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Text Versus Verbal Real-time Feedback During Simulation-based Training Of Higher-order Cognitive Skills

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TEXT VERSUS VERBAL REAL-TIME FEEDBACK DURING SIMULATION-BASED TRAINING OF HIGHER-ORDER COGNITIVE SKILLS

by

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ABSTRACT

A crucial component of instructional design for simulation-based training systems involves optimizing the presentation of complex material in order to maximize knowledge acquisition and application. One approach toward facilitating the learning of this complex information is to instantiate instructional strategies within the training systems themselves. However, there are few established guidelines in place which are meant specifically for real-time guidance strategies within simulation-based environments. Consequently, this study aims to apply findings from the literature on instructional information presentation to drive decisions for how to most effectively provide real-time feedback during training of simulated decision-making tasks. Research has shown that presenting text information in an auditory mode during direct instruction of operational tasks enhances learning and reduces the probability of learners experiencing cognitive overload. Similar effects have been found regarding the presentation modality of feedback during operational tasks. In the current study, this principle was extended by comparing text versus verbal real-time feedback presentation during learning of higher-level cognitive skills in a virtual environment. Participants were instructed on how to perform a simulated decision-making task, while receiving text, verbal or no instructional feedback in real-time, based on their performance. Participants then completed an assessment scenario in which no feedback was provided to any group. It was hypothesized that a linear relationship would exist across each of the three conditions, with the verbal group making the best decisions, followed by the text group, and then by the control group. Additionally, reduced cognitive load was expected throughout the instructional process for those receiving verbal feedback prompts compared to those receiving text prompts and the control. Analyses revealed several significant linear trends across conditions regarding measures of knowledge acquisition and application. The results provide support for the hypothesis that verbal real-time feedback is more effective than text during training of primarily visual tasks for the acquisition of higher-order cognitive skills such as decision making. There were no significant linear trends regarding the amount of cognitive load subjectively reported during training and assessment. The results of this study indicate that instructional systems intended to train primarily visual tasks should present real-time feedback in verbal rather than text form.

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INTRODUCTION

The identification and application of effective real-time support and guidance strategies represent a major challenge for the development of simulation-based training (SBT) systems (Bell, Kanar, & Kozlowski, 2008). These strategies intend to manage cognitive load in order to support maximum knowledge acquisition and application. Thus, implementing effective instructional design principles is essential for achieving these goals (Sweller, 1999). For instance, the modality through which the learning environment presents instructional material impacts the effectiveness and efficiency of knowledge acquisition (Ginns, 2005).

Substantial research on instructional information presentation has led to the development of the modality effect. The modality effect suggests that instructional information presented across both the visual and verbal channels of working memory reduces the potential of cognitive overload and enhances knowledge acquisition (Sweller, van Merrienboer, & Paas, 1998). Several studies illustrate this principle by presenting text information in verbal form, concurrent with visuals (e.g., pictures, graphics), resulting in greater learning efficiency than if both were presented visually (e.g., Mayer & Anderson, 1992; Mayer & Moreno, 1998; Moreno & Mayer, 1999). However, currently, the literature comparing modalities of instructional information presentation has been dominated by research focused on direct instruction and operational learning tasks. For instance, the way in which information is presented and its effects on cognitive load have been key considerations for the design of multimedia learning environments (Mayer & Moreno, 2003). Consequently, several strategies have been identified to mitigate the potential for cognitive overload during direct instruction (Sweller, van Merrienboer, & Paas, 1998; Mayer &

Moreno, 2003). Additionally, some research suggests that modality effects exist with the presentation of instructional feedback, indicating that text feedback may not be the most effective approach for training visual tasks. However, similar to that of the research regarding direct instruction, it has largely involved learning operational tasks that require low-level knowledge (O'Neil, Chuang, & Baker, 2010; Lalley, 2008, Rieber, 1996; O'Neil, et al., 2000). Thus, while modality effects have been studied with regards to the presentation of to-be-learned material (Ginns, 2005), research is still needed in order to inform the design of real-time guidance strategies within automated instructional systems (Salas & Cannon-Bowers, 2001).

In response, this paper focuses on leveraging previous findings from studying the modality effect in operational tasks and direct instruction and applies it to the use of real-time feedback during SBT. The specific feedback modalities of interest in this paper are text and verbal feedback. Many overlapping theories exist in terms of how different types of information (e.g., visual and auditory) are processed and how they should be presented most effectively. This paper will provide a theoretical background describing two such theories and their applications. Based on these theoretical underpinnings and previous research, recommendations for implementing real-time feedback within SBT are presented and empirically tested.

Simulation-Based Training

SBT systems have become increasingly popular, with applications for training across a wide range of domains, including business (Faria, 1998), education (Moreno & Mayer, 2004), medicine (Ziv, Wolpe, Small, & Glick, 2003), and the military (Jacobs & Dempsey, 1993).

Simulations provide a realistic, experiential training environment and allow learning to occur in a meaningful context where trainees are active in the learning process (Bell & Kozlowski, 2007). SBT also offers unique flexibility for instruction, providing realistic representations of environments for tasks that are too dangerous, impractical, costly, or time consuming to practice in real world settings (Cannon-Bowers & Bowers, 2009).

While there is evidence that SBT systems can be effective learning tools (Cannon-Bowers & Bowers, 2009; Washburn & Gosen, 2001), the contribution of specific features of the systems to overall effectiveness has not been fully quantified (Bell, Kanar, & Kozlowski, 2008; Cannon-Bowers & Bowers, 2009; Salas & Cannon-Bowers, 2001). Cannon-Bowers & Bowers (2009) argue that this is because too much focus is placed on the effectiveness of the training system as a unit, as opposed to examining the individual instructional features within the systems (Cannon-Bowers & Bowers, 2009; Kozlowski & Bell, 2007). As a result, SBT systems are most commonly used as places in which training can occur but to do so would require the input and guidance of skilled instructors. In response, and in an effort to allow SBT systems to be instructional rather than practice environments, researchers are now suggesting that the developers of these systems should focus first on their instructional impact and secondarily on their physical or psychological effects (Schatz, Vogel-Walcutt, & Nicholson, 2010).

To achieve this goal, one of the challenges involves developing effective feedback interventions that provide support and guidance to learners within SBT context. One factor to consider in order to identify the most effective and efficient interventions is the modality through which feedback is presented. In this paper, Multiple Resource Theory (MRT) and Cognitive Load Theory (CLT) are reviewed because they can provide guidance regarding the most effective and efficient modality in which to present real-time feedback.

Theoretical Background

Multiple Resource Theory

Multiple resource theory (MRT; Wickens, 1984) is a theory of human workload and performance in multi-tasking environments. According to this theory, humans are not limited to one single source for processing information but possess several different "pools" of resources that can be used simultaneously. Wickens' (2002) multiple resource model identifies four dimensions that account for the variability in time-sharing performance: processing stages (perception/cognition, responding), perceptual modalities (visual, auditory), visual channels (focal, ambient), and processing codes (spatial, verbal). The purpose of the multiple resource model is to "predict the level of performance of two or more time-shared tasks" (Wickens, 2002). MRT suggests that the amount of interference between time-sharing tasks depends on the extent to which they share levels of each dimension.

The dimension of most relevance for this paper is that of perceptual modalities. Several studies have investigated the perceptual modalities dimension by comparing multi-task environments requiring visual and auditory resources (Wickens, 1980; Wickens et al., 1983, Parkes & Coleman, 1990). This research has provided support for the effectiveness and efficiency of crossmodal time-sharing (tasks requiring visual and auditory resources) over intra-modal time-sharing (tasks requiring visual or auditory resources alone).

Multiple resource theory has been applied to several high-demand multi-tasking environments, including driving (Parkes & Coleman, 1990) and aviation (Dixon & Wickens, 2003). It has also been utilized to inform the design of visual and auditory displays (Boles & Wickens, 1987). However, while multiple resource theory is meant to inform task configuration in order to optimize applied performance and workload, it has not be directly applied to instructional information presentation intended to improve learning. Thus, Cognitive Load Theory (CLT) is also considered. CLT provides instructional procedures that may provide implications for determining how guidance strategies such as feedback should be implemented within SBT.

Cognitive Load Theory

The purpose of Cognitive Load Theory (CLT) (Chandler & Sweller, 1991; Sweller, 1993; Sweller, van Merrienboer, & Paas, 1998) is to utilize principles of human cognition to provide recommendations regarding the way in which instructional information should be most effectively and efficiently presented. The foundation of the theory is based on three main assumptions of information processing that parallel those described in MRT (Sweller, van Merrienboer, & Paas, 1998): (1) Working memory is limited in capacity, (2) working memory consists of independent subcomponents, and (3) working memory load must be managed, while schema construction is encouraged.

These assumptions are based on a large body of research on human cognition. First, it is widely accepted that working memory capacity is limited and only capable of holding approximately seven “chunks” of information at a time (Miller, 1956). Second, according to Baddeley and Hitch’s (1974) theory, working memory consists of independent subcomponents that deal with processing different types of information. According to their model, working memory consists of a “visuospatial sketchpad” that deals with processing visually-based information and a “phonological loop” that deals with processing auditory (mostly speech-based) information. The two subcomponents are governed by a central executive, which is responsible for the integration of the information processed in both systems.

The third assumption of CLT is that working memory load should be managed throughout instruction in order to facilitate the schema construction. This is the central component of the theory. Since all conscious processing of information occurs in a structure limited in processing capacity, instruction should be designed in order to optimize the demands on working memory (Sweller, van Merrienboer, & Paas, 1998). Instead of placing unnecessary demands on working memory, the construction of schemas, or categorizations of information elements, should be encouraged. In other words, with a limited amount of cognitive capacity, instruction should help learners focus on the most important or pertinent information, in order to increase knowledge acquisition, rather than providing learners with extraneous information not relevant to learning. Schemas reside in the virtually unlimited store of long term memory and are retrieved when needed for processing in working memory. While working memory is limited in the number of elements it can hold, it is not limited in the complexity of those elements. Schemas allow for complex knowledge to be organized and held as one element, effectively reducing working memory load. Thus, the goal of CLT is to optimize the way instructional information is presented and subsequently processed in order to encourage schema construction in long-term memory (LTM). The following section describes one of the instructional procedures identified by CLT in order to achieve this goal.

Modality Effects during Instruction

The assumptions of CLT have led to the development of several instructional procedures found to impact the cognitive load experienced by learners during instruction (Sweller, van Merrienboer, & Paas, 1998; Sweller, 1999; van Merrienboer & Sweller, 2005). Most of the design recommendations are intended to reduce unnecessary load on working memory (Sweller, van Merrienboer, & Paas, 1998) while simultaneously encouraging the acquisition and assimilation of relevant material; however, working memory capacity can vary, depending on the modality through which information is presented. Specifically, presenting information across both subcomponents (visual and auditory) of working memory, rather than presenting information that requires processing in only one memory channel (visual or auditory alone) optimizes working memory capacity. Several studies have shown that this has implications for instructional design, finding that the presentation of instructional information in both visual and auditory modalities leads to more effective learning (Mayer & Anderson, 1992; Mayer & Moreno, 1998; Moreno & Mayer, 1999; Moreno, Mayer, Spires, & Lester, 2001; Mousavi, Low, & Sweller, 1995; Tindall-Ford, Chandler, & Sweller, 1997; van Merrienboer & Sweller, 1997). In a meta-analysis, Ginns (2005) found significant support for modality effects during instruction, with the analysis revealing a mean effect size of .72 across thirty-nine between-subject study designs. Furthermore, all but four of the studies analyzed by Ginns resulted in a positive effect.

Modality effects of instructional material have also provided implications for the design of multimedia learning environments (Mayer & Moreno, 2003). Mayer & Moreno (2003) define multimedia learning as learning from pictures and words. While pictures must be presented visually, words may be presented as text or spoken verbally. Several studies of multimedia instruction have suggested that presenting words verbally, concurrent with pictures, is more effective for learning than the same words presented as text (Mayer & Moreno, 1998; Moreno & Mayer, 1999; Moreno, Mayer, Spires, & Lester, 2001). For example, in two experiments by Mayer & Moreno (1998), participants watched multimedia explanations about the process of lightning formation (Experiment 1) or the components of a car's brake system (Experiment 2). In both studies, one group watched a presentation involving concurrent animation and text, while the other group watched animation with the words narrated. Both experiments found that the group receiving animation and narration performed better on transfer, retention, and matching tests than those receiving the words in text form, suggesting that words with animation better support learning than when text is additionally provided. In other words, when information is present that optimizes the use of both the visual and auditory channels, learning improves. Thus, moving essential information from one channel of processing (i.e., visual) to another (i.e., verbal), or *off-loading*, has been a useful strategy for increasing knowledge acquisition and managing cognitive load during multimedia instruction (Mayer & Moreno, 2003). In other words, learning environments that include both pictures and words should present words in verbal form to avoid overloading the visual channel of processing.

Current Research Limitations

However, there are some limitations to the research on modality effects during instruction. First, the research largely involves the presentation of to-be-learned information during direct instruction. Much less research has focused on possible modality effects of guidance strategies such as feedback. Furthermore, the studies exploring modality effects have been applied to operational domains (i.e., math and science explanations) that require learning low-level declarative and procedural knowledge, rather than to the instruction of higher-order cognitive tasks (i.e., decision making) within training simulations. This paper focuses on determining the optimal modality for providing real-time instructional feedback during training of higher-order cognitive skills with in a simulation-based environment.

Feedback

Feedback is meant to provide information regarding one's performance or understanding of a task (Hattie & Timperley, 2007) and is widely accepted as significant support for learning (Hattie & Timperley, 2007; Gagne & Driscoll, 1988; Gagne, Briggs, & Wager, 1992; Kluger & DeNisi, 1996; Ilgen, Fisher, & Taylor, 1979). Kluger & DeNisi (1996) conducted a meta-analysis of performance gains due to feedback interventions and found an average effect size of .41, suggesting a moderate impact on learning. However, more recently, Hattie & Timperley (2007) compared the effect sizes of 12 meta-analyses on feedback and found the average to be

.79, considered a moderate to large effect (Cohen, 1988). Based on these review data, it is clear that providing feedback is better than not providing feedback at all; however, there is considerable variability regarding the effectiveness of approaches to feedback presentation (Hattie & Timperley, 2007). This is because the effectiveness of feedback depends on several factors (Bolton, 2006): the level of analysis, training audience, whether it is intrinsic or extrinsic, the timing, and the mode of delivery. The level of analysis refers to whether feedback provides information about an individual event (event-based) or a summary of multiple events (summary-based) during a training task. The second dimension to consider is whether the training audience involves an individual or team. Third, intrinsic feedback is provided within a training environment, while extrinsic feedback refers to feedback provided as an external training intervention. The final two dimensions of feedback, timing and modality, are of most relevance to this paper and will be discussed in the following sections.

Feedback Timing

The timing of feedback is generally classified as either immediate or delayed. In automated systems, immediate feedback is presented during the training exercise (e.g., Bolton, 2006), while delayed feedback is provided following the completion of a training task (e.g., After Action Review (AAR), O'Neil, Chuang, & Baker, 2010). The differential effectiveness of these two types of feedback has been a large focus within the literature, with the research generally favoring immediate over delayed feedback (Bolton, 2006; Azevedo & Bernard; 1995; Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Kulik & Kulik, 1988). In a meta-analysis, Azevedo & Bernard compared the effect sizes of twenty-two studies that provided immediate feedback and nine studies providing delayed feedback during computer-based instruction. The analysis calculated effect sizes of .80 for immediate and .35 for delayed, providing strong evidence in favor of immediate feedback presentation. Building on these data, Corbett, Koedinger, and Anderson (1997) found that feedback should be provided as early as possible in dynamic decision-making contexts.

However, there is any important distinction to make between two different ways in which to present immediate feedback. Immediate feedback can either be provided following the completion of a sub-task during the training exercise, or, due to recent advances in the ability to assess individual's performance in real-time, it can be given immediately and presented *during* the sub-task. However, real-time feedback, while improving the issues associated with delayed feedback (e.g. Learner forgets the situation about which the feedback is provided, learner must un-learn and then re-learn the information acquired incorrectly), it also creates a potential cognitive overload issue due to interruption of the primary task (Cannon-Bowers & Bowers, 2009; Goldstein & Ford, 2002). Thus, while real-time feedback is meant to identify and prevent potential mistakes, providing feedback during the sub-task may increase the risk of interrupting the learning process. As a result, it is important to determine the optimal approach for presenting real-time feedback.

Despite the apparent effectiveness of feedback on learning, one major concern for presenting feedback in real-time is the effect of disruption on cognitive load (Sweller, van Merrienboer, & Paas, 1998). The feedback may disrupt learners from the primary task (Cannon-Bowers &

Bowers, 2009; Goldstein & Ford, 2002) and consequently negate its positive effects and reduce efficiency. Thus, in order to ensure the effectiveness of feedback during SBT, specific guidelines are still needed for effectively embedding real-time guidance strategies into SBT systems, not only to minimize the potentially detrimental effects of interrupting the learner, but also to maximize knowledge acquisition (Salas & Cannon-Bowers, 2001; Bell, Kanar, & Kozlowski, 2008). This paper is interested in exploring the effects of the modality for which real-time feedback is presented.

Feedback Modality

Many computer-based and simulation-based instructional systems utilize visual feedback in the form of on-screen text (Bolton, 2006; Guralnick, 2008; O'Neil, Chuang, & Baker, 2010; Eitelman, Ryder, Szczepkowski, & Santarelli, 2006). However, only a small number of studies have compared text feedback with forms of verbal feedback presentation (O'Neil, Chuang, & Baker, 2010; Lalley, 2008, Rieber, 1996; O'Neil, et al., 2000; Park & Gittelman, 1992). For instance, text feedback has been compared to narrated feedback (O'Neil, et al., 2000), narration and text combined (O'Neil, Chuang, & Baker, 2010), video representation feedback (Lalley, 2008), and animated feedback (Rieber, 1996; Park & Gittelman, 1992). The results of these studies suggest that narrated feedback, whether alone or combined with text, is more effective than text alone (O'Neil, et al., 2000; O'Neil, Chuang, & Baker, 2010). Additionally, animated feedback and video representation feedback are more effective than static text feedback alone (Lalley, 2008; Rieber, 1996; Park & Gittelman, 1992). These results suggest that modality effects also exist within instructional feedback presentation. Therefore, providing text feedback may not be the most effective modality through which to present instructional feedback during primarily visual tasks.

O'Neil et al. (2000) conducted one of the few studies specifically comparing text-based and narrated instructional feedback, which is also the focus of this paper. In their experiment, participants were placed in a virtual environment where they examined the fuel system of an F-16 and completed objectives in order to learn more about how the system worked. Instructional feedback was provided based on their performance either in the form of pop-up text or the same information was presented in verbal form. The results of the study indicated that participants receiving the audio instructional feedback performed significantly better than the text group on various learning assessments, including transfer, matching, and knowledge mapping. However, there were no significant differences between the two groups regarding retention. While cognitive load was not specifically measured, participants were asked to rate their level of "effort," which was not significantly different between the text and verbal groups.

Current Study

This paper aims to replicate and extend O'Neil et al.'s (2000) work. In their study, participants were trained on an operational task (e.g., the components of a fuel system) that involved acquiring mostly low-level declarative and procedural knowledge. The current study involves training of higher-order cognitive tasks (i.e., decision making) that consist of learning conceptual knowledge. Additionally, the current study focuses on measuring the cognitive load experienced by learners during the training process. Finally, feedback was presented in the study by O'Neil and colleagues in near real-time form but not in real-time. This means that the feedback was provided immediately following a task, after a mistake was made, as opposed to during the task and before a mistake is made. The current study involves the presentation of real-time feedback.

The present study applies the concept of the modality effect to real-time instructional feedback presented during simulation-based training of a military task to determine its effects on cognitive load and learning. Participants played the role of a Forward Observer, one of four members of a military Fire Support Team (FiST). They were instructed on how to perform Call for Fire (CFF) tasks by applying knowledge of FiST team concepts and decision-making rules during scenarios in a computer-based simulator. Participants were assigned to one of three groups that received either text feedback via a message-box appearing on the computer screen, verbal feedback, or no feedback during two simulation-based training scenarios. Knowledge acquisition and application were measured by performance on an assessment scenario that provided no feedback to either group and on paper-based knowledge tests. The perceived cognitive load of participants was also measured throughout the experiment.

Hypotheses

Hypothesis I: Performance during Training

Participants in the verbal group will score the highest on decision-making measures during simulation-based training scenarios, followed by the text group, and then by the control group.

Hypothesis II: Knowledge Application

Participants in the verbal group will score the highest on decision-making measures during a simulation-based assessment scenario and on paper-based knowledge tests, followed by the text group, and then by the control group.

Hypothesis III: Cognitive Load

Participants in the verbal group will subjectively report the lowest cognitive load during simulation-based training and assessment scenarios, followed by the text group, and then by the control group.

METHODOLOGY

Participants

This study included 45 undergraduates from a large southeastern university who received course credit for their participation. There were 31 males and 14 females with ages ranging from 18 to 21 (M=18.53; SD=0.79). Participants were assigned to one of three groups, receiving either text (n=15), verbal (n=15), or no feedback (n=15) during simulation-based scenarios. None of the participants had significant prior knowledge regarding Fire Support Teams or Call for Fire (CFF) tasks.

Materials

Simulation-based Materials

Training Tutorial

The Threat-Assessment Training System (ThreATS; Vogel-Walcutt & Nicholson, 2009) tutorial is a narrated video presentation that consists of three parts: an introduction and two parts (Part 1 and Part 2) focused on explaining the decisions participants would make while using the USMC's Deployable Virtual Training Environment (DVTE) simulator.

Figure 1: Screenshot of Introductory Training Tutorial

The introductory trainer (see Figure 1) describes background information about FiST teams and how to execute CFF tasks in the simulator. Specifically, participants were shown how to complete the simulated radio sheet required for executing the CFF task.

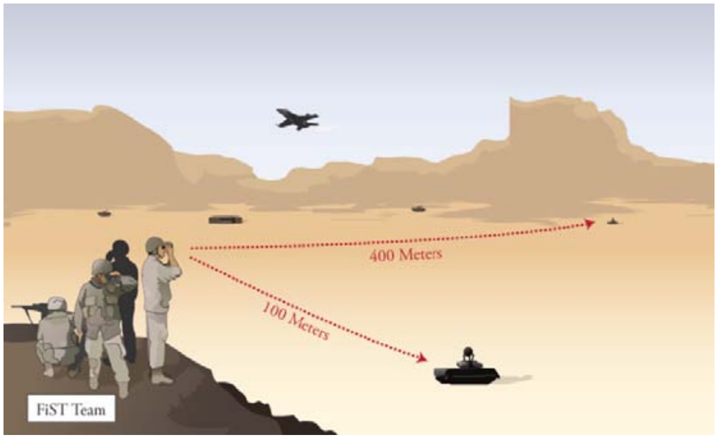

Figure 2: Screenshot of Training Tutorial Part 1

Part 1 of the tutorial (see Figure 2) presents the first rule-based decisions for which participants were to learn and apply in selecting the appropriate targets (tanks or vehicles) to destroy within their environment, as well as the correct order for which they should be destroyed. The rules in Part 1 include distinguishing between friend and foe targets and determining the correct order in which to destroy targets based on their relative distance from the perspective of the participant.

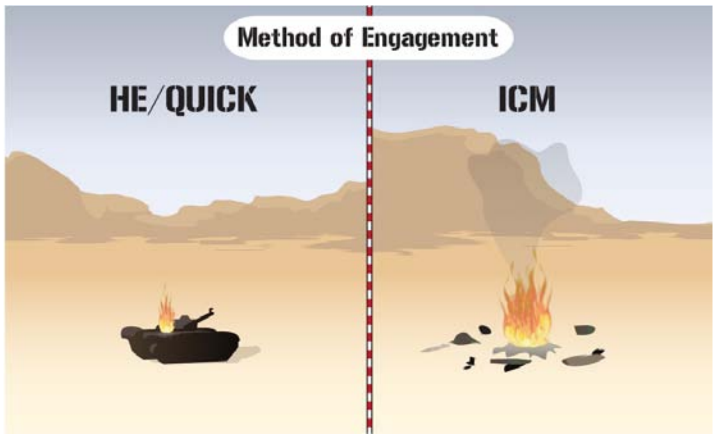

Figure 3: Screenshot from Training Tutorial Part 2

Part 2 of the tutorial (see Figure 3) extends what was learned in Part 1 and explains that moving targets are a higher priority than static ones, and therefore, should be destroyed first. Additionally, Part 2 describes the different ammunition for participants to consider when executing the CFF task. First, they were required to determine the correct warning order based on whether the target was moving or static. Second, they chose a method of engagement that based on whether the target was a tank or a typical military vehicle. The tutorial did not explicitly tell participants which type of ammunition to use in each situation. For instance, they were told that one method of engagement was more powerful, but also more expensive, so it should not be wasted. Participants had to infer that the more powerful and expensive method of engagement should be used to destroy tanks, as opposed to vehicles that were less durable and could be destroyed using less expensive ammunition. In other words, the tutorial required participants to understand the reasons behind choosing different ammunitions options as oppoed to simply memorizing explicit rules and procedures.

DVTE Simulator

The Deployable Virtual Training Environment simulation testbed is used to test and practice military procedures. Study participants engage in simulated Call for Fire (CFF) tasks during four separate scenarios: a practice scenario, two training scenarios, and an assessment scenario. The environment of the scenarios consisted of friendly and enemy targets that were either moving or stationary.

Figure 4: Screenshot of DVTE Rangefinder

Figure 5: Screenshot of DVTE Radio Sheet

Participants were required to make rule-based decisions regarding the location, movement, and methods of attacking enemy targets within the environment. They utilized three simulated items to execute missions: a GPS, a rangefinder (see Figure 4), and a radio (see Figure 5). The GPS provides the location of the participant in the simulated environment, while the rangefinder is used to acquire location coordinates of targets within the environment. Information from the GPS and rangefinder is communicated through the use of the radio in order to execute a CFF task.

Presentation Characteristics

The simulator presents primarily visual information in the form of graphics. The only auditory information presented in the simulator (other than the feedback for participants in the verbal group), comes from minimal intrinsic sound effects, such as the sound of an explosion after a shot has been fired or a simulated FiST team member telling the user that a shot had been fired. The text information presented (other than the feedback for participants in the text group) consists mainly of the radio sheet options, but text also labels the different items of equipment (GPS, Rangefinder, Radio) and the location coordinates of targets within the environment.

Scenarios

The practice scenario consisted of an environment in which two enemy tanks were presented. Participants were to select one of the tanks and follow the appropriate procedure to destroy it. The practice scenario is utilized for task familiarization regarding the functions of the simulator and the procedural aspects of executing a CFF task.

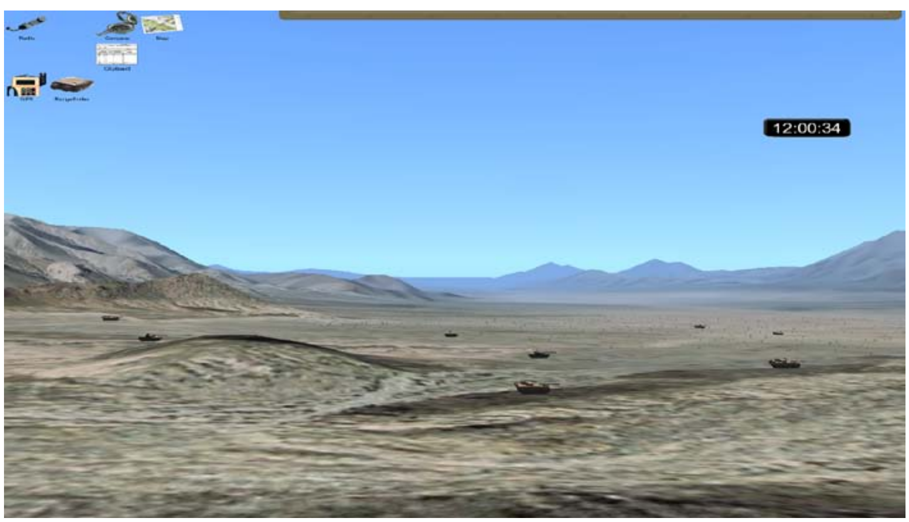

Figure 6: Screenshot of DVTE Training Scenario 1

The training scenarios consist of either eight (Training Scenario 1; see Figure 6) or sixteen (Training Scenario 2) targets, with friendly and enemy targets distributed equally in both scenarios. All targets were static in Training Scenario 1, while half of the targets in Training Scenario 2 were moving. Both training scenarios provided either visual or auditory real-time feedback based on participants' decision-making performance. Visual feedback included a text-box appearing in the corner of the screen. Text and verbal feedback delivered the same content.

The assessment scenario consisted of sixteen targets, with the number of friend/enemy and moving/static targets distributed equally. Feedback was not provided during the assessment scenario.

Decision-Making Performance Measures:

Decision-making performance was assessed using three measures. First, participants' ability to choose the correct order for destroying targets was assessed by calculating their Target Order Score. This score was calculated by deducting varying amounts of points, starting from zero, depending on the degree to which the participant's decision was incorrect. In other words, the closer a participant's Target Order Score is to zero, the better they performed in the scenario. Participants also lost the most points if they chose to destroy a friendly target.

The last two measures of decision-making performance were the Warning Order Score and the Method of Engagement Score. Both were calculated based on the number of correct ammunitions decisions made during the scenarios. Since there were eight enemy targets present in Scenario 2 and the Assessment Scenario, the Warning Order Score and the Method of Engagement Score were calculated out of eight possible correct decisions for each.

Paper-based Materials

Demographics Questionnaire (DQ)

The DQ is a fourteen-item questionnaire requesting the biographical information of participants, including gender, age, vision, and degree of comfort working with computers.

Prior Knowledge Questionnaire (PriKQ)

The PKQ consists of four lab-developed, free-response questions regarding participants' prior knowledge of Fire Support Teams or Call for Fire tasks.

Knowledge Tests

Procedural Knowledge Questionnaire (ProKQ)

The Procedural Knowledge Questionnaire is a lab-developed questionnaire consisting of seven multiple-choice questions regarding the proper procedure for executing a CFF task. For instance, the ProKQ includes questions regarding the order for which to use the different pieces of equipment (GPS, rangefinder, radio) in order to execute a CFF task.

Conceptual Knowledge Questionnaire (CKQ)

The Conceptual Knowledge Questionnaire is a lab-developed questionnaire consisting of eighteen multiple-choice questions regarding FiST team and CFF task concepts, including the decision making rules participants are to follow during the scenarios. For example, it asks about why different types of ammunition for destroying different targets.

Integrated Knowledge Questionnaire (IKQ)

The Integrated Knowledge Questionnaire is a lab-developed questionnaire consisting of ninefree response questions regarding the application FiST team and CFF task knowledge to novel situations. For instance, it asks about what should be done if one of the FiST team members was to be killed.

Cognitive Load Questionnaire (CLQ)

The Cognitive Load Questionnaire is a self-report 9-item likert scale used to measure of perceived cognitive load, or subjective mental exertion, during a task or set of tasks (Paas, Tuovinen, Tabbers, & Van Gerven, 2003).

Scenario Reference Materials

Radio Sheet Guide

The radio sheet guide is given to participants during all scenarios to assist with completion of the simulated radio sheet in DVTE. The guide consists of a diagram representing the radio sheet and provides which options should be selected.

Scenario Target Sheets

Scenario Target Sheets provide a diagram depicting the layout of targets within the environment of each scenario. Target sheets are given to participants during all scenarios.

Procedure

After providing informed consent, participants completed the DQ and the PKQ. Next, they watched the Introductory ThreATS Tutorial and answered the CLQ regarding the mental effort required to process the information presented in the tutorial. Participants then completed the Practice Scenario in the DVTE simulator.

Following pre-testing, introductory training, and becoming familiar with the simulator's functions, participants underwent two training phases. In both phases, participants watched a training tutorial and then completed a Training Scenario within DVTE. The CLQ was administered after both the tutorial and scenario to assess the cognitive load experienced during each of the respective tasks In both training phases, participants received verbal, text, or no real-time feedback based on their decision making performance.

Following the second training phase, the assessment phase required participants to complete the ProKQ, CKQ, IKQ, and the Assessment Scenario in DVTE (in which no feedback was provided). After both the tests and simulator assessment, participants again completed the CLQ (see Table 1).

Table 1: Experimental Procedure

Activity	Time	Materials/Measures
Task Familiarization Phase		
Consent, DQ, and PriKQ	3 min.	Consent Form, DQ, PriKQ
Introductory Tutorial	11 min.	10 minute ThreATS Tutorial, CLQ
Practice Scenario	3 min.	5 minute scenario (Radio Sheet Guide given)
Training Phase		
Part 1 Training Tutorial	5 min.	5 minute ThreATS Tutorial, CLQ
Training Scenario 1	16 min.	15 minute scenario, text, verbal, or no feedback (Radio Sheet Guide and Scenario Targets Sheet given), CLQ
Part 2 Training Tutorial	5 min.	5 minute ThreATS Tutorial, CLQ
Training Scenario 2	16 min.	15 minute scenario, text, verbal, or no feedback (Radio Sheet Guide and Scenario Targets Sheet given), CLQ
Assessment Phase		
Paper-Based Knowledge Tests	15 min.	ProKQ, CKQ, and IKQ, CLQ
Assessment Scenario	16 min.	15 minute scenario, no feedback (Radio Sheet Guide and Scenario Targets Sheet given), CLQ
Total	90 min.	

RESULTS

Data Analysis Plan

Because all hypotheses predicted an underlying linear trend in the outcomes across the three feedback conditions, one-way analyses of variance (ANOVA) with a linear contrast were used to evaluate whether the dependent variables were linearly related to the modality through which feedback was presented. To ensure that the homogeneity of variance assumption was satisfied, Levene's (1960) test was conducted. In instances where this assumption was untenable, consistent with recommendations by Myers, Well, and Lorch (2010), Welch's (1951) F approximation was used instead of the standard F. Table 2 and Figures 9-12 describe the tests of the hypotheses below. Means and standard deviations among the study variables are presented in Table 2.

Table 2: Study Means and Standard Deviations

Phase	Measure	Feedback Group: Verbal *M*	Verbal *SD*	Text *M*	Text *SD*	Control *M*	Control *SD*
Training							
Scenario 1	Target Order Score*	**-1.33_a**	1.95	$-9.20_{a,b}$	20.11	**-5.07_b**	3.85
	Cognitive Load	4.53	1.46	4.13	1.36	4.80	0.94
Scenario 2	Target Order*	**-4.67_a**	3.83	$-18.93_{a,b}$	21.42	**-21.47_b**	10.91
	Method of Engagement Score	5.80	1.78	3.80	2.08	3.20	1.78
	Warning Order Score	5.87	1.81	4.47	1.78	4.60	1.99
	Cognitive Load	6.00	1.56	5.53	1.25	5.93	1.16
Assessment							
Assessment Scenario	Target Order Score*	**-5.07_a**	6.54	$-18.00_{a,b}$	26.60	**-15.87_b**	14.61
	Method of Engagement Score	7.13	1.60	5.93	2.15	4.40	1.72
	Warning Order Score	7.47	1.36	6.87	1.73	6.13	1.69
	Cognitive Load	4.87	1.77	4.00	1.56	4.67	1.45
Knowledge Tests	Procedural Knowledge	19.00	2.36	17.07	3.88	15.27	3.85
	Conceptual Knowledge	10.93	0.80	10.93	1.39	10.20	1.66
	Integrated Knowledge	7.04	0.88	7.68	1.66	7.60	1.96

Note. Means with different subscripts within a row marked with an asterisk (*) differ significantly at $p < .05$, as indicated by Games-Howell procedure; $n = 15$ for all feedback groups; Target Order Scores were derived by deducting varying point values, starting from 0, depending on the severity of their errors.

Hypothesis I

For Scenario 1, Levene's test of homogeneity of variance revealed that the variances of the Target Order Score were heterogeneous across the three conditions. Consequently, Welch's *F* (2, 22.43) = 6.36 ($p < .01$) indicated that there were significant differences between the three groups. The Games-Howell procedure (see Table 2) revealed a significant difference between the Verbal and Control groups, $q = 3.35$ ($p < .01$), suggesting that verbal feedback improved decision making during Scenario 1, while text feedback was no more effective than the control group.

Levene's test also revealed that the variances of the Target Order Score for Scenario 2 were heterogeneous across groups. Consequently, Welch's *F* (2, 21.19) = 17.72 ($p < .01$) indicated that there were significant differences across the three groups. The Games-Howell procedure (see Table 2) again revealed a significant difference between the Verbal and Control groups, $q = 2.54$ ($p < .01$). Additionally, the mean difference between the Verbal and Text groups approached significance, $q = 5.62$ ($p = .056$). These findings suggest that providing verbal feedback not only improved decision making when compared to the control group, but it was also more effective than providing text feedback.

Regarding the number of correct Warning Order decisions made, the analysis revealed a linear trend across the three groups that approached significance, $F(1, 42) = 3.48$, $p = .069$. A statistically significant linear trend did exist, however, regarding the number of correct Method of Engagement decisions made, $F(1,42) = 14.27$, $p > .001$ (see Figure 7). These findings suggest that the ability to make higher-order ammunitions decisions is enhanced when real-time feedback is provided, and when the feedback is presented in verbal as opposed to text form.

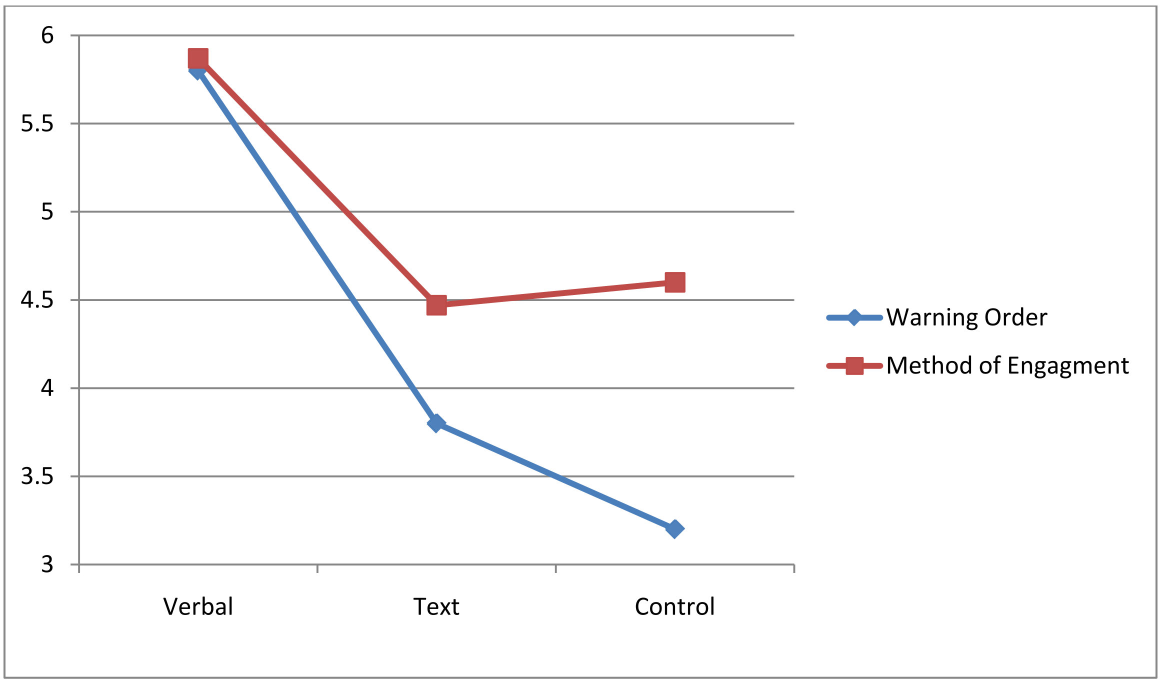

Figure 7: Training Scenario 2 – Ammunitions Decisions

Hypothesis II

As with both training scenarios, Levene's test of homogeneity revealed that the variances of the Target Order scores for the Assessment Scenario were heterogeneous across the three conditions. Consequently, Welch's F (2, 22.54) = 4.53 (p = .022) indicated that there were significant differences across the three groups. The Games-Howell procedure (see Table 2) again revealed a significant difference between the Verbal and Control groups q = 2.61 (p = .043). These findings suggest that providing verbal feedback during training enhanced participants' ability to apply their acquired conceptual knowledge regarding the correct order to destroy targets to an assessment scenario in which no feedback was provided. Text feedback, however, was no more effective in improving target order decisions than the control group.

One-way ANOVA revealed a significant linear trend across the three groups regarding both the number of correct Warning Order decisions made ($F(1, 42) = 5.22$, $p = .027$) and the number of correct Method of Engagement decisions made, $F(1,42) = 16.54$, $p < .01$ (see Figure 8). These findings suggest that knowledge of ammunitions concepts is most effectively transferred when verbal feedback is provided during training. Additionally, the results indicate that providing text feedback during training translates into improved knowledge application over the control group.

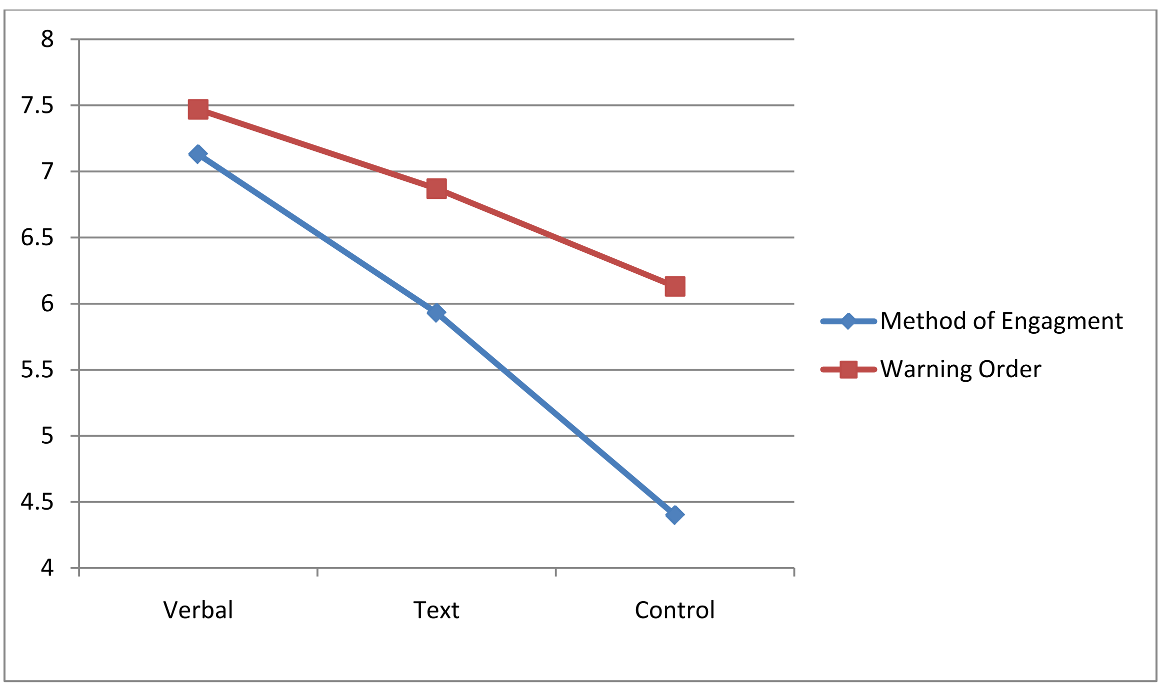

Figure 8: Assessment Scenario – Ammunitions Decisions

The linear contrast in ANOVA indicated that a significant linear trend existed regarding performance on the Procedural Knowledge Test ($F(1, 42) = 8.85$, $p = .005$; see Figure 9);

however, there was no significant linear relationship regarding performance on the Conceptual Knowledge Test ($F(1,42) = 2.28$, $p = .138$) or the Integrated Knowledge Test, $F(1,42) = 0.95$, $p = .336$. These findings suggest that the acquisition of procedural knowledge was optimized by providing real-time verbal feedback, while feedback modality did not influence the acquisition of conceptual or integrated knowledge.

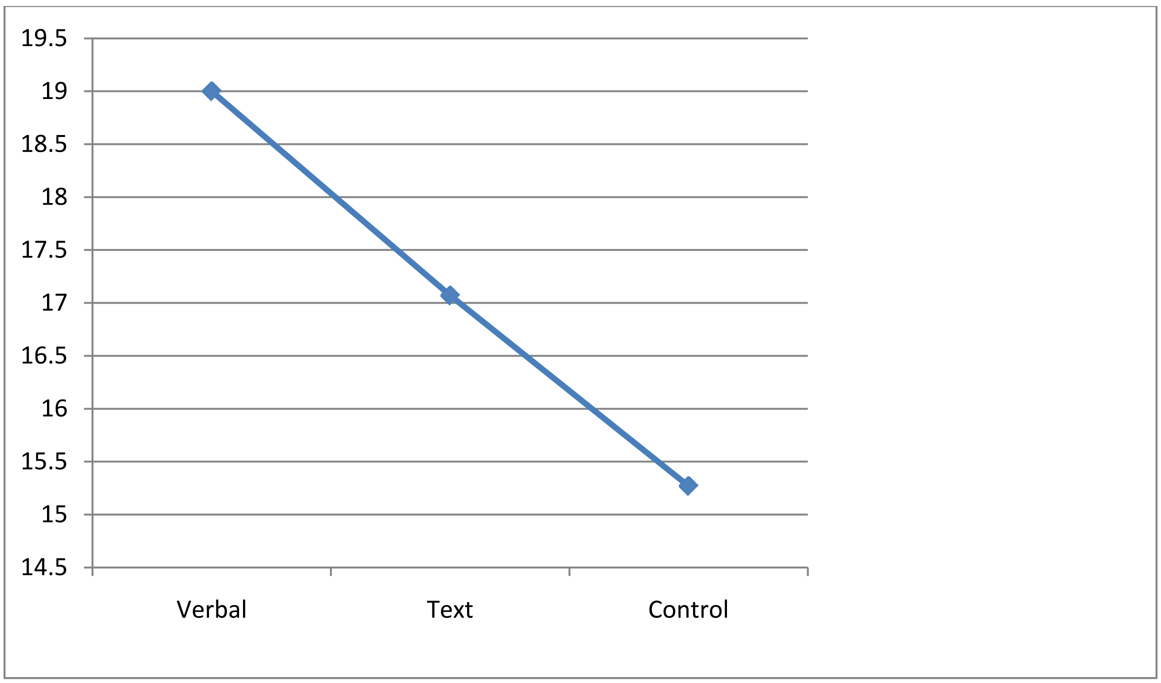

Figure 9: Procedural Knowledge Test

Hypothesis III

A one-way ANOVA revealed no significant linear trends across the three groups regarding cognitive load during both Scenario 1 ($F(1, 42) = .33$, $p = .569$) and Scenario 2 ($F(1, 42) = .02$, $p = .892$). Additionally, there were no significant linear trends across conditions regarding cognitive load during the Assessment Scenario, $F(1, 42) = .12$, $p = .733$. These findings suggest that feedback modality did not impact participants' subjective reports of cognitive load experienced during training and assessment scenarios.

DISCUSSION

This study provides strong support for the hypothesis that the modality of real-time instructional feedback impacts higher-order knowledge acquisition and application. The data suggest that feedback is not only important for improved decision-making, but whether the feedback is presented in a verbal or text mode in visually demanding training contexts is also an important factor to consider. This study found a consistent trend in the data, with verbal feedback being the most effective, followed by text feedback, and then providing no feedback. This trend existed not only in the acquisition of decision-making concepts during training but also in the transfer and application of that knowledge in a simulation-based assessment. These performance trends suggest that those receiving verbal feedback are experiencing less cognitive load and are able to effectively process the visual information presented in the scenario, as well as the feedback presented in verbal form. Presenting text feedback during a training task that is primarily visual can potentially overload learners with too much visual information to process in working memory. This position is strengthened by the decision-making performance differences across the three feedback conditions. However, subjective reports of cognitive load did not support this claim. Despite that finding, however, the validity of such measures depends on participants being aware of their own mental effort during a task. Potentially, objective measures of workload such as EEG or eye-tracking may provide additional and more reliable insight into learners' cognitive load levels during learning.

The findings of this study are consistent with past research on the modality of instructional information presentation. Past studies have found that presenting words in verbal form is more effective than text when they are accompanying other visual information. To this point, research on the modality of instructional information has mostly focused on the presentation of new material for the training of procedural tasks that involve acquiring lower-level knowledge. Additionally, the research on instructional feedback modality also has focused on the acquisition of lower-level declarative and procedural knowledge. In general, this research has suggested that presenting words in verbal form is more effective than text. This study has extended the current research, and has indicated that modality effects of instructional information apply to real-time feedback and for the training of higher-order cognitive skills.

Recommendations

The current study provides implications for the design of future instructional systems. First, clear support now exists for providing real-time instructional feedback in verbal form during learning tasks utilizing primarily visual information presentation formats. This study, along with past research, suggests that this principle can be applied across several training domains, as well as tasks requiring both low-level and higher-order knowledge. Many current systems present feedback in the form of on-screen text. This study suggests, as expected, that providing feedback is more effective than not providing feedback; however, the modality of the feedback is also a significant factor. Instead of potentially overloading the visual channel of working memory with pictures and text, the text information should be off-loaded to the verbal channel by providing feedback in an auditory mode.

Limitations

As in any study, there are always limitations that may have influenced the results. The first limitation of this study is the relatively small sample size. A larger sample size would have provided more statistical power and also could have possibly avoided the large variation across groups in Target Order scores for the training and assessment scenarios. Another possible limitation of this study is validity of the measures used. For instance, a ceiling effect appeared to exist across groups regarding scores on the CKT. This test may not have been a valid measure of the conceptual knowledge required for the simulation-based scenarios, as performance in the simulator was often linearly related to the feedback conditions, but there was no linear trend across groups on the CKT. The validity of CLQ is also questionable because of this reason. It is possible that participants are not aware of the cognitive load they are actually experiencing, and therefore, their self-report responses are not accurate representations of their cognitive state. Consequently, it may be more effective to utilize objective measures of mental effort, such as through the use of physiological sensors.

Future Research

This study provides several implications for further research. First, the current study focused specifically on the modality of real-time instructional feedback. Future studies could investigate possible interactions between feedback timing (e.g. real-time, immediate, or delayed) and modality (e.g. text or verbal). Another factor to consider is whether or not the content of the feedback makes a difference in modality effects. For instance, future research could compare corrective and explanatory forms of feedback and how their effectiveness is influenced by modality. The location of the text feedback presented on the screen may also play a role in determining which modality is most effective. In the current study, on-screen text was provided in the corner of the screen and did not interfere with the essential visual information presented in the simulation-based scenarios. Moving the location of the text-box to the center of the screen or having it cover the entire screen may also have an impact on knowledge acquisition and application, as well as cognitive load.

In the current study, feedback was adapted based on the performance of participants throughout the scenario. It may be beneficial to look at other measures that “trigger” feedback, such as from physiological measures. Finally, neuro-physiological measures, such as EEG, may be better indications of the amount of cognitive load experienced while performing a task. These methods could offer a more valid measure of mental effort than subjective, self-report measures of cognitive load.

APPENDIX A: IRB APPROVAL LETTER

University of Central Florida

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Christopher Fiorella and Jennifer Vogel-Walcutt**

Date: **May 26, 2010**

Dear Researcher:

On May 26, 2010, the IRB approved the following human participant research until 5/25/2011 inclusive:

Type of Review:	UCF Initial Review Submission Form
Project Title:	Auditory Feedback Study
Investigator:	Christopher L. Fiorella
IRB Number:	SBE-10-06928
Funding Agency:	Office of Naval Research
Grant Title:	Algorithms Physiologically derived to Promote Learning Efficiency (APPLE)
Research ID:	N/A

The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 5/25/2011, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Joseph Bielitzki, DVM, UCF IRB Chair, this letter is signed by:

Signature applied by Janice Turchin on 05/26/2010 12:38:19 PM EDT

Janice M Turchin

IRB Coordinator

Page 1 of 1

APPENDIX B: INFORMED CONSENT

INFORMED CONSENT
Adaptive Feedback Study

Principal Investigator(s):	Logan Fiorella
Sub-Investigator(s):	Jennifer J. Vogel-Walcutt, Ph.D. Denise Nicholson, PhD., Jennifer Luli
Investigational Site(s):	IST, 3100 Technology Pkwy, Orlando, FL 32826

Introduction: Researchers at the University of Central Florida (UCF) study many topics. To do this we need the help of people who agree to take part in a research study. You are being invited to take part in a research study which will include up to 100 people at UCF. You have been asked to take part in this research study because the researcher is interested to know how people learn through the use of adaptive feedback during computer-simulated military tasks. You must be 18 years of age or older to be included in the research study and sign this form. You can read this form and agree to take part right now, or take the form home with you to study before you decide.

What you should know about a research study:

- Someone will explain this research study to you.
- A research study is something you volunteer for.
- Whether or not you take part is up to you.
- You should take part in this study only because you want to.
- You can choose not to take part in the research study.
- You can agree to take part now and later change your mind.
- Whatever you decide it will not be held against you.
- Feel free to ask all the questions you want before you decide.

Purpose of the research study We are investigating the effects of adaptive feedback on learning efficiency during military computer-based simulation tasks.

What you will be asked to do in the study: After agreeing to participate in this study, you will be given a demographics questionnaire and a questionnaire assessing your prior knowledge of military Call for Fire tasks. Then, you will watch a short training presentation and complete a military Call for Fire task using a computer-based simulator in which you will be asked to engage enemy tanks in your environment. You will also be asked to answer some questionnaires about your experiences while completing the scenarios as well as knowledge tests to assess your learning.

Location: IST, Partnership II Building (Room 338), 3100 Technology Pkwy., Orlando, FL 32826

Time required: We expect that you will be in this research study for a total of 1.5 hours.

Risks: There are no foreseeable risks or discomforts associated with the simulator.

Benefits: There are no expected benefits to you for taking part in this study.

Compensation or payment: Compensation will be given as credit for class through SONA. SONA decides how many credit points are awarded for each hour of experimental participation. The results of the research study may be published, but your name or the names of your students will not be used. You must be an American citizen and at least 18 years old to participate.

Confidentiality: We will limit your personal data collected in this study to people who have a need to review this information. We cannot promise complete secrecy.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you talk to Logan Fiorella or by email at lfiorella@ist.ucf.edu, Graduate Student, Institute for Simulation and Training, Dr. Vogel-Walcutt, Research associate, Institute for Simulation at (407) 823-1366 or by email at jjvogelwalcutt@yahoo.com or Dr. Nicholson, Research Associate, Institute for Simulation at (407) 823-1444 or by email at dnichols@ist.ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901. You may also talk to them for any of the following:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You want to get information or provide input about this research.

UCF
University of Central Florida IRB
IRB NUMBER: SBE-10-06928
IRB APPROVAL DATE: 5/26/2010
IRB EXPIRATION DATE: 5/25/2011

APPENDIX C: BIOGRAPHICAL QUESTIONNAIRE

Participant Code: ______________

BIOGRAPHICAL QUESTIONNAIRE

1. **Age** _______

2. **Gender** (please circle) a. Female b. Male

3. **Race/Ethnicity** (please circle one only):

a. Caucasian b. African-American c. Asian-American d. Hispanic e. Other

4. **SES/combined income of house hold** (circle one only):

a. $0-29,999 b. $30,000-59,999 c. $60,000-89,999 d. $90,000 +

5. **Marital status** (circle one only):

a. Single b. Married c. Divorced d. Widowed e. Living with partner

6. **What is your current working status?** (<u>You may circle more than one</u>)

a. Staying at home b. Work full-time c. Work part-time d. Student e. Retired

7. **What is the highest degree that you have obtained?** (Circle one only)

a. Some High School b. High School Diploma c. Some College

d. Bachelor's Degree e. Some Graduate Experience f. Completed Graduate Degree

8. **What is your primary language?** (Circle one only)

a. English b. Spanish c. Other

9. **What is your hand preference?** (Circle one only)

a. Right-Handed b. Left-Handed c. No Preference

10. **Do you require corrected vision?** (Circle one only) Yes No
    If so, do you wear glasses or contacts? (Circle one only.) Yes No
    And if so, are you wearing them now? (Circle one only.) Yes No

11. **Have you ever served in the military or ROTC?** (Circle one only.) Yes No
    If so, with whom and when? ____

12. **How often do you play video games** (computer or console)? _____ hours/week

13. **How often are you on the computer**? _____ hours/week

14. **How would you describe your degree-of-comfort with computers?** (Circle one only.)
a. Poor b. Fair c. Average d. Above Average e. Proficient

APPENDIX D: PRIOR KNOWLEDGE QUESTIONNAIRE

AF Study

Participant Code: ______________

PRIOR KNOWLEDGE QUESTIONNAIRE

1. **What do you know about Fire Support Teams?**

____

____

____

____

____

2. **What do you know about Forward Observers?**

____

____

____

____

____

3. **What do you know about Call for Fire tasks?**

____

____

____

____

____

4. **Have you ever used a military simulator? If so, please explain your experience.**

____

____

____

APPENDIX E: COGNITIVE LOAD QUESTIONNAIRE

Participant Code: _______________

COGNITIVE LOAD QUESTIONNAIRE

In solving or studying the preceding problem I invested: (Circle one only)

1. Very, very low mental effort
2. Very low mental effort
3. Low mental effort
4. Rather low mental effort
5. Neither low nor high mental effort
6. Rather high mental effort
7. High mental effort
8. Very high mental effort
9. Very, very high mental effort

APPENDIX F: PROCEDURAL KNOWLEDGE QUESTIONNAIRE

Participant Code: ______________

PROCEDURAL KNOWLEDGE QUESTIONNIARE

1. What is the order of events that a FIST should follow? (Number from 1 to 4.)

_____ Determine each enemy's exact location.
_____ Find a place to hide.
_____ Request the support team to fire at the given coordinates.
_____ Watch the enemies' activities.

2. In this simulation, what is the order in which a Forward Observer Artillery should destroy his enemies? (Number from 1 to 4.)

_____ Moving enemy close to his platoon.
_____ Static enemy close to his platoon.
_____ Moving enemy far from his platoon.
_____ Static enemy far from his platoon.

3. In this simulation, what is the order in which the Forward Observer Artillery should use his pieces of equipment? (Number starting from 1. For pieces of equipment that are not used, write *N/A*)

_____ Binoculars
_____ Clipboard
_____ Compass
_____ GPS
_____ Map
_____ Radio
_____ Rangefinder

4. In this simulation, what is the order in which a Forward Observer Artillery should communicate with the artillery team in order to call for fire? (Number from 1 to 5.)

_____ Transmit his own location.
_____ Transmit Danger Close, Trajectory and Splash
_____ Transmit the Method of Engagement
_____ Transmit the target's coordinates
_____ Transmit the Warning Order

5. When will the Artillery Team fire?

a. Right after the Forward Observer Artillery declares the End of Mission.
b. Right after the Forward Observer Artillery transmits Danger Close, Trajectory and Splash.
c. Right after the Forward Observer Artillery transmits the Method of Engagement.
d. Right after the Forward Observer Artillery transmits the target's coordinates.
e. Right after the Forward Observer Artillery transmits the Warning Order.

6. Which one is *NOT* a role of the Forward Observer Artillery? (Circle one only)

a. Determine enemies' locations.
b. Locate a place to hide.
c. Surround enemies.
d. Watch enemies' activities.

7. **What is the earliest time that a Forward Observer Artillery should declare End of Mission?** (Circle one only)
    a. After calling for fire against the current target, even before the current artillery round has landed.
    b. Only after all targets have been destroyed.
    c. Only after the current artillery round has landed.
    d. Only after the current target has been destroyed.

APPENDIX G: CONCEPTUAL KNOWLEDGE QUESTIONNAIRE

Participant Code: _______________

CONCEPTUAL QUESTIONNAIRE

1. **What is true about the Adjust Fire warning order?** (Circle one only)
   a. It doesn't require extremely precise coordinates and it's less expensive than Fire for Effect; therefore it's very effective against moving targets.
   b. It doesn't require extremely precise coordinates but it's more expensive than Fire or Effect; therefore it's very effective against moving targets but should not be wasted.
   c. It requires more precise coordinates and it's more expensive than Fire for Effect; therefore it isn't very effective against moving targets and shouldn't be wasted.
   d. It requires more precise coordinates but it's less expensive than Fire for Effect; therefore, it isn't very effective against moving targets.

2. **Why does it take a while for munitions to achieve the given coordinates once the fire has been ordered?** (Circle one only)
   a. That's mainly because of the radio delay between the moment the fire is ordered and the time the message is received by the Artillery team.
   b. That's mainly because of the time it takes for the ammunition to exit the cannon and reach the given coordinates.
   c. That's mainly because of the time it takes for the support team to prepare their weapons before shooting.
   d. This delay is mainly due to the movement of the target, and it does not occur when the target is static.

3. **What is true about moving units?** (Circle one only)
   a. They are likely to be serving other purposes besides just shooting the enemy but they are always ready to fire; therefore they are more dangerous than static units.
   b. They are likely to be serving other purposes besides just shooting the enemy and aren't ready to fire; therefore they aren't as dangerous as static units.
   c. They are traveling closer to their point of detonation and are ready to fire; therefore they are more dangerous than static units.
   d. They are traveling closer to their point of detonation but aren't ready to fire; therefore they aren't as dangerous as static units.

4. **What is true about the HE/Quick method of engagement?** (Circle one only)
   a. It's *less* expensive and *less* powerful than ICM; therefore it isn't very effective against tanks.
   b. It's *less* expensive and *more* powerful than ICM; therefore it's very effective against tanks.
   c. It's *less* powerful but *more* expensive than ICM; therefore, it isn't very effective against tanks and should not be wasted.
   d. It's *more* expensive and *more* powerful than ICM; therefore it's very effective against tanks but should not be wasted.

5. **What is true about static units?** (Circle one only)
   a. They are easier to be detected and destroyed than moving units.
   b. They are not as dangerous as moving units.
   c. They are more dangerous than moving units.
   d. They are not as easily detected and destroyed as moving units.

6. **What is true about the ICM method of engagement?** (Circle one only)
    a. It does not require as precise coordinates as HE/Quick does.
    b. It is not as effective against tanks as HE/Quick.
    c. It requires more precise coordinates than HE/Quick.
    d. It is more effective against tanks than HE/Quick.

7. **What is true about the Fire for Effect warning order?** (Circle one only)
    a. It should not be used against tanks.
    b. It should not be used against vehicles other than tanks.
    c. It is more effective against moving targets than Adjust Fire.
    d. It is not as effective against moving targets as Adjust Fire.

8. **How can a Forward Observer Artillery figure out a target's coordinates?** (Circle one only)
    a. Using Binoculars to figure out the target's position.
    b. Using a Compass to figure out the target's direction.
    c. Using a GPS to figure out a target's position.
    d. Using a Map to figure out a target's distance and direction.
    e. Using a Rangefinder to figure out a target's distance and the direction it's located.

9. **Which one of these enemy units is a bigger threat?** (Circle one only)
    a. A moving enemy close to your platoon.
    b. A static enemy close to your platoon.
    c. A moving enemy far from your platoon.
    d. A static enemy far from your platoon.

APPENDIX H: INTEGRATED KNOWLEDGE QUESTIONNAIRE

Participant Code: ______________

INTEGRATIVE KNOWLEDGE QUESTIONNAIRE

1. What might be the undesirable consequences if the wrong type of ammunition were chosen?

____
____
____

2. The selection of the observation post is critical to the ability of a Forward Observer to effectively call for fire and to survive. What must the selected position enable him to do?

____
____
____

3. Why are accurate fires important? What could happen if a fire failed?

____
____
____

4. Why do you think it's important for the Forward Observer Artillery to tell his supporting unit whether to use a high or low arching trajectory?

____
____
____

5. Besides the Forward Observer Artillery, the FiST usually has 3 more members. One of them is the FiST Leader. What do you think his roles are?

____
____
____

6. What options do you think the FiST would have if the Leader were killed during the mission planning stage?

____
____
____

7. What do you think the other two members do? Why are they necessary?

____
____
____

8. Do you think it's important that the Forward Observer Artillery knows what the other FiST members are doing? Why?

____
____
____

9. Why is a FiST team necessary? Why don't the supporting units simply fire in the direction of the enemy?

____
____
____

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