruction should begin with a description of the procedure (alternative representations and focusing cues can add depth to this description). The description is followed by at least two demonstrations of the procedure. Again, alternative representations and focusing cues can be added. Moreover, matched cases can be used to highlight the difference between appropriate and inappropriate application. Instruction concludes by providing the student with at least two opportunities to practice using the procedure (some level of feedback is generally provided). CDT provided guidance on how to associate an instructional method with each learning objective. In addition, motivation enhancing components were added using the ARCS framework, advanced by Keller (1983), which holds that instructional motivation (the willingness to work) is

influenced by four dimensions: Attention, Relevance, Confidence, and Satisfaction. That is, the instructional material should: attract the student's attention, be relevant to them in the short- and/or long-term, help build confidence in their ability to succeed in the undertaking, and ensure success is rewarding. Described next are the organizing components for constructing the TADMUS integrated trainer and an illustration is provided, using stress skills training as an example, on how the components are combined to support instruction.

## ORGANIZING INSTRUCTION

Six instructional spaces organize the TADMUS integrated training. They can be thought of as classrooms in which different aspects of instruction take place. The six spaces are: Transition, Presentation, Laboratory, Practice, Notebook, and Test. The ***transition space*** has two functions. First, it bridges the transitions among the other spaces to create a smoother instructional experience. Second, it provides a convenient venue for motivational interventions. Third, it provides an opportunity for interactions such as descriptions of learning goals or suggestions of processing strategies.

Based on the CDT framework, the ***presentation space*** provides a vehicle through which we can present descriptions, as well as examples, demonstrations of facts, concepts, procedures, and principles; it encompasses traditional multimedia instruction. The courseware "talks" and the student "listens," there are windows for graphical materials (stills, animation, video) and text, and it supports audio presentations. It is a simple interface that allows the student to repeat a "frame" of instruction and to move forward and backward through the instructional sequence.

The ***laboratory space*** has its instructional roots in constructivist thought as well as in contemporary developments in CDT (*e.g.*, Transaction Theory) (Merrill, 1983). The laboratory space allows the student to explore the subject-matter in a less constrained manner. Within this space, the student is led through specific activities and is asked a series of questions. Activities and questions are designed to lead the student to think about new ideas, develop an intuitive appreciation for new ideas, or connect new ideas to his or her base of experience.

The ***practice space*** provides the student with an opportunity to remember or apply the material presented in the laboratory or presentation space. It provides immediate, instructionally motivated, feedback after each response. In other words, the primary function of the practice space is instruction, not assessment.

The ***notebook space*** provides an opportunity for generative thought and is consistent with many constructivist notions (e.g., Jonassen, 1988). It is a venue in which the student can record his or her thoughts and make connections among ideas. During instruction the student is placed in the notebook space and asked to respond to various prompts. Following instruction the student can return to the notebook to review the responses. During this period, the student can also review responses to the questions he or she encountered in the laboratory space. In both cases, an "instructor comment" is available and models a reasonable response. The comments are not available during instruction.

The ***test space*** provides an opportunity for the student to demonstrate their knowledge in an assessment (as opposed to instructional) environment. The student visits the test space prior to and after instruction (i.e., for pre-tests and post-tests). The test space is driven by a testing engine. Given a test definition that includes the learning objectives to be addressed, and targets for test difficulty, duration, and length (i.e., number of questions), the test engine dynamically assembles a test for the student. The test is then presented to the student within the test space. During a test, the student can move forward and backward through it to answer questions in any order. The student can also state that he or she does not know the answer to one or more items. When the student has completed the test it is immediately scored and feedback is provided. The student has access to two levels of feedback. First, the student is told the percentage of correctly answered items. Second, the student can review each item in the test. Within this review, the student is shown the item, his or her answer, the correct answer, and a explanation of why each incorrect option is wrong.

### *Example: Stress Skills*

To illustrate how the instructional spaces are used to deliver instruction we review one of the stress skills lessons in detail. The last lesson on stress skills is designed around the principle that, although stress is

inevitable, performance declines are not. The supporting content includes specific strategies for maintaining performance in high stress environments.

***Transition*.** The lesson begins in the transition space. The goal within this space is to increase motivation along the attention and relevance dimensions, to inform the learner of the objectives of the upcoming material, and to suggest a processing strategy. To accomplish this goal we turn the student's attention to a multimedia-based combat team scenario event we had introduced and extended throughout the earlier three lessons. The below sample event is illustrative of how the TADMUS integrated trainer vignettes embody in vivid terms the cognitive, social, and emotional effects of such typical stressors as time compression, ambiguity, and lack of team coordination:

> "The aircraft continue to close. You ask the AIC when the CAP will get a VID on the bogeys. The AIC doesn't know so you tell him, "I need an ID NOW." You're getting more anxious as the aircraft get closer so you speak faster and louder as you coordinate team efforts. The TAO orders GQ, but he doesn't have the information he needs. You hear the GQ alarm and your stomach feels lousy plus you have to go to the head. The team is wondering what is going on. The EW supervisor has data on the inbound aircraft, but you're too busy on the net. You're jumping on the TIC and AICs figuring they can't do their jobs right. You're thinking that you can't do what you need to do because you're worried about what they should be doing. Your performance is starting to decline as your reactions intensify. You know you've got to pull yourself together but you feel like you're watching yourself move in slow motion.
>
> In this lesson, we discuss performance strategies in the face of stressful situations like the one you just saw that will enable you to maximize your performance. Increasing your mastery of stress-reducing performance strategies will increase your confidence in your ability to perform in a shipboard environment. By the end of lesson 4, you will understand how to apply relaxation techniques to reduce stress reactions, recognize and change your thought patterns to reduce stress effects, and recognize and change your team interactions to reduce the negative effects of stress on team performance. As you are introduced to each new strategy in this lesson, consider some time from your past when you used or could have used a similar strategy to reduce stress."

***Presentation*.** From the transition space, the student moves to the presentation space where the goal is to present the organizing content for the lesson; the principle is that performance strategies can be used to maintain performance in stressful situations. A variety of situations from military and civilian life are presented in a matched-case format that includes alternative representations and focusing cues. Below is a sample case :

> "The shipboard environment can be used to illustrate how declining performance can be avoided by applying stress-reducing strategies. For example, as CSC, one of your responsibilities is to monitor equipment status in CIC and reconfigure as required to support current operations. Let's look at two CIC scenes and compare your performance as the CSC. In the first scene, you are attempting to get aircraft altitude from link but you're not getting any data.. But, before you can even think about investigating the problem, the TAO wants to know what happened to the link. Without thinking, you yell over the net "Why have I lost link?" You immediately regret your outburst, and the back of your neck is starting to tighten up. You then learn that the TIC didn't report that the link was down. You yell at him, then at the CIC supervisor. This gets everyone upset including the OS chief. The TAO yells, "What the heck's going on back there?" You're so angry and frustrated with your watch team for not reporting loss of link earlier, that you're at a loss for words. Meanwhile, the rest of the team is waiting for direction from you.
>
> In this scene, you experience physical and emotional responses and your performance starts to decline. The rest of the team reacts to your stress by interacting negatively with each other. Now consider the same scene but this time you use performance strategies that interrupt the stress cycle.
>
> As chaos blooms around you, you focus on relaxing your tense neck muscles, then you tell yourself that you can handle this problem. You turn your attention to communicating with the other team members. You find out that the link frequency had changed, and immediately take steps to restore the link. Later, you will hold a

team debrief to find out why the frequency had not been changed on time.

As the CSC, you interrupted your stress responses with new physical and cognitive strategies that prevented your performance from declining. Now, you are going to return to your notebook to think more about how to apply performance strategies when you experience stress. "

***Notebook***. Following conclusion of the presentation, students move to their electronic notebooks where they are asked to describe situations in which their performance could be improved by using the performance strategies and list performance strategies they could employ in the face of stress. Next, they transition from the notebook to the presentation space for the upcoming objectives. Techniques to maintain physical relaxation and cognitive focus in stressful environments are discussed, with emphasis on the importance of maintaining team skills in stressful settings. The presentation begins with a motivational statement that describes the importance of maintaining cognitive focus (e.g., "If you spend a lot of time and effort worrying about being worried, you won't have anything left to do your job"). This is followed with a description of cognitive focusing strategies. As each strategy is described, the students return to their notebooks and are led through an exercise that links the strategy to the students' experiences. Then a demonstration of the cognitive focusing strategies is used to consolidate the presentation. The same pattern of motivation, description, practice, and demonstration is then applied to physical relaxation.

***Laboratory***. Next, the students enter the transition space to prepare for the upcoming laboratory exercise. They are informed of the goals for their laboratory experience and a processing strategy is suggested. The stress laboratory enables students to have the opportunity to apply various cognitive focusing and physical relaxation performance strategies to stressful scenarios. The students begin by establishing a situation and a stress level by selecting various world events and teammate behaviors. They then apply various physical and cognitive performance strategies and record a strategy's affect on performance. They are also led to consider how stress affects them and which performance strategies might be most effective for them. After leaving the laboratory space the students enter the transition space to receive a brief summary of the lessons learned from the laboratory and a preview of the next presentation. It will follow the same motivation, description, demonstration sequence that was used earlier. In this case, the content of the presentation will be first, then team coordination skills, and finally behavioral monitoring. After the presentation, the students transition back into the stress lab. As before the transition will offer a preview of the upcoming transaction and suggest a processing strategy. Within the stress laboratory, the students will have the opportunity to apply team coordination skills and behavioral monitoring to a stressful situation. As before, they will establish a situation, apply performance strategies, and relate the content to their personal experiences. After the transaction the students will transition to the practice environment which provides a number of opportunities for them to describe and apply the performance strategies they have just reviewed. The number of practice problems and the level of feedback are determined by the student's performance level.

After practicing with the lesson content, the students return to the presentation space for a summary and synthesis of the course material. It begins with a summary of the main points of lesson 4 which emphasizes that performance strategies can help to maintain individual and team performance and the specific performance strategies that were offered. A synthesis of the course is provided including: the stress-performance principle, the definition of stress and stressors, the students as a stress receiver and transmitter, the principle that performance is affected by the linked physical, cognitive, social, and emotional effects of stress, and that performance can be maintained and improved through the use of performance strategies.

***Testing***. Each lesson concludes with a self-check item. It is a detailed scenario against which the students can measure their understanding of the content. After completing all the lessons they take a mastery test. Prior to testing they transition to the notebook space. The transition encourages the student to review his/her notes prior to taking the test. The student's electronic notebook will then be presented. After, the student closes the notebook the testing space appears and the student is informed of the number of problems the test will include, the covered content, and that feedback will be provided after the test has been submitted for grading. The student answers the test questions which are presented one at a time. As a result of testing, one or more lessons may be repeated prior to another testing session.

## RESEARCH PLANS AND POTENTIAL APPLICATIONS

In this paper we have described the development of a PC-based learning environment that encompasses training stress, team, and decision skills. The instructional approach is based on empirically derived principles and guidelines demonstrated in a team training environment. In addition, established instructional theory was applied in structuring the PC-based training sequence, methods, and organization. The next step for the TADMUS Integrated Trainer will be to conduct validation and effectiveness experiments over the next year at a shorebased Navy training command. Experiments will be conducted using classroom traning, as well as in conjunction with a team-based combat simulation system that includes the Decision Support System developed under TADMUS. We expect that the training will be as effective as was shown for the individual training strategies, which would support our case for reducing instructor curriculum delivery workload and emphasizing where instructors are most needed: facilitating combat team training and team performance feedback.

In addition to demonstrating training effectiveness, the results from the research will advance the capability to easily construct such training for other task domains. Ideally, an authoring and training delivery shell could be developed to enable insertion of event-based training vignettes that apply to teams concerned with such high stress environments as damage control, firefighting, emergency medical situations, and police crisis situations. Finally, software development could be internet-compatable so that training could reach shipboard teams and other types of teams that work in a distributed environment, while allowing for curriculum changes at a single shorebased facility.

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