Assessment of a Novel Chat Messaging Interface for Rapid Communication in Tactical Command and Control

Benjamin A. Knott[1], W. Todd Nelson[2], Rebecca D. Brown[1], Allen W. Dukes[2], & Robert S. Bolia[2]

[1]General Dynamics, Advanced Information Systems, Dayton, Ohio
[2]Air Force Research Laboratory, Wright-Patterson AFB, Ohio

Two experiments explored speed of communication when transmitting and receiving chat messages in different formats for a military command and control (C2) task. In Experiment 1, participants were prompted with a tactical display and responded by composing chat messages with an appropriate command. Speed, accuracy, and subjective workload were compared for three chat messaging formats: 1) full-text; 2) abbreviated text; or 3) click-chat. Writing full-text messages took longer, resulted in more typing errors and higher workload ratings than abbreviated text or click-chat. Although there was no difference in response times between abbreviated and click-chat messaging, the abbreviated chat yielded higher error rates. A translation delay was evidenced by slower initial response times for abbreviations and click-chat compared to full-text. However, faster message completion, once initiated, compensated for this delay resulting in faster communication overall. Experiment 2 demonstrated that there was no difference in the speed, accuracy, or workload for completing commanded actions when receiving abbreviated compared to full-text chat messages

INTRODUCTION

Rapid and clear communication is essential to timely information sharing and maintaining tempo in tactical military operations. A recent study on the use of text "chat" communication in a high-tempo air battle management (ABM) scenario showed that when chat was used as the primary communication mode it led to reduced mission performance when compared to voice communications over radio (Knott, Bolia, Nelson & Galster, 2006). Several hypotheses were offered by the authors to explain the observed decrement.

First, entering text into a chat application required operators to let go of the mouse, their primary control device, and look away from their tactical situation display. This may have both increased the manual control demand, and consumed visual processing resources that may have been more profitably directed toward the operator's situation display. Cummings (2004) provided some support for this view. She found that the primary task of monitoring and retargeting cruise missiles from a control station was disrupted by a secondary chat task. The chat task constituted an interruption that shifted operators' attention away from the primary mission application, thereby affecting their ability to maintain awareness of the changing situation.

Second, speed of communication differed between the two experimental conditions of interest (voice versus chat communication). Indeed, previous studies have shown that text-based communication leads to longer task completion times compared to face-to-face communication (Hiltz, Johnson, & Turoff, 1986; Weisband, 1992), and that this difference is partially attributable to the fact that it takes longer to type than to speak words and phrases (Bordia, 1997; Siegel, Dubrovsky, Kiesler, & McGuire, 1986). In the fast-paced tactical ABM scenario, it is reasonable to expect that typing chat messages slowed communication, thereby limiting the teams' ability to exchange information and make decisions quickly and effectively.

One way to address the speed of communication issue for chat messaging is to use abbreviations. In an effort to reduce the time needed to type critical messages, participants in the Knott et al. (2006) study were trained to use a set of abbreviations to refer to common objects and actions within the scenario. This approach was inspired by the natural tendency within the general population to use abbreviations for frequently used phrases (e.g., 'lol') as a way to reduce typing effort and increase speed. It is unclear however, whether or not the use of abbreviated text effectively increased speed of communication, leading to a third hypothesis.

It is possible that the use of abbreviations in chat messages led to translation delays as transmitters converted familiar utterances into abbreviated messages, and receivers translated abbreviated code into linguistically meaningful commands and then into actions. Most adults are *expert* readers in that they automatically recognize and decode the phonetic units associated with words and sentences. This automaticity relieves conscious processing capacity that can be devoted to reasoning and decision making (Chi, Glaser, & Farr, 1988). Using abbreviations may have disrupted the automaticity usually associated with reading, resulting in greater communication demands and fewer cognitive resources available for reasoning about the ABM task.

The purpose of the experiments described herein was to evaluate the suitability of two methods of speeded text communication for command and control (C2). The first method was the use of a system of abbreviations to reduce the number of characters operators must type to communicate C2 messages in chat. The second method was a semi-automated chat tool that aided operators in composing common C2 messages. This tool was referred to as 'click-chat.' The experiments were designed to evaluate speed of communication in text messaging and the possibility of translation delays when transmitting and receiving text messages in abbreviated format.

The click-chat tool was designed specifically to address the temporal demands of ABM as well as the issues discussed above with respect to text messaging. Rather than typing text messages, operators constructed text strings by selecting objects or words from a customized chat console designed for a specific mission. Radio button clicks were translated into words and phrases that automatically populated a chat text field in a standard format – hence, click-chat. The pre-formatted messages could then be modified if necessary before sending.

There are several proposed advantages of this tool over the use of traditional full-text messages or abbreviated messages for speeded communication: 1) the click-chat tool nearly eliminates the need for operators to release control of the mouse to type on a keyboard; 2) the automated tool produces command messages in a formalized and consistent structure; 3) it reduces text message composition to a few mouse clicks; and 4) it produces full-text messages with no need for abbreviations to be decoded by the receiver. The ABM environment allows for the use of such automation because of the highly constrained grammar and lexicon of military brevity communication.

In Experiment 1, participants were prompted with a tactical situation display depicting a simulated ABM task. Participants responded by composing a chat message with the appropriate command instructions. Speed, accuracy, and perceived mental workload were compared for three chat formats from the sender's perspective. The baseline condition required participants to type full-text messages. These were messages that conformed to a strict command brevity code, but words were typed out in their entirety. The abbreviated message condition called for a specialized system of abbreviations that were used to represent common entities and actions. In the click-chat condition, operators constructed text strings by making selections from a response consol.

In Experiment 2, differences in the speed, accuracy, and workload for completing a commanded action were compared for participants receiving text messages in either the full-text or abbreviated format. These formats correspond to the chat conditions in Experiment 1 in that both the baseline and click-chat conditions result in full-text messages.

For sending chat messages, the baseline condition (full-text) was expected to be slower and more effortful than either the abbreviated or click-chat conditions. As a result, the full text condition was predicted to yield more errors as well due to the reduced typing demands in the latter two conditions. Click-chat was expected to be faster and less effortful than the abbreviated text condition because operators were not required to take their hands off the mouse to type messages. Moreover, click-chat was predicted to lead to fewer typing errors than the abbreviated text condition, since the text was created by an automated process.

For receiving chat messages, operators were expected to take longer, and report higher workload, when responding to messages in abbreviated as compared to full-text format due to the additional time required to translate the abbreviations into meaningful messages and actions.

EXPERIMENT 1: SENDING MESSAGES

Method

Seven males and five females (*M* = 23.6 years) participated in the study. All participants reported regular use of chat applications. All individuals had previously participated in the team experiment reported in Knott et al. (2006), and therefore had received prior training on communication brevity and the use of abbreviations in ABM messages. Participants completed a typing test to assess their typing speed and accuracy (*M* = 45 wpm, *SE* = 2.6).

After the typing test, participants completed computer based training on the experimental task followed by two training sets of 32 trials. Training trials were identical to the experimental trials, but with system-generated scoring and feedback on each response. All participants reached the training criterion of 90% accuracy after two training sets.

During the experiment, participants initiated each trial by clicking a button in the center of a computer screen to control for starting mouse position. A simplified tactical display was then presented that depicted a set of ten friendly assets and six enemy targets randomly assigned (without replacement) to different grid locations. In addition, symbols on the display cued participants to the type of command message required. For example, Figure 1 represents a trial in which participants had to direct the friendly asset with callsign 'Alpha-Three' to intercept the target labeled 'Mig-130' at grid location 'H-8.' Participants entered the appropriate text message into the field provided, and selected the "Send" button to complete the trial. Text messages were entered with words typed out in their entirety (full-text), with words abbreviated, or by using the click-chat interface.

In the click-chat condition, participants responded by using the menu-driven response interface shown in Figure 2. In this example, the participant selected the correct asset name, target name, and intended action from the menus provided. The intercept location was entered by selecting the correct square on the response grid shown. As menu selections were made, the appropriate text would automatically populate the chat text field. The message could then be reviewed before selecting the "Send" button to complete the trial.

There were four types of command message trials: 1) Request Intercept; 2) Coordinate Refueling; 3) Retrieve Fuel Status; and 4) Send Fuel Level. Commands were sent in three messaging formats: 1) full-text messaging; 2) abbreviated-text messaging; and 3) click-chat messaging. Messaging format trials were blocked and counterbalanced across participants. Within each block participants received 32 trials at random with eight trials of each command type. This yielded a 4 (command type) × 3 (message format) within-subjects experimental design. After each block of trials, participants completed the NASA Task Load Index workload questionnaire (NASA-TLX: Hart & Staveland, 1987). At the end of the experiment, participants rank-ordered their preferred format for sending messages.

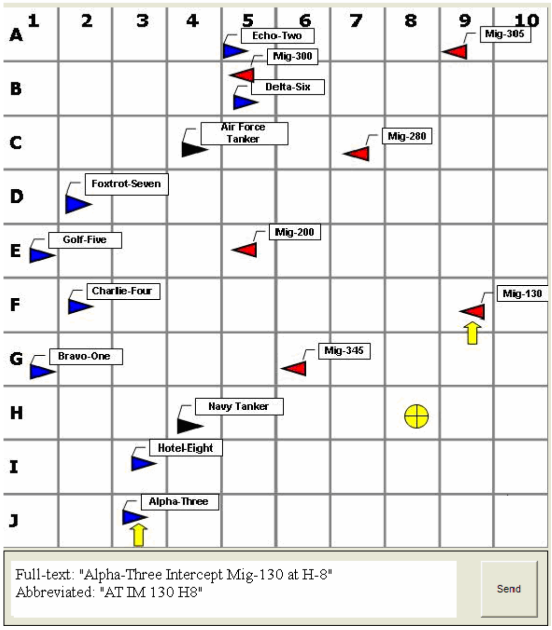

Figure 1. A sample of a trial stimulus and responses for full-text and abbreviated text conditions.

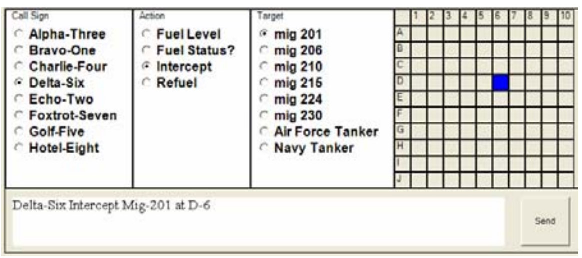

Figure 2. A sample of the response console for the click-chat condition. This console appeared immediately below the stimulus display on each trial.

Results

Response Error. The text responses from each trial received a percentage score by comparing it to the expected correct response for each trial. Each response was then coded as a correct response or as an error. Responses were coded as an error if they contained any typing mistake. The frequency of correct and error responses was submitted to a Chi-squared analysis. The relationship between messaging type and error responses was significant with full-text resulting in the highest percentage of errors (M = 10.4%), followed by abbreviated messages (M = 4.7%), and then click-chat (M = 1.6%), $\chi^2(2)$ = 29.5, $p < .05$.

Response Time (RT in seconds). Two measures of RT were recorded. The *initial RT* was the interval between stimulus onset and the participant's initial key press. The *total RT* was the interval between stimulus onset and the end of the trial. Response latencies were computed for correct trials only. All RTs were submitted to a 3 (messaging format) × 4 (command type) within-subjects REML analysis.

There was a main effect of messaging format on *initial RT* indicating that participants took longest to begin composing a message with click-chat (M = 2.74 s, SE = .05), followed by abbreviated (M = 1.76 s, SE = .03), and then full-text messaging (M = 1.25 s, SE = .03), $F(2, 32.6) = 67.1$, $p < .05$. Bonferroni-corrected pairwise post-hoc comparisons indicated that all differences were reliable (p<.05/3). There was also a main effect of messaging format on *total RT*, $F(2, 28.8) = 36.4$, p<.05, indicating that the time to compose and send command messages was slowest using full-text messaging (M = 11.7 s, SE = .20), but there was no difference between the click-chat (M = 7.4 s, SE = .16) and abbreviated messaging formats (M = 6.3 s, SE = .16). The main effect and interaction of command type with messaging format were also significant, $F(3, 28.5) = 164.5$, $p<.05$, and $F(6, 63.8) = 12.2$, p<05. Simple effects analyses on the interaction showed that each level of command type resulted in significantly different RTs for full-text, but not for abbreviated and click-chat conditions. This suggests that the command types imposed different demands that were apparent only in the full-text condition.

Workload. The main effect of messaging format, $F(2, 150) = 4.3$, $p < .05$, and post-hoc comparisons, confirmed that full-text messaging imposed the highest workload demands (M = 47.0, SE = 3.3) when compared to abbreviated or click-chat messaging. There was no difference in mean workload ratings, however, between the click-chat (M = 38.4, SE = 3.5) and abbreviated messaging formats (M = 34.5, SE = 3.1). The significant main effect involving NASA-TLX subscale ratings provided a workload profile of the task, $F(4, 150) = 11.6$, $p < .05$. Figure 3 shows the dominance of Effort, Temporal Demand, and Mental Demand, with relatively low ratings for Physical Demand, Frustration, and Performance. The two-way interaction was not significant.

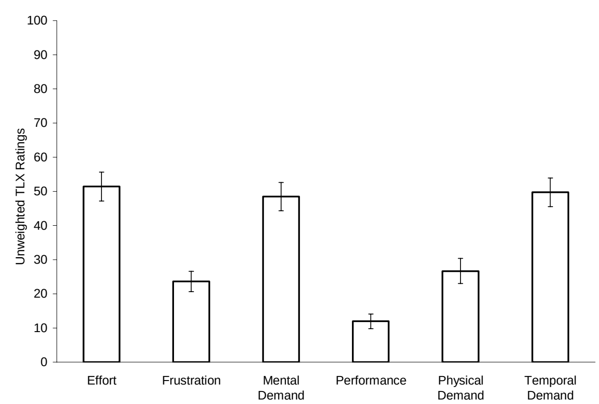

Figure 3. Unweighted mean NASA-TLX ratings by subscale.

Preference. Participants were asked to rank order the messaging formats from most to the least preferred for sending chat. Table 1 shows the preference rankings for chat messaging format.

Table 1. The frequency of rankings by messaging format.

		Messaging Format		
		Full-text	**Abbreviated**	**Click-chat**
Preference (Rank)	**1st**	0	9	3
	2nd	4	3	5
	3rd	8	0	4

Conclusions

Overall, full-text messages took longer to compose and resulted in more typing errors in comparison to the other chat formats. There was no difference in total RT between the abbreviated and click-chat formats, but abbreviations did yield a higher error rate. The delayed *initial* RT for both abbreviations and click-chat, compared to full-text, suggests that there may be a small translation delay for these conditions as participants convert command intent into abbreviations or manual selections. However, once initiated the increased speed to compose a message compensated for this initial delay resulting in faster speed of communication overall.

EXPERIMENT 2: RECEIVING MESSAGES

Method

Experiment 2 employed the same twelve individuals who participated in Experiment 1. They were required to complete a computer based training module followed by two training segments of 32 trials each. All participants were required to receive at least 90% accuracy during training to continue in the experiment.

Experiment 2 examined differences in the time and accuracy to complete a commanded action in response to a message that was *received* by participants in either the full-text or abbreviated messaging formats. Participants received a command within a chat window and responded by carrying out the appropriate sequence of actions in the form of menu selections on a situation display. The situation display in this experiment was similar in appearance to the one used in Experiment 1 with the exception that all entities on the display occupied the same location for all trials. To control for mouse location, each trial began with the selection of a button in the center of the screen. Participants were then presented with a text message, to which they responded by carrying out the appropriate sequence of actions. All participant responses were recorded, time-stamped, and automatically scored as correct or incorrect by the experimental software. Participants completed two blocks of 32 trials that contained eight of each of the four command types. Messaging format was blocked and counterbalanced, and trials were presented in random order. The command types were identical to those used in Experiment 1. After each block of trials participants completed the NASA-TLX. At the end of the experiment, participants rank-ordered their preferred text format for receiving messages.

Results

There were no significant differences between full-text or abbreviated text for number of error responses, initial RT, total RT, or NASA-TLX ratings ($p > .05$). Neither messaging format nor command type had any effect on participant performance. On average, participants took 2.4 sec to initiate a response to a command message and 6.4 sec to complete the response. Similarly, messaging format had no effect on TLX ratings suggesting that participants did not perceive a difference in the difficulty of responding to full-text or abbreviated messages.

Participants ranked chat format from the most to the least preferred for receiving chat messages. Table 2 shows the frequency of rankings by messaging format.

Table 2. The frequency of rankings by messaging format.

		Messaging Format	
		Full-text	**Abbreviated**
Preference (Rank)	**1st**	8	4
	2nd	4	8

Conclusions

The hypothesis that abbreviated chat messages would affect operator performance, due to the cognitive costs of translating received messages into meaningful action, was not supported by the results for error, response time, or workload ratings.

DISCUSSION

Knott et al. (2006) demonstrated that in high-tempo operations, text messaging has a deleterious effect on team performance and workload. Nonetheless, there are many purported advantages to using chat as a means of communication in tactical C2. For instance, since chat communication is not transient like radio communications, it can relieve some of the demands on short term memory during high workload operations. Chat applications also allow operators to engage in and manage multiple threads of communication by employing chat rooms. Moreover, chat eliminates some of the intelligibility problems associated with radio communications, caused by noise, interference, static, or speaker accents. When combined with sophisticated language translation tools, chat can also support the multilingual conversations that are becoming more prevalent in coalition military missions. Finally, chat applications provide a useful history and archive of communication and decision making events. Given the potential benefits of chat communication, it is prudent to explore a variety of methods and novel interfaces for rapid and effective text-based communication.

The present study evaluated two methods of rapid chat messaging and compared them to a baseline standard messaging. The first method was a prescribed system of abbreviations to reduce the typing demands on operators. The second method was a semi-automated 'click-chat' interface for composing messages with mouse selections on a control consol. The aim was to evaluate performance costs and benefits of either sending messages using these approaches or receiving the resultant messages. We speculated that although sending abbreviated messages may relieve the typing demands on an operator, there may be a cognitive cost associated with translating a command message into the appropriate set of abbreviations. Similarly, an operator receiving abbreviations may also incur some cost due to translation of abbreviated text into the appropriate actions. The click-chat tool was offered as a possible alternative to using abbreviations in that text messages can be constructed with relatively few manual inputs, but with full-text output for the receiver.

The results of Experiment 1 showed that although there was indeed an initial delay in chat composition, both abbreviations and click-chat improved the total speed of communication and reduced error when compared to traditional full-text. For the receiver, there was no measurable difference in time to complete a commanded action when receiving either abbreviations or full-text, and thus no functional evidence of a translation delay for the receiver within this context. It is noteworthy, however, that in Experiment 2 participants preferred full-text messages over abbreviations. In a debriefing questionnaire, participants reported that they preferred full-text because it was easier to read, a claim that was not supported by either the performance data or workload ratings in the present experiment.

Together, these findings clearly suggest a speed and accuracy advantage for abbreviated and click-chat communication over full-text, and perhaps an advantage for click-chat over abbreviations as well. Click-chat resulted in the fewest messages with errors, and matched abbreviations on speed of communication (Experiment 1). Moreover, one of the advantages of the click-chat condition is that while input is simplified to a few mouse clicks, output is in preferred full-text format (Experiment 2).

Note that the current click-chat tool required users to select entities and action commands from a menu located adjacent to the primary situation display. In future implementations, the click-chat method could be more fully integrated into an operator's primary situation display, thereby maximizing the time that they attend to the changing situation. For example, operators could construct messages by selecting objects and context-sensitive menus directly within the situation display so there is no need to leave the primary workspace for communication during high-tempo operations. This is part of a more general approach to embed communication tools into the mission context in an advantageous way. In this approach, the mission application (the tactical situation display) is merged with the tools for communication (chat messaging), thus providing a bridge between mission context and communication technology. The approach is also consistent with Bolstad & Endsley's (2005) assertion that some contexts warrant domain-specific tools tailored to the needs of individuals in a well defined task domain.

There are caveats for the click-chat format, however. First, it is only effective for highly constrained, limited vocabulary communication. Therefore, the click-chat format may be suitable only for certain types of C2 missions. Second, errors may be more severe and persistent in click-chat than the other conditions. Erroneous clicks will generate official looking messages with no obvious mistakes as compared to a typed message with misspelling or other apparent errors. Errors generated by click-chat may be more likely to go undetected and propagate. Such a situation could have unintended and possibly castastrophic consequences.

The purpose of this study was to evaluate speed of communication for chat messaging. Future studies will evaluate issues of visual attentional focus in more integrated chat interfaces and compare speeded chat messaging directly with voice communication over radio. Additionally, there is a need to explore in greater detail the impact of automated chat interfaces on the detection and propagation of communication errors.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the contributions to this research of the following individuals: Lt Megan McCroskey and Capt Dustin Weeks for their role in the development of experimental stimuli and training materials; Gregory Funke and April Bennett for software testing and useful discussions on experimental design; and Dr. Camilla Knott for her insightful review of an earlier draft of this paper.

REFERENCES

Bordia, P. (1997). Face-to-face versus computer-mediated communication: A synthesis of the experimental literature. *The Journal of Business Communication*, *34*, 99-118.

Bolstad, C.A. & Endsley, M.R. (2005). Choosing team collaboration tools: Lessons from disaster recovery efforts. *Ergonomics in Design,* 13, 7-14.

Chi, M. T. H., Glaser, R., & Farr, M. (Eds) (1988). *The nature of expertise*. Hilsdale, NJ: Erlbaum.

Cummings, M. L. (2004). The need for command and control instant message adaptive interfaces: Lessons learned from tactical tomahawk human-in-the-loop simulations. *CyberPsychology & Behavior*, *7*, 653-661.

Hart, S.G., and Staveland, L.E. (1988). Development of NASA-TLX (Task Load Index): results of empirical and theoretical research. In P.A. Hancock and N. Meshkati (Eds.), *Human Mental Workload* (pp. 139-183). Amsterdam: Elsevier Science/North Holland.

Hiltz, S. R., Turoff, M., & Johnson, K. (1989). Experiments in group decision making, 3: Disinhibition, deindividuation, and group process in pen name and real name computer conferences. *Decision Support Systems*, *5*, 217-232.

Knott, B. A., Bolia, R. S., Nelson, W. T., & Galster, S. M. (2006). Effects of collaboration technology on the performance of tactical air battle management teams. *Proceedings of the Human Factors Issues in Network-Centric Warfare Conference*, Sydney, Australia, 1-3 May 2006.

Siegel, J., Dubrovsky, V., Kiesler, S., & McGuire, T. W. (1986). Group processes in computer-mediated communication. *Organizational Behavior and Human Decision Processes*, *37*, 157-186.

Weisband, S. P. (1992). Group discussion and first advocacy effects in computer-mediated and face-to-face decision making groups. *Organizational Behavior and Human Decision Processes*, 53, 352-380.