Journal of Human Performance in Extreme Environments

Volume 7 | Issue 2 Article 8

Published online: 10-1-2003

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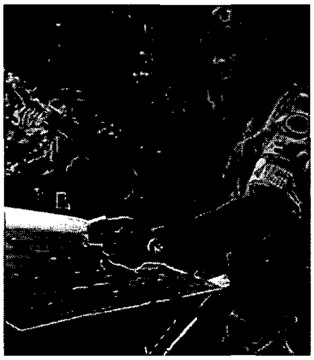
Recommended Citation

Scielzo, Sandro and Greenwood-Ericksen, Adams (2012) "Supporting Decision-Making in the Battlefield: Utility of Multimedia Information Transmission," *Journal of Human Performance in Extreme Environments*: Vol. 7: Iss. 2, Article 8.
DOI: http://dx.doi.org/10.7771/2327-2937.1033



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Supporting Decision-Making in the Battlefield: Utility of Multimedia Information Transmission

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In the theatre of war, environmental and workload factors (e.g., noise, time pressure) may dramatically overburden operator's cognitive processes. Well designed multimedia technology can successfully minimize both *intrinsic* (working memory capacity) and *extrinsic* (inefficient use of information) sources of cognitive load, thereby facilitating the decision-making process. These positive mediating effects of multimedia technology can occur during three distinct phases of human information processing: 1) during sensorial information acquisition, by filtering out unnecessary environmental noise and transferring information via context-dependent modalities; 2) during decision-making, by making critical task-relevant cues more salient; and 3) following response execution, by providing necessary feedback to effectively evaluate the appropriateness of the decision taken. After analyzing the dramatic events that led to many US soldier casualties in a Somali rescue mission, this paper will propose a set of recommendations to help future task forces in urban environments, and to specify the greater goal of multimedia use on the battlefield.

Introduction

On October 3rd 1993, 75 US Rangers, 40 Delta Force operators and a number of Navy SEALS and Air Force Special Operations personnel staged a daylight raid into the Bakara market in downtown Mogadishu, Somalia. Together, these forces made up a combat unit known as Task Force Ranger, under the command of Major General William F. Garrison. The goal of the raid was the capture of several leaders of the Habr Gidr clan, a local Somali political organization which had been engaged in a bloody confrontation with UN and American forces for over a year. The United States had stepped in to assist a failing UN humanitarian mission, but a number of poor strategic decisions on the part of the US and the UN, coupled with a sophisticated propaganda campaign by Habr Gidr leaders contributed to a climate in which US forces were perceived by the general population as enemies. Eventually, US policymakers decided to mount an operation to remove the leader of the clan, Mohammad Farrah Aided, from power and try him for crimes against humanity. It was to this end that US forces began attempting to round up members of Aidid's inner circle and advisors. The raid in question was expected to capture two of these individuals.

The Mission

The original plan was for four security elements from the 75th ranger regiment (also known as "chalks") to deploy from UH-60 "Blackhawk" helicopters and establish a security perimeter around the target building where the clan leaders were meeting. Delta Force operators would then deploy from AH-6 "Littlebird" assault helicopters, clear the building, and secure the hostages. A ground vehicle column waiting nearby would approach the area and load up the prisoners and Delta operators. The ranger security forces would then collapse back to the assembly area in front of the target building, load up into the vehicles, and the whole force would be transported by Humvee and truck back to base. Unfortunately, everything did not go according to plan. Seconds into the raid, an 18 year-old ranger fell from a helicopter and was badly injured. Minutes later, another helicopter was shot down by a rocket propelled grenade (RPG), a

http://dx.doi.org/10.7771/2327-2937.1033

simple but highly effective Soviet-designed weapon. Shortly thereafter, a second chopper was shot down in the same manner. US efforts on the ground were immediately redirected toward securing the crash sites and extracting survivors. Humvee columns which had originally been tasked to transport American soldiers and their prisoners were reassigned to locating and protecting downed aircrews and injured soldiers. The carefully planned operation disintegrated into chaos as units scattered in different directions, hunting crashed helicopters or attempting to find tenable defensive positions as thousands of armed militiamen converged on their locations. Many units spent the entire night pinned down under heavy fire, while constant close air support missions by AH-6 "Littlebird" helicopters kept them from being overrun. With dawn came additional support units with light armor support, and the survivors were evacuated to safety.

Escalating Chaos

A number of specific errors contributed to the chaos on the ground. There were persistent problems with communication between ground units and air scout and command units. Often information was relayed inaccurately, too late, and in a confused manner. To make matters worse, there was a significant time delay between the time when the scout choppers in the air identified the route the vehicle columns were to follow, and the time that the drivers on the ground got the information. The time lag was so bad that the vehicles repeatedly missed turns because they didn't get the information in time. The solution proposed by the command structure, that the Humvees slow down, exposed them to heavier fire and produced more casualties.

The evacuation column became lost and was forced to navigate the streets with little useful guidance from the air, taking heavy fire from buildings, rooftops, and alleys and suffering terrible casualties as a result. Back at the command center, the operation commander, Maj. Gen. William Garrison, could see the action from above courtesy of relayed camera footage from the circling scout choppers and advanced satellite imaging, but he was largely unable to communicate that information to the troops in any useful format. Ultimately, communications were the greatest weak spot in the entire operation, and the greatest source of confusion on the ground (Bowden, 1999).

A Costly Toll

The total human cost for US forces during the operation was 18 American special operators killed and 84 wounded. This disaster represented the single bloodiest day in American military history since the Vietnam conflict. Worse, the individuals lost were members of the most elite of American fighting units, those with the best training and equipment, the most combat experience, and therefore the hardest to replace. It is estimated the average American special operator costs upwards of a million dollars a year to train and equip, and units composed of these individuals serve a strategic role far in excess of that suggested by their numbers. While poor planning, questionable tactical decisions, ineffective weaponry, and bad luck all played a role in this disaster, the predominant causal factor for this mission's failure was the inability of US forces to adequately manage and disseminate information. It is imperative that US forces learn to adequately communicate information where it is needed most, and in the most usable format.

A Case for Multimedia

Could these tragic events have been prevented with the kind of technology our armed forces have at disposition considering that technological advances have changed the way we communicate information, and presumably for the better? This question might never be fully answered; however, it is possible to examine with a critical eye the extent to which information was optimally transmitted. In other words, were the correct context dependent modalities used when conveying information? Was this information provided at the right time and in a way that minimized cognitive load? One of the goals of this paper will be to answer to these questions while providing an optimal information transmission framework based on multimedia principles and information processing.

Multimedia has been proposed as an optimal way of delivering information in that it makes use of multiple modality delivery methods such as video and audio. The military is quick in adopting new technologies; however, the central issues are: first, *when* does a multimodal transmission of information enhance the acquisition of information; and, second, *where* should multimedia be employed to produce an environment that would facilitate the acquisition of information. It is of paramount importance to understand how information from the environment is processed in order to deliver it in such a way that it facilitates decision making.

What is Multimedia?

Multimedia generally refers to "using, involving, or encompassing several media" (Mayer, 2001). Using multimedia can provide several sources of information both within and across modes. An example of collapsing information within one modality is the association of visual animations with its textual description. In this case, the modality used is visual, and even though text and animations are differentially processed within our memory, both sources of information are perceptually channeled through the visual system. An example of distributing information across modalities occurs when an audio source of information is overlaid with the content of an animation. In this case, the audio and the animation are respectively channeled through the visual and auditory modality. While technological advances make it easy to deliver several sources of information simultaneously (e.g., visual and audio), it is important to keep in mind what are the operator's cognitive limitations when processing incoming multimodal information. Thus, when modalities are combined in a proper way, they can contribute to enhance both information acquisition and processing, thereby maximizing good decision-making.

Technology versus Operator Centered Approach

This increased amount of information that can be delivered using technological tools has led to the *technology-centered* approach of multimedia learning as coined by Mayer (2001, p.8). This approach focuses on the technology's power to convey information. However, it is necessary to stress again that the technology's capability to handle vast amount of information that is transmitted to us may not guarantee an appropriate perception and assimilation of the information itself. It is of paramount importance to recognize that the resources allocated by the brain in order to integrate perceived information are limited and therefore competing with each other. This idea of simultaneous tasks (i.e., integrating information across or within modalities) competing with one another for the limited mental resources available, which may cause performance to deteriorate, have been collectively called *resource* theories (e.g., Kahneman, 1973; Wickens, 1987). Similarly, the notion of information competing for our limited cognitive capacity, which is in contrast to the technology centered approach, led to the development of a theoretical framework aiming to determine under which conditions multimedia presentation preserves mental resources from being depleted. The theoretical framework in question could be described as the *operator-centered* approach of multimedia, similar to the learner-centered approach described by Mayer (2001) as "the use of multimedia technology as an aid to human cognition" (p.10). The focus of this approach is to establish how learning can be fostered by technology, thereby elevating the role of technology as a cognitive aid capable of adapting to learner's cognitive processing.

Cognitive Capacity

Early studies in experimental psychology revealed how limited cognitive resources could be when dealing with the acquisition of new information (Miller, 1956). More specific on the handling of new information, the development of Baddeley and Hitch's (1974) working memory model more systematically demonstrated the differing capacities of dynamic human information processing. Essentially, Baddeley and Hitch (1974) proposed that auditory and visual information is differentially processed via two separate and distinct channels in working memory. Auditory stimuli, that is, acoustic and verbal information (e.g., audio information), is processed through the *phonological loop*, which is comprised of both a phonological store and an articulatory rehearsal component. The *phonological store* is a system for temporarily maintaining speech-based input and the *articulatory rehearsal* component represents a system for refreshing this information as it decays. This latter component of the phonological loop is also used to translate printed input into a phonological form. Similarly, visual stimuli, that is, information pertaining to the visual and spatial features of a given stimulus event (e.g., animations, diagrams), is processed through the *visuospatial sketchpad*. A third, higher order component, the *central executive*, coordinates and allocates limited attentional resources to these two other subsystems of working memory. The take home message from this theory is that the two working memory subsystems, or *slave* systems, can be easily overburdened. In other words, it is easier for working memory to handle incoming information that is visual and audio (e.g., driving a car and talking to a radio) than incoming information that is both visual (e.g., two simultaneous visual tasks could be ready a map while driving a car).

Cognitive Load

How much is too much information? The cognitive load theory, conceptualized by Sweller (1994), examined how the characteristics of incoming information may make material more difficult to acquire. Sweller (1994) described how concept integration consists of schema acquisition and transfer of learned procedures from controlled to automatic processing, both of which decrease the burden on working memory. Furthermore, Sweller and his colleagues (e.g., Kalyuga, Chandler, & Sweller, 1999; Marcus, Cooper, & Sweller, 1996; Sweller, 1999; Sweller & Chandler, 1994) differentiated between two sources of cognitive load: intrinsic cognitive load arising from the training's content or extrinsic cognitive load due to training system design factors. It is important to understand how those two forms of cognitive load operate in order to optimize the processing of multimodal information.

Intrinsic cognitive load depends on the interactivity of the information to be acquired and how complex that interaction is. In other words, when there are many information rich elements that need to be related together the intrinsic cognitive load is high, as well as the strain on the limited cognitive capacity. The other main source of cognitive load, extrinsic cognitive load, is artificially produced because of inadequate presentational modes, which mainly impose *split-attention* and *redundancy* of information. Split-attention refers to how multiple sources of information presented simultaneously have a negative load on working memory. For example, conveying information visually with both images and text will cause learners to devote one part of their attention to the animation and another part to the text. Overall, extrinsic cognitive load will be caused by an inadequate use of modalities when presenting information.

In sum, the cognitive load theory suggests that not only it is necessary to present information via the right modalities in order to reduce extrinsic load, but the information itself has an intrinsic component that can saturate working memory. In case of combat, it becomes crucial to optimize information transmission in order to minimize potential decision-making errors.

Information Processing

When conveying information, one way to maximize the efficiency with which information is transmitted is to capitalize on multimedia. However, it is necessary to understand *when* to use multimodal information in the greater context of information processing. Wicken's model of human information processing (1992) provides a general framework that isolates the different stages of information, from the perception of stimuli to the physical responses (see Figure 1). Understanding how information is processed is fundamental in order to better understand how soldiers on the battlefield handle the processing and execution of commands.

Wicken's model is important not only to understand information processing but also to be aware of the stages in which attention resources are being depleted. A review of the main stages is necessary before attempting to integrate a multimodal component aimed at maximizing attention resources and information processing.

Stages of Information Processing

Stimuli from the environment are initially processed by our sensory receptors. The quality of the processed stimuli will depend on the stimulus source itself. At this stage it only matters that according to the environment context, any type of information in the form of a sensory stimulus (e.g., visual, audio) can be registered in order to be effectively processed. Specifically, each sensory modality is capable of holding incoming stimuli at a pre-attentive level, however the information decays rapidly ranging from a few seconds to up to half a minute in case of the auditory registry.

Perceptual encoding is the next stage of information processing and requires the depletion of some mental resources in order to be attended to. In this stage long-term memory will attribute meaning to the oncoming stimuli. This stage is also crucial since most non salient stimuli from the environment will be filtered away. At this point it also important to note that other internal factors like stress can reduce attention resources, thereby impeding some information to be processed optimally or altogether.

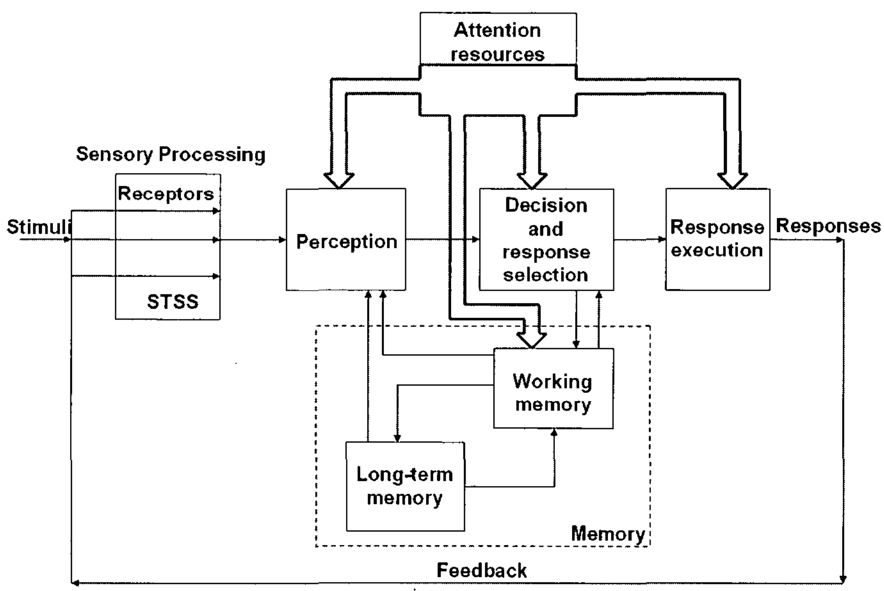

Figure 1. *Adaptation of Wicken's model of human information processing*

The stage of decision-making comes after stimuli are attended to. Again, attention resources are drawn from our mental capacity in order to process the perceived information in order to decide and select what response to enact. Decision-making is a complex process that can heavily draw on the limited cognitive resources we have at our disposal when processing information. Since decision-making is directly influenced by the perceived information and the ability to make sense of it, it because critical to ensure that the information received is high in quality, or at least minimize its degradation.

Following decision-making a response execution occurs. In other words, after the operator has selected what plan to enact based on the information received, that plan will have to be executed physically. In turn, the execution of a decision taken will become a source of feedback that will be relayed to the sensory store under the form of environmental stimulus. It is important to stress the utility of feedback and the importance of perceiving it in a timely manner to help determine the appropriateness of a decision taken.

Enhancing Information Processing

Altogether, these stages of information processing are critical to identify what areas can be enhanced when using multimedia.

In particular, multimedia can provide the short term sensory store with quality stimuli according the environmental context. For example, a specific type of information that is typically conveyed via audio (e.g., two-way radio communication) might not be appropriate in case of an environment saturated with noise, which is not unlikely during combat operations. In this case, the right modality of use should be visual or even tactile in order to transmit the same information. Furthermore, by using some common technology, unwanted stimuli could be automatically filtered out. On the combat field, this could be the case of headphones that filter out unnecessary background noises.

Another stage of information processing that can be enhanced by the use of multimedia is decision-making. Specifically, it is during the intermediate decisions that eventually lead to a response that multimedia can be most effective in helping select the appropriate information that will serve as a basis onto which a response is made. For example, in order to facilitate the rehearsal of information that can lead to responses, some information can be displayed in time until an execution is made, thereby decreasing the cognitive load imposed by the rehearsal process. Concretely, this could mean that a specific order to any infantry soldiers would keep feeding into their sensory store until they perform the very order. On another level, special displays could enhance the visual information received by highlighting certain important features in the environment.

Following response execution probably comes the most important phase within a combat situation in which the use of the right modalities can drastically improve information processing. This is the feedback stage. The critical component of this stage is that feedback should be provided in a timely manner in order to give time to the operator to correct a specific response that has not been properly executed.

Putting the Pieces Together

Multimedia shows great promise in addressing a number of the issues inherent in infantry combat in urban environments. One of the most salient features of light infantry operations is the importance of timely and effective communication. Good communication is a force multiplier which can greatly influence the outcome of a conflict, particularly when one force greatly outnumbers the other. This idea is hardly new; over two thousand year ago, Sun Tzu identified "clear signals and signs" as one of the most vital requirements for victory in battle (Sun Tzu, trans. 2001). The point has been made repeatedly since (Barnett, 2003, Clausewitz, trans. 1950). When communications fail or are compromised, unit coordination and cohesion suffer drastically (Clausewitz, trans. 1950, Hart, 1954). The use of multimedia provides a number of significant advantages to a force in the field.

Modes of Communication

Much of the information that needs to be transmitted in combat is simple: "we're under attack," "we're taking casualties," "we're pinned down." These pieces of information can be readily communicated in a number of ways and are unlikely to provoke confusion. Much of the information, which needs to be communicated in combat is highly sensitive to the context and environment in which it originates. Additionally, it is quite difficult to communicate the majority of complex tactical information through traditional means. Often a clear understanding of the transmitter's environment is necessary in order for the receiver of information to effectively assimilate it. The phrase, "I'm taking fire from the second floor of that large building," only has meaning if the individual receiving the information knows which building the speaker is referring to. Often, in the fluid environment of battle, this additional information is not readily available.

Moreover, the most common form of communication, speech, is poorly suited to the task of communicating spatial information, regardless of whether the speech occurs in person or over some form of remote communications system. Text format is not much better in terms of the user's ability to provide context for information, and has the additional drawback of preventing access to many of the cues humans use in face to face communication, such as tone of voice, body language, and facial expression. Video format has a significant number of advantages in transmitting visual or spatial information, but is costly, both in terms of attention (as discussed above) and technological complexity.

The clearest communication occurs when individuals are able to speak face to face because all modalities and cues for communication are available. Thus, the more modalities involved in communication, the more cues are available; the more cues available, the clearer communication is. Therefore, simultaneous video and audio communication provides the best quality of communication.

The Cost of Multimedia: Balancing Demands

However, the level of attention and processing required by multiple modality communication means that the cognitive load on the communicators will be significantly increased, as will the demand for attentional resources. Accordingly, while communication would be clearer, performance on other tasks which need to be performed simultaneously might suffer. The last thing that a platoon leader needs is to try to carry on a videophone conversation with a superior officer while engaged in a life-or-death firefight. Additionally, the level of technology currently available allows for this type of interaction only at great financial expense and technical difficulty. Worse, this relatively new technology has significant reliability issues, further reducing its current usefulness.

The need for improved communication must therefore be weighed against the communicators' need to perform other activities such as driving, navigating, and giving orders and conducting tactical operations. An appropriate application of multimedia must consider both the information which needs to be communicated and the demands of the communicators' environment.

While an empirical examination of these concepts is necessary, before attempting to apply them to units in the field, a few recommendations of appropriate applications of multimedia to communications in the infantry combat domain can be made based on existing literature. Some material, such as tactical level commands, should retain the current "voice only" format. This allows for an acceptable level of clarity in communications while minimizing demand on spatial mental resources and interference with perceptual abilities needed for other tasks.

When information with high spatial or visual content must be transmitted, the use of video or still images supplemented by text or speech is recommended. For instance, when identifying a route on a map, a visual representation of a map, supplemented with still images of various landmarks would provide a great deal of information in the clearest possible way, particularly if supplemented by text or speech. One example of particular interest is the common requirement of identifying targets for artillery or air strike. Commonly termed a "call for fire," this type of activity is of great tactical importance but presents great danger to friendly personnel if it is not performed in an accurate and timely manner. Visual imagery of the target site and the area around it, as well as the exact location of the request for fire, both marked on a digital map and supplemented by map grid coordinates and a time stamp, both in text form, could clearly and unambiguously communicate the information necessary for a successful call for fire while reducing the chances of a potentially disastrous error.

While some specific recommendations can be made regarding the use of multimedia technologies, it is important to understand that each specific application of multimedia to combat communications must be carefully examined and standard operating procedures developed prior to operationalizing this technology. While multimedia offers remarkable benefits to an armed force in the field, it can also cripple communications and degrade performance on other vital tasks. Careful thought must be given to specific uses of these forms of communication and the context in which they operate before decisions are made to incorporate them into field units.

Could Multimedia Have Helped Task Force Ranger?

The events of October 3rd and 4th, 1993 were tragic in their implications for the American soldiers who were killed and maimed, their families, the military establishment and America as a whole. A great number of factors contributed to the outcome of these events; no one factor or set of factors bore sole responsibility. Moreover, it is not the intent of this work to analyze in depth the failings in tactical planning or political policy that led to the final outcome. The purpose of this section is to suggest ways in which the appropriate use of multimedia might have helped to protect and assist the American servicemen on the ground during these events.

Navigation

One of the most significant factors which led to the high casualty rate incurred by American forces was their inability to effectively navigate the battle-scarred, chaotic city of Mogadishu. The Humvee column which was intended to extract the prisoners and friendly forces and was later reassigned to locating and securing the two crash sites was constantly missing turns throughout the engagement because scout choppers could not provide them with accurate and timely information on their route. For most of the battle, scout choppers were attempting to scout routes for the convoy on the fly, giving them verbal directions on when and where to turn. Unfortunately, spoken communications were poorly suited to describing a spatial route which had to be navigated visually, and the Humvees were often unable to recognize important intersections where turns had to be made.

Feedback

The problem was exacerbated by a clumsy relay system which forced the scout choppers to route their information first through one officer in charge of air operations, then through the overall commander, then to the officer in charge of ground operations, then to the soldiers on the ground, racing along in their vehicles. Often information about turns reached them long after they had already passed the intersection. Additionally, the information was sometimes garbled in translation, making a bad situation even worse. As a result, the Humvee columns drove erratically around the combat area, circling repeatedly trying to locate the correct route to reach the troops they were supposed to evacuate. Eventually, the original column was so badly shot up that they were forced to retreat the base to regroup and rearm before they reentered the city to try once again to reach their comrades. Had an effective form of multimedia communication been available to the scout choppers and Humvees, they might have been able to effectively communicate through visual imagery and annotated maps the best route to follow. The greater complexity of information available through a map and image format of information transmission could have allowed the vehicles on the ground to see multiple turns at once, far in advance of actually arriving at them. Such a system might have allowed them to successfully reach the scattered units attempting to rendezvous at the crash sites before the situation deteriorated completely.

Coordination and Communication

An additional area in which multimedia could have assisted the men of TF Ranger is through improved coordination between soldiers. Since most units were scattered and lost, they were unsure of the locations of fellow Americans, which resulted in a number of dangerous friendly fire incidents and a general lack of coordination among units. This significantly weakened the American forces, who needed the advantage of superior coordination and massed firepower to overcome the vast disparity in numbers between them and the disorganized bands of Somali militiamen they faced. By representing the known locations of friendly units spatially, they might have been more able to maintain contact with other units and coordinate their movements so as to concentrate against important targets, such as enemy forces approaching the crash sites.

Ultimately, a great number of factors contribute to the success or failure of military operations. The complexity of the environment, the state and strength of enemy and friendly forces, and the tactics and plans utilized by each side are merely a few of the myriad factors involved in determining the outcome of combat. Superior communications are merely one element which affects the course of battle, but they are indeed an important element. Multimedia shows impressive promise as one means of dramatically improving communications between units in combat, and offers significant tactical and strategic advantages to the armed forces of the nation which employs it.

Conclusion

The Somali example illustrates how breakdown in communications lead to a tragic escalating effect that turned what should have been a typical rescue mission into chaos. Could a context dependent use of multimedia have saved the day? This question might never be fully answered; however, this paper isolated a number of circumstances in which using the right modalities to convey information would have at least helped events unfold in a more positive manner.

Applying multimedia to the battlefield is a difficult task that has to account for several factors. First, it is necessary to realize that technology should only be a vehicle to support multimodal information transmission. In fact, it is dependent upon our limited cognitive capacity to process information perceived by our senses. As a result, multimedia technology should be *learner-based* (Mayer, 2001) in order to maximize information processing. Second, multimedia should be presented in such a way as to minimize both *intrinsic* and *extrinsic* forms of cognitive load, especially in a battlefield context which exacerbates mental capacities. Finally, multimedia should be used to maximize the main stages in information processing. Only then can the use of multimedia technology be warranted.

This paper pointed out specific areas that could have helped the task force to achieve its goals. Specifically, problems concerning the navigation of the Humvee column through the Mogadishu maze could have been largely prevented by presenting orders in a timely manner and utilizing multimedia technology. As a result better coordination and communication patterns would have emerged.

Multimedia technology still has a long way to go before it can be efficiently integrated in urban combat in order to maximize information transmission. However, there are no doubts that eventually, a sound use of multimedia technology will indeed provide task forces with a new weapon capable of being a decisive factor between life and death.

References

Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. A. Bower (Ed.), *Recent advances in learning and motivation* (Vol. 8, pp. 47-90). New York: Academic Press.

Bowden, M. (1999). *Black Hawk Down: A Story of Modern War.* New York: Penguin Books.

Hart. B.H.L. (1954). *Strategy.* New York:Fredrick A. Praeger

von Clausewitz, K. (trans. 1950). *On War.* Translation by O. J. Matthijs Jolles. Washington, D.C.: Infantry Journal Press.

Kalyuga, S., Chandler, P, & Sweller, P. (1999). Managing split-attention and redundancy in multimedia instruction. *Applied Cognitive Psychology, 13*, 351-371.

Mayer, R. E. (2001). *Multimedia learning.* Cambridge, England: Cambridge University Press.

Marcus, N. Cooper, M. & Sweller, J. (1996). Understanding instructions. *Journal of Educational Psychology, 88*, 49-63.

Sweller, J. (1994). Cognitive load theory, learning difficulty and instructional design. *Learning and Instruction, 4*, 295-312.

Sweller, J. (1999). *Instructional design in technical areas.* Camberwell, Australia: ACER Press.

Sweller, J. & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12*, 185-233.

Sun Tzu. (trans. 2001.). The Art of War. In T. Cleary (Translator), *Classics of Strategy and Council.* Boston: Shambhala Publications, Inc.

Wickens, C. D., & Carswell, C. M. (1997). Information processing. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (2nd ed.) (pp. 89-129). New York: Wiley.