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The Effect of Battlefield Combat Identification System Information on Target Identification Time and Errors in a Simulated Tank Engagement Task

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Thirty enlisted men served as subjects in an experiment to determine how availability of target identification information, such as friend or unknown, might affect human performance of a simulated tank engagement task. For half the subjects, target identification information was available if requested, while for the other half, additional information was unavailable. Accuracy and response time measures of the two groups were no different when targets were not interrogated. When target information was available, however, subjects interrogated targets on only one-seventh of the presentations. Receipt of target information led to considerable gain in accuracy and loss in response time. False alarm rate (calling enemies friends) was highly inflated when target identification was unavailable. Implications of the findings are discussed.

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THE EFFECT OF BATTLEFIELD COMBAT IDENTIFICATION SYSTEM INFORMATION ON TARGET IDENTIFICATION TIME AND ERRORS IN A SIMULATED TANK ENGAGEMENT TASK

INTRODUCTION

The U.S. Army is developing a battlefield combat identification system (BCIS) as an aid to identifying friendly vehicles on the battlefield. As envisioned, the system will, "...provide a .90...probability of correct identification...of targets not identified by other means for friendly ground (mounted/dismounted) and air platforms..." (TRADOC, 1993). In one proposed system, targets are interrogated using a directional, encoded, radio frequency (RF) transmission, and properly equipped friendly platforms respond using an omnidirectional, encoded RF reply. Immediately following an interrogation (i.e., in less than 1 second), one of two possible outcomes is displayed to the user. Either an appropriate RF response is received and the target is designated "friend," or a correct response is not received, and the target is designated "unknown." An important point is that the set of targets designated as unknown can include friendly platforms equipped with a BCIS that, for whatever reason, is not so identified (with a probability of occurrence not greater than .10), friends or allies without a BCIS, friends or allies with a disabled BCIS, noncombatants, and enemies. Hence, it does not follow that an unknown designation means the target is an enemy.

Several opportunities for identification errors exist with this type of system. As noted earlier, the system is not perfectly reliable, and approximately 10% of the time, interrogations of properly equipped friendly platforms will not result in a BCIS designation of friend. Additionally, because of the nature of the interrogating platform's RF radiation pattern, it is possible for a user to receive a BCIS designation of friend when the suspect target is actually an enemy. This can occur if a properly equipped friendly platform is near the interrogator or near the enemy. When the enemy is interrogated, the adjacent friendly platform will receive the RF interrogation and will respond with the proper friendly signal. The user will most likely believe that a friendly response has been received from the suspect target, never realizing that an unseen friendly platform actually generated the response. Finally, the user must integrate the BCIS response with the visual picture and with what is known about and expected from the current situation. The identification decision therefore depends on data-driven elements (visual stimuli and BCIS response) and on cognitive-driven elements (expectations, training, awareness of recent events, etc.). Resolving inconsistencies between these sources of information can be a difficult task. Because people are adaptive, operators cope with these inconsistencies by adopting strategies that reduce cognitive processing to manageable levels. Unfortunately, using these strategies to simplify decision making also introduces considerable bias (and thus error) in the process (Tversky & Kahneman, 1974; Slovic, Fischoff, & Lichtenstein, 1977; Einhorn & Hogarth, 1981; Kahneman, Slovic, & Tversky, 1982).

With the addition of a BCIS, new perceptual and cognitive tasks will be added to the engagement process, and fundamental questions about how this may affect engagement time and identification accuracy are of considerable importance. For example, engagement times will be increased not just by the BCIS cycle time, but also by the time required for the user to perceive and integrate this new information. Also, the probability of a target being correctly identified will depend on how the BCIS information is interpreted by the user. At issue is the user's decision-making performance and how it may be affected by the addition of a BCIS.

The objective of this study was to determine if significant differences in either identification accuracy or identification time would occur between two equivalent groups of subjects performing identical vehicle identification tasks, except that one group had available a simulated BCIS as an aid to target identification.

METHOD

A simulated tank gunner's sight was selected as the method for presenting an identification task to the subjects. The simulator used a computer monitor to present target stimuli through a direct view monocular sight. The monitor was visually isolated from the subject except as viewed through the sight, which was centered on the intersection of the horizontal and vertical midlines of the monitor. Subjects responded to the identification task by pressing buttons on two small boxes that were designed to fit the subjects' left and right hands. The subjects sat in a 3-m by 3-m acoustically isolated chamber illuminated with a standard tungsten filament light bulb in a ceiling fixture that provided an ambient luminance of approximately 20 cd/m^2. An intercom provided voice communication between the subject and the experimenter, who was located in an adjoining control room.

Subjects

Thirty male military subjects between the ages of 18 and 35 participated in this study. They were selected from the soldier operator maintainer test and evaluation (SOMTE) personnel attached to the U.S. Army Combat Systems Test Activity (now known as the Aberdeen Test

Center), Aberdeen Proving Ground, Maryland. Subjects were screened for far monocular visual acuity of at least 20/20 (Snellen), corrected or uncorrected.

Apparatus

Vision screening was accomplished using a Bausch & Lomb Master orthorater™, model 71-21-40-65. The experiment was conducted using a Compaq Deskpro™ 386/20e running Interpretive Stimulus Language and an Electrohome color video monitor, model 38-D051MA-YU. Each subject was seated so that, when looking through the sight, his eye was 3.7 meters from the monitor. The sight yielded approximately a 3.2° field of view at a luminance of approximately 50 cd/m^2. This was equivalent to viewing a circular area of 20 cm diameter on the monitor screen. For the subjects' viewing comfort, a rubber eye cup and forehead rest were provided. Both the sight and a pair of three button subject response boxes were of local design and construction.

Stimuli

Before a target is interrogated, some degree of uncertainty about the target's identity will exist. To investigate the effects of BCIS information on engagement performance, a set of images was required, which varied in their ability to be correctly identified. Toward this end, ten vehicle images were selected from the 50 included in the Army's graphic training aid 17-2-13 CH. 1 (Department of the Army, 1987).[1] Each vehicle's front and side views were electronically scanned into a Macintosh™ Quadra® 950 using a Microtek ScanMaker™ Model 600ZS set for gray scale scanning with a resolution of 300 dots per inch. This resulted in a stimulus set of 20 computer images (ten vehicles at two orientations). Seven apparent ranges were then created for each vehicle by manipulating the image size. The sizes were calculated so that subjects would see the images at the same visual angle as subtended by the actual vehicles when viewed through the M1A1 Abrams gunner's primary sight adjusted for narrow field of view (10x). The final result was a set of 140 images (ten vehicles at two orientations and seven apparent ranges). An assumption was made that some of these images would be more difficult to identify than others because of the orientation of the vehicle and the apparent range from the observer. These two image characteristics (orientation and range) would then serve as a means of manipulating the image's difficulty of being correctly identified. However, as the apparent range of the image increased on the computer monitor, not only did the image become smaller, but display artifacts

[1]This training aid is used to teach vehicle identification to students attending advanced individual training at the U. S. Army Armor Center at Ft. Knox, Ky.

resulted in some target details with high spatial frequencies disappearing at some ranges and then reappearing at others. Because display artifacts acted as a third, uncontrolled, source of identification error, the images had to be "calibrated" in the sense that the identification error had to be measured for each image.

A pilot study was undertaken to determine the target identification error associated with each of the 140 target images. Thirty military subjects participated in the study and the results were used to select those images that exhibited differential identification errors based solely on vehicle orientation and apparent range. The resulting set of 70 target images is described in Appendix A. Targets from this set, when displayed on the monitor, subtended visual angles of from 0.3^{o} to 2.8^{o} and generated probabilities of correct identification between 34% and 100%. The apparent distances that were selected were necessary to obtain the desired range of probabilities for correct identification. The far distances seem extreme compared with those typically encountered with real tank sights. However, the simulated tank sight did not use any optics and thus produced no optical aberrations. Further, there was no jitter, no atmospheric effects, and the target consisted of a high contrast image against a clutter-free, uniform background.

Procedure

Upon arrival at the U.S. Army Research Laboratory (ARL), subjects were tested for acceptable visual acuity, asked to read a description of the experiment, and then asked to sign a volunteer agreement affidavit. Following this, a short questionnaire was administered concerning such things as past and present military occupational specialties held, educational background, and personal interests.

Orientation and Training

Twenty study cards, taken from the Army's graphic training aid 17-2-13 CH. 1, were modified so that the obverse of each card showed either a front or side view of one of the ten target vehicles. Each vehicle's nomenclature and identification (friend or enemy) was provided on the reverse of the card. The experimenter showed the card set to each subject and solicited questions before proceeding. Occasionally, subjects asked why a particular vehicle had been designated as a friend or an enemy. These queries were anticipated, and the rationale for each vehicle's identification was provided upon request. Subjects were then instructed to learn the identification of the vehicles so that they could correctly identify them as friend or enemy 100% of the time. Learning the vehicles' nomenclature was not required. Subjects were allowed

15 minutes or more, if needed, for the learning task. When the subjects were satisfied that they could meet this criterion, they were informally tested by being asked to sort all 20 cards into friend and enemy stacks, two consecutive times without error. If they were not successful, they were given more time to study the cards.

After successfully completing the card-learning criterion, subjects were placed in a semi-darkened test room where they were familiarized with the appearance of the same target images on the video monitor as viewed through the sight. During training, the targets were always shown at the closest apparent range. As each target was presented, its correct identification was announced by the experimenter. Subjects were allowed to view each target until they notified the experimenter that they were ready to continue. Between presentations, a fixation point (cross) appeared for 2 seconds.

Following this familiarization, the 20 targets were presented in random order, and subjects were asked to identify each as friend or enemy. They were told to respond as quickly as possible by pressing a button held in the left hand if the target was a friend or a button held in the right hand if the target was an enemy. Following a correct response, the target was immediately replaced with the fixation point and the next target appeared after a 2-second interstimulus interval. An incorrect response or no response after 8 seconds triggered an audio tone (250 Hz at 85 dB(a) for 300 msec) through a concealed speaker. In addition, the target continued to be visible for 5 seconds longer before being replaced with the fixation point. This gave the subject a chance to study targets that had been incorrectly identified.

Following their response to the last target, subjects were told the percent of targets correctly identified for that run and, if requested, were again shown each of the targets that were identified incorrectly. This procedure was repeated (presentation order randomized each time) until at least 90% of the images (nine front and nine side views) were correctly identified in two successive runs. Subjects unable to meet this criterion in six attempts were allowed to participate in the test trials, but their data were excluded from analysis.

Testing

Subjects reaching criterion during training were randomly assigned to either the treatment group or a control group. The subjects participating in the treatment group could request simulated BCIS information as an aid to target identification. The control group subjects could not receive BCIS information. Testing continued until 15 subjects had been tested in each group. Both groups were shown the set of 70 targets 6 times for a total of 420 trials per subject.

The treatment group subjects were instructed to use the BCIS whenever they were not positive about their ability to visually identify a target. Control group subjects were instructed to choose a target identification even if they were uncertain. Finally, instructions were given, addressing the critical aspect of speed-accuracy trade-off. Briefly, subjects were told that their foremost responsibility was to correctly identify the target. Making this correct identification as quickly as possible was referred to but in such a way as to be clearly interpreted as secondary to accurate performance.

During testing, the targets were shown for a maximum of 5 seconds or until a response button was pressed. The fixation point was shown for a constant interstimulus interval of 2 seconds. Unlike the learning portion, there was no tone following an incorrect identification and the image did not remain in view for an extended time. Subjects in both groups were given delayed feedback during a short rest period at the conclusion of each block of 70 target trials. Feedback consisted of verbal notification about the percent of correct identifications made during the preceding 70 trials and how many friendly targets were identified as enemies.

Subjects assigned to the treatment group were instructed about the use of a third button to initiate a simulated BCIS interrogation of the target. Approximately 750 msec after the interrogate button was pressed, a visual BCIS declaration was presented to the subjects. A "friend" designation consisted of a continuously lit, red, light-emitting diode (LED). A designation of "unknown" consisted of a continuously lit, yellow LED. Both light sources were inside the subject's sight, on opposite sides, horizontally separated by the maximum extent possible and depressed 20° from the horizontal midline of the sight tube. The distance from the subject's eye to the LEDs was approximately 8 cm. The LEDs remained lit until the subject responded with a final decision by pressing either the friend or enemy button. Following the onset of the BCIS visual signal, subjects had as long as 5 seconds to make this final response. In accordance with the operational requirements document, the probability that the simulated BCIS returned a correct identification was set to .90 per interrogation. The probability that the BCIS returned a false positive response (i.e., calling an enemy a friend) was set at .04 per interrogation. This value, although speculative in nature and very much a function of the relative densities of friendly and enemy vehicles in an actual engagement arena, was based upon a Goldsmith (1986) report about ground-to-ground fratricide.

Both groups received identical instructions about the real-world importance of their speed of response for survival and their accuracy of response for reduced fratricide and loss from enemy fire. The treatment group subjects were informed about the performance characteristics of the BCIS.

Experimental Design and Analysis

The experiment used a between-groups repeated measures design with the availability or nonavailability of the BCIS information as the between-groups variable. The experiment was divided into 6 blocks of 70 targets each, for a total of 420 trials per subject. Fifteen random presentation orders were created, and each ordering was used twice, once for a subject in the treatment group and once for a subject in the control group.

The dependent measures of interest were response time and both types of identification errors (identifying a friend as an enemy [fratricide] and identifying an enemy as a friend [akin to "suicide" on the battlefield]). Response time was defined as the elapsed time, in seconds, from the onset of a visual stimulus (an image of a vehicle) to the subject's identification response (a button press). If a subject did not respond to a stimulus, a response time of 5 seconds was recorded, equaling the temporal duration for stimulus presentation, and the trial was excluded from analysis. Four different response time categories were established: the time for a friendly response given that the target was a friend (F|F); the time for a friendly response given an enemy target (F|E); the time for an enemy response given an enemy target (E|E); and the time for an enemy response given a friendly target (E|F). Fratricide rate was determined by the equation

$$\text{Fratricide Rate} = \frac{\text{Number of Friends Identified as Enemies}}{\text{Total Number of Targets Identified as Enemies}} \times 100$$

Suicide rate was similarly determined by

$$\text{Suicide Rate} = \frac{\text{Number of Enemies Identified as Friends}}{\text{Total Number of Targets Identified as Friends}} \times 100$$

Because the fratricide and suicide measures are ratios, a transformation is recommended for stabilizing variances (Winer, 1971). Therefore, before analysis, these ratios were transformed by the equation

$$\text{Transformed Score} = \text{Arcsine}\sqrt{\text{rate}}$$

RESULTS

Analyses of all data were first performed, regardless of interrogation behavior, regarding the effect of a BCIS on identification performance.

The identification errors were subjected to an analysis of variance (ANOVA) with groups (availability versus nonavailability of the BCIS information), as the between-subject variable, and error type (fratricide versus suicide) and blocks of trials (six repetitions) as the within-subject variables. The main effect of error type was significant, $F(1,28)=12.093, p<.01$, indicating that suicide, with a mean of 15.6% was committed more frequently than fratricide, with a mean of 10.8%. The main effect of blocks of trials was also significant $F(5,140)=9.859, p<.001$, indicating that both types of identification errors decreased with increasing exposure to the task. Mean identification errors were 15.8, 14.5, 14.4, 12.2, 10.8, and 11.9% for blocks 1 to 6, respectively. There was no significant main effect of groups or significant interaction found at the .05 level.

Response times were also analyzed in an ANOVA, with groups as the between-subject variable and response category, (F|F, E|F, F|E, E|E) and blocks of trials as the within-subject variables. The main effect of response category was significant, $F(3,84)=64.545, p<.001$. The means were 1.694, 2.486, 2.381, and 1.796 seconds, for the response categories of F|F, E|F, F|E, and E|E, respectively. Subsequent analysis of the four response category means indicated that correct responses (F|F and E|E), with a mean of 1.745 seconds, were faster than incorrect responses (F|E and E|F), with a mean of 2.478 seconds. There was no difference between the means of the two correct response categories or between the means of the two incorrect response categories. The main effect of blocks of trials, $F(5,140)=17.239, p<.001$, was significant, indicating that all response times decreased with increasing time on task. Mean response times were 2.458, 2.225, 2.048, 2.063, 1.939, and 1.936 seconds for Blocks 1 to 6, respectively. No significant main effect of groups or significant interaction was found at the .05 level.

To examine interrogation behavior, treatment group data were partitioned into trials with interrogation (assisted trials) and trials without interrogation (unassisted trials). Since each random stimulus presentation order was used twice, once for a subject in the treatment group and once for a subject in the control group, it was possible to compare group performance during identical stimuli by likewise partitioning the control group data into "assisted" and "unassisted" trials equivalent to the treatment group data. The equivalent control group trials were then scored for errors and response times. Note. Only 14.5% of the total trials presented to the treatment group were assisted. The remaining 85.5% of the trials were unassisted.

Separate ANOVAs were run on the unassisted and assisted trials. Identification errors during unassisted trials alone, with groups as the between-subject variable, and error type and blocks of trials as the within-subject variables, produced a significant main effect of error type, $F(1,28)=10.213, p<.01$. This indicated that suicide, with a mean of 14.0% was committed more frequently than fratricide, with a mean of 10.1% across trials. The main effect of blocks of trials was also significant, $F(5,140)=8.020, p<.001$, indicating that errors made during unassisted trials decreased with increasing time on task. Mean identification errors were 14.4, 12.5, 13.5, 11.1, 9.8, and 10.9% for Blocks 1 to 6, respectively. No significant main effect of groups or significant interaction was found.

A similar analysis of the assisted trials was performed. A significant main effect of groups was found, $F(1,28)=6.206, p<.05$, indicating that the control group, with a mean identification error rate of 24.3%, committed twice as many errors as the treatment group did, with a rate of 12.0%. More importantly, a significant Blocks of Trials x Groups interaction was found, $F(5,140)=2.850, p<.05$, and is shown in Figure 1.

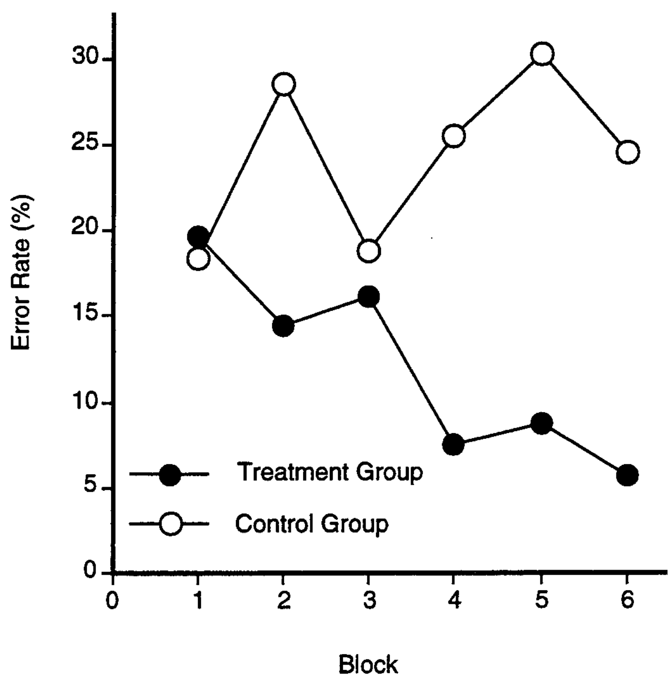

Figure 1. Combined error rates during assisted trials for the treatment group and the equivalent trials for the control group.

Figure 1 indicates that the control group identification means fluctuated from 18 to 30% across blocks, while the treatment group means generally decreased across blocks. Specifically, for the control group, the mean error rate in Block 1 was 18.3% and generally increased to 24.5% by Block 6, while for the treatment group, the mean error rate in Block 1 was 19.6% and decreased to 5.7% by Block 6.

The main effect for type of identification error, (fratricide versus suicide rate) also reached significance, $F(1,28)=10.881, p<.01$, indicating that suicide, with a rate of 23.9%, was committed more frequently than fratricide, with a rate of 12.5%. More interesting, however, was a significant Error Type x Groups interaction, $F(1,28)=5.304, p<.05$, which is shown in Figure 2.

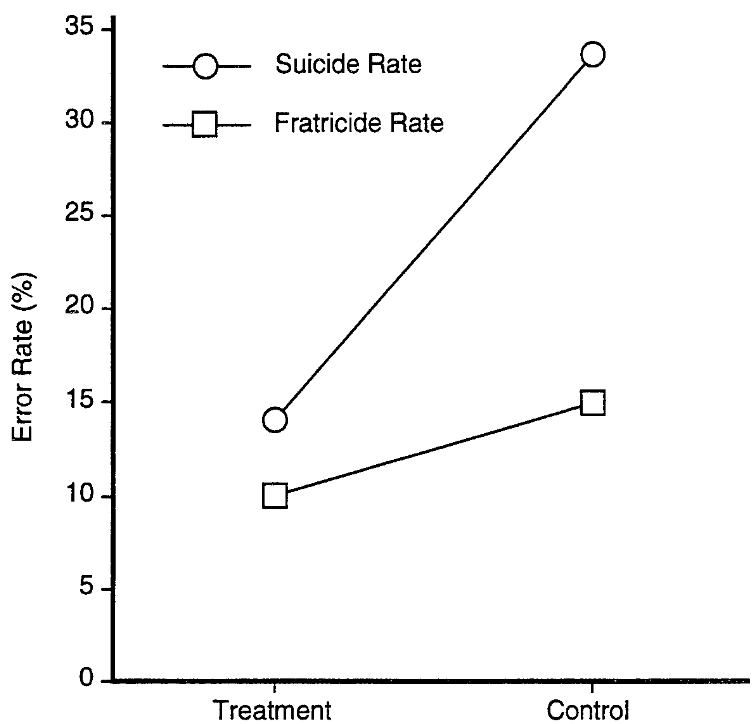

Figure 2. Mean suicide and fratracide rates during assisted trials for the treatment group and the equivalent trials for the control group.

Subsequent analyses of this interaction indicated that the suicide rate of the control group was significantly greater than that of the treatment group, $F(1,28)=7.630, p<.01$, while there was no significant difference in fratricide rates. Further, there was no difference between fratricide and suicide rates for the treatment group.

Response times during assisted trials were analyzed in an ANOVA with groups as the between-subject variable and blocks of trials as the within-subject variable. The main effect for groups was significant, $F(1,22)=42.277, p<.001$, with mean response times of 4.149 and 1.933 seconds for the treatment and control groups, respectively. Note. The treatment group subjects had to respond twice when interrogating a target, once to request BCIS information and once to finalize their identification of the target. The main effect for blocks of trials was also significant, $F(5,110)=17.903, p<.001$. Mean response times were 3.937, 3.268, 2.854, 2.904, 2.655, and 2.628 seconds for Blocks 1 to 6, respectively. More importantly, there was a significant interaction between blocks of trials and groups, $F(5,110)=5.417, p<.001$. These data are shown in Figure 3.

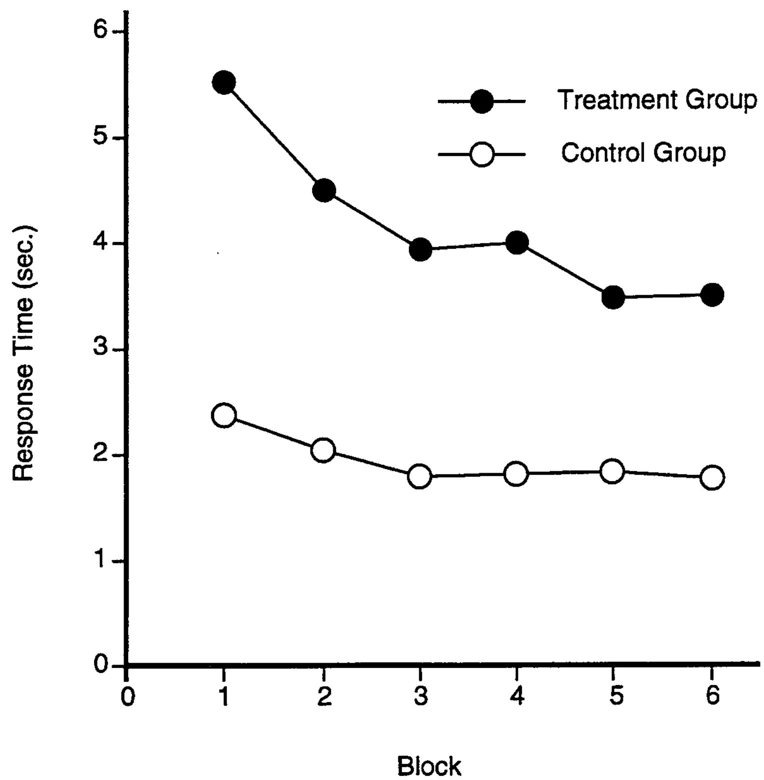

Figure 3. Mean response times during assisted trials for the treatment group and equivalent trials for the control group.

It can be seen in Figure 3 that while the response times for the control group subjects remain the same across blocks of trials, the response times for the treatment group subjects tend to decrease.

DISCUSSION

The objective of the present experiment was to determine how availability of a BCIS might affect human performance of a target identification task.

If one considers only overall performance, paying no attention to whether targets were interrogated, the results indicate that there was no significant effect of BCIS availability on target identification accuracy or response time. Overall, we found that suicide rate was significantly higher than fratricide rate, and correct target identification responses were faster than incorrect responses. In addition, a considerable amount of learning apparently took place throughout the experimental task because errors decreased and response times became shorter with repetition of trials.

Several questions arise at this point. The first concerns why the suicide rate was significantly higher than the fratricide rate, and the second concerns why we saw no effect of BCIS availability. A third question, primarily related to performance speed, concerns not so much why correct responses appeared to be faster than incorrect ones (intuitively, an expected behavior related to decision uncertainty), but why that fact was also apparently unaffected by BCIS availability. Before considering these questions, we return to the results based upon a more detailed examination of interrogation performance.

As reported in the results, all treatment group data were divided into assisted and unassisted trials, and the same division of data was also projected onto the equivalent trials of the control group. If one considers only the performance during assisted trials and their equivalent control group trials, then the results indicate an effect of BCIS availability on both target identification accuracy and response time. The data in Figure 2, which relate to those trials, show that when the BCIS was used (treatment group), there was no difference between fratricide and suicide rates, and when no BCIS was available (control group), the difference between fratricide and suicide rates was significant. In addition, fratricide rates of each group appeared to be unaffected by BCIS availability, while there was a significantly higher suicide rate when a BCIS was not available.

It should be clear that a response of "enemy" means firing at a target, while a response of "friend" means not firing at a target. Fratricide rate can only increase when a friend is fired upon and decrease when an enemy is fired upon. In other words, responses of "enemy" exclusively affect fratricide rate because they are incidents of firing at targets. Using the same reasoning, responses of "friend" may be said to exclusively affect suicide rate because they are incidents of not firing at targets.

If there is a conscious effort of subjects to reduce fratricide rate, as there certainly was in this experiment, then the most probable response with identification uncertainty would be a response of "friend" or not firing at the target. When there is no available BCIS, this response must increase suicide rate if the target is really an enemy. The effect of this bias is seen in Figure 2 as the high suicide rate of the control group.

When there is a BCIS, identification uncertainty will first elicit an interrogation response. The same bias of responding "friend" when there is identification uncertainty is also present but is now influenced by the BCIS response to the interrogation. A red LED, meaning "friend," largely supports the bias and reinforces a response of "friend." A yellow LED, meaning "unknown" only partially supports the bias and sometimes leads to a response of "friend" but largely encourages a response of "enemy" because of its high correlation with enemy targets. We see in Figure 2 that when the BCIS was used, fratricide and suicide rates of the treatment group were the same. The only way the suicide rate of the treatment group could have been reduced to the level shown, was for the response of "enemy" to be used more frequently. The enemy response occurred most often when the BCIS response was a yellow LED. The fact that the fratricide rate of the control group was as low as that for the treatment group is also an effect of the bias. After all, if all targets elicited a response of "friend," fratricide would be 0%.

With reference to the questions posed earlier in the discussion, we see that inflated suicide rates are a direct result of conservative risk taking in an effort to reduce fratricide incidents. The BCIS availability did affect performance, but we see the effect only when we specifically look at assisted performance.

On a more general level, BCIS availability affected response times as well as identification accuracy. The interaction of blocks and groups, for response time (shown in Figure 3) and the interaction of blocks and groups, for error rate (shown in Figure 1) may have resulted from the feedback nature of the BCIS information itself. Both groups received feedback about their target identification performance at the end of each block of trials. At that time, they were told how many targets they incorrectly identified and how many of them were incidents of fratricide. In addition, the treatment group received feedback about each assisted trial in the form of a BCIS response. The opportunity to interact with each BCIS response provided a source of interest, motivation, and feedback unavailable to the control group. This may have led to improvement in response times and accuracy as well as to the continuation of such improvement across all blocks of trials.

When we examined only overall performance, the effect of the BCIS was not apparent. One reason for this finding was that subjects made infrequent use of the BCIS information. It was used on only 14.5% of all trials. A possible reason for the lower than expected usage of the BCIS information could be that the subjects were overly confident in their ability to correctly identify familiar targets visually. This is consistent with the results observed in a series of aided target recognition experiments in which subjects were asked to detect and classify targets in varying levels of clutter and noise (MacMillan, Entin, & Serfaty, 1994). In those experiments, even though various types of nonvisual information could be called upon to aid in the task, most subjects relied on their visual sense alone in making their decisions.

CONCLUSIONS

Initially, one question of interest was whether a BCIS would encourage a user to interpret the "unknown" (yellow LED) designation as meaning enemy and thus actually increase the chance of committing fratricide by firing upon more targets than would normally be fired upon without a BCIS. If the user believes the BCIS is highly reliable in identifying friends, would that confidence translate to "if the BCIS does not respond 'friend,' the target must be an enemy"? The answer to this question is probably yes. More targets were fired upon when the BCIS was available than when it was unavailable. However, whether that factor would actually lead to a dramatic change in fratricide rate depends not only upon the user but also upon the relative concentrations of friends and enemies on the battlefield. There would certainly be an increase in firing if all yellow LEDs were signals to fire. If there were more friends in the area than enemies, even slight increases in firing would likely increase the fratricide rate. If there were more enemies than friends in the area, it is more likely that the fratricide rate would decrease.

The usefulness of a BCIS cannot be easily disputed, as evidenced by the results related to the assisted trials. However, conditions that might contribute to such a system's disuse can be powerful. For example, in battle, is it reasonable to assume that a tank gunner would orient the main gun directly at a vehicle to interrogate it, when he already "knows" the vehicle is friendly? Not only would this action be perceived as hostile by the vehicle being acquired, but the process would take precious time away from searching for and engaging enemy targets. In other words, there is no evidence to support an argument that tank commanders and gunners, in the "heat of battle," will not sort targets based on what they see. The danger here is, of course, that this research suggests that soldiers can be extremely confident of their identification accuracy and still be quite wrong. We found an error rate of 11.8% during unassisted trials. Further, if BCIS information is given automatically for each and every target detected on the battlefield, the errors of uninterrogated target sampling by the user would be reduced. In such a situation, however, there would be an increase in the frequency of disagreement between BCIS information and what the gunner thinks he sees. How will more frequent occurrences of disagreement eventually impact on the user's confidence in the system's accuracy or effectiveness? Will it result in the system being eventually turned off or at least ignored by the user in the heat of battle or simply relegated to use only during those conditions when visual target identification is uncertain? Thus, we return full circle to the fact that the user will ultimately make the final choice of when to use a system or when to ignore it.

Secondary sources of target information, such as objective reports about the situational aspects of a scenario or informational reports of a BCIS probably have more credibility when they do not conflict with familiar visual tasks that tend to be more reflexive than reflective in nature. Alternate sources of information are probably the first to be ignored in situations when exigencies of the moment take priority for survival. We are basically more trusting of our own senses and subjective experience than of our ability to process and integrate objective information, especially when we believe that a quick decision is needed for our survival. In other words, seeing is believing.

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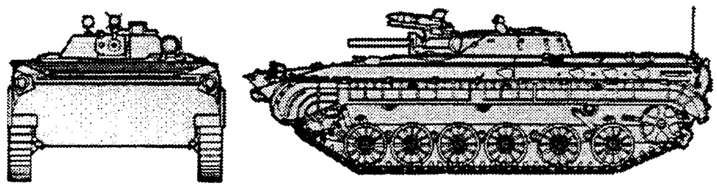
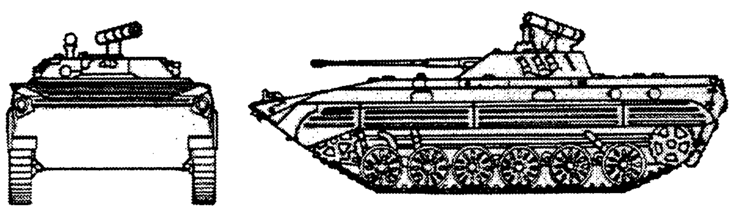
APPENDIX A

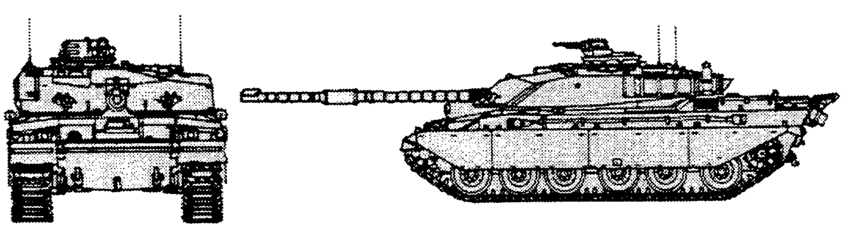
VEHICLE FRONT AND SIDE VIEWS (NOT TO SCALE) WITH DEFINING CHARACTERISTICS



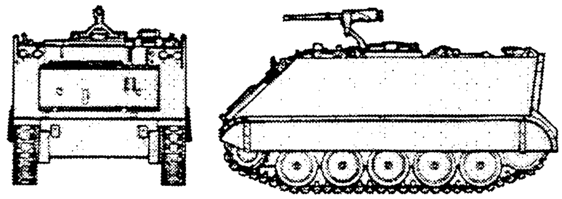
NOMENCLATURE: BMP Armored Personnel Carrier
DESIGNATION: Friend
RANGES (m): Front View 2400, 3000, 4800, 6000
Side View 3000, 4200, 6000



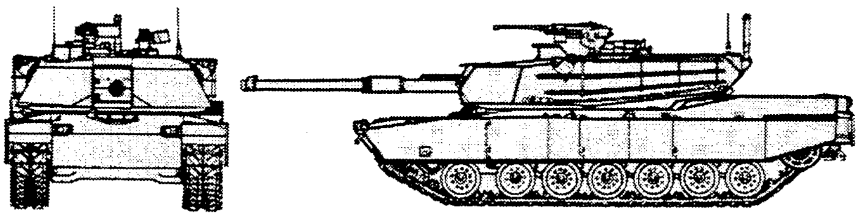
NOMENCLATURE: BMP M1981 Armored Personnel Carrier
DESIGNATION: Enemy
RANGES (m): Front View 2400, 4200, 5400, 6000
Side View 3000, 3600, 4200, 6000



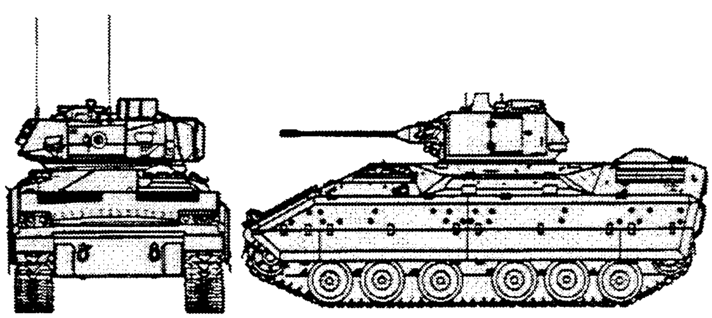
NOMENCLATURE: Challenger Main Battle Tank
DESIGNATION: Friend
RANGES (m): Front View 3600, 4200, 4800
Side View 2400, 3000, 3600, 4200, 5400



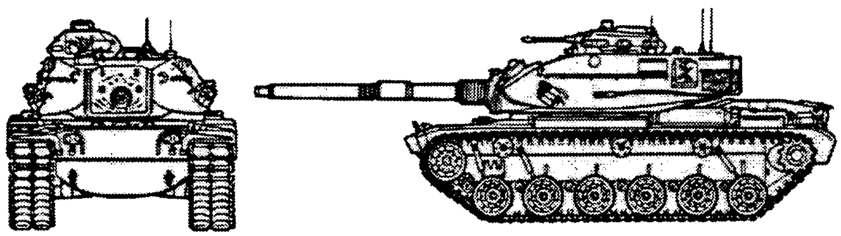
NOMENCLATURE: M113 Armored Personnel Carrier
DESIGNATION: Enemy
RANGES (m): Front View 3000, 3600, 4800
Side View 3000, 5400



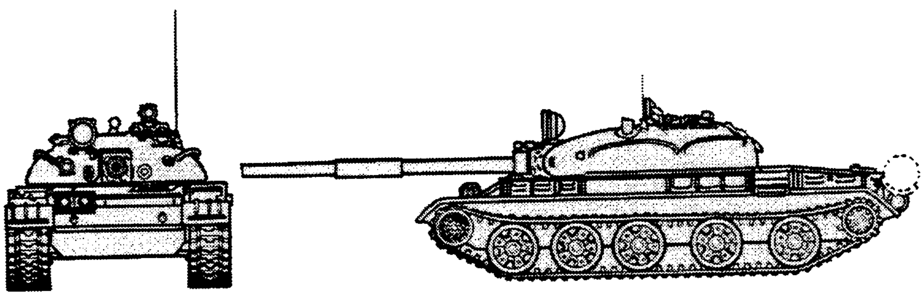
NOMENCLATURE: M1 Abrams Main Battle Tank
DESIGNATION: Friend
RANGES (m): Front View 3600, 4200, 4800, 5400, 6000
Side View 2400, 3600, 6000



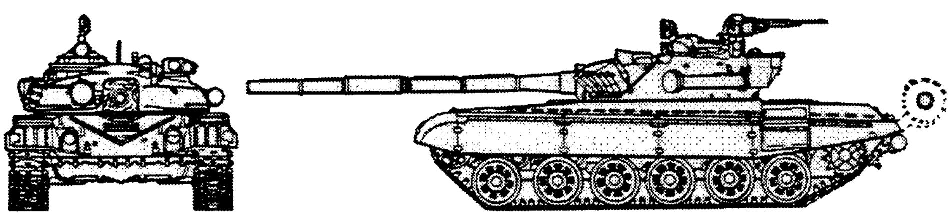
NOMENCLATURE: M2 Infantry Fighting Vehicle
DESIGNATION: Friend
RANGES (m): Front View 3000, 6000
Side View 2400, 3000, 6000



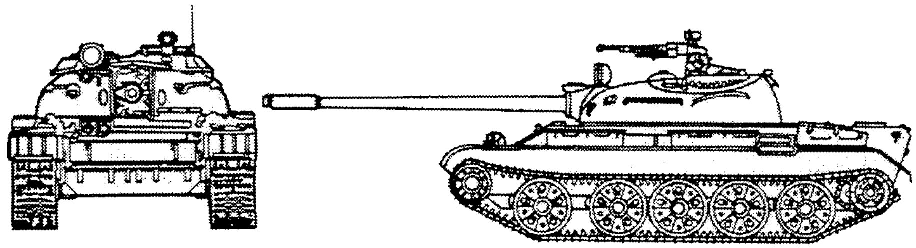
NOMENCLATURE: M60A3 Main Battle Tank
DESIGNATION: Enemy
RANGES (m): Front View 2400, 3600, 4800, 6000
Side View 2400, 3600, 6000



NOMENCLATURE: T-62 Main Battle Tank
DESIGNATION: Friend
RANGES (m): Front View 2400, 3600, 5400
Side View 2400, 4200, 5400



NOMENCLATURE: T-72 Main Battle Tank
DESIGNATION: Enemy
RANGES (m): Front View 2400, 3600, 4200, 4800
Side View 3000, 4800, 6000



NOMENCLATURE: T-54/55 Main Battle Tank
DESIGNATION: Enemy
RANGES (m): Front View 3000, 3600, 4200, 5400
Side View 2400, 3000, 3600, 4800, 6000

Table A-1

Number of Friend and Enemy Targets by Orientation

	Front view	Side view	Total
Friend	16	18	34
Enemy	18	18	36
Total	34	36	70

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FORT KNOX KY 40121-5620

1 C ARL HRED ARDEC FIELD ELMT
ATTN AMSRL HR MG (R SPINE)
BUILDING 333
PICATINNY ARSENAL NJ 07806-5000

1 C ARL HRED ATCOM FIELD ELMNT
ATTN AMSRL HR MI (A MANCE)
4300 GOODFELLOW BLVD
BLDG 105 1ST FLOOR POST A-7
ST LOUIS MO 63120-1798

1 C ARL HRED FIELD ELEMENT
AT FORT BELVOIR
STOP 5850 ATTN AMSRL HR MK
(P SCHOOL)
10109 GRIDLEY RD SUITE A102
FORT BELVOIR VA 22060-5850

1 C ARL HRED CECOM FIELD ELMT
ATTN AMSRL HR ML (J MARTIN)
MYERS CENTER ROOM 3C214
FT MONMOUTH NJ 07703-5630

1 C ARL HRED MICOM FIELD ELMT
ATTN AMSRL HR MO (T COOK)
BUILDING 5400 ROOM C242
REDSTONE ARSENAL AL 35898-7290

1 C ARL HRED TACOM FIELD ELMT
ATTN AMSRL HR MU
(M SINGAPORE)
BUILDING 200A 2ND FLOOR
WARREN MI 48397-5000

1 C ARL HRED AVNC FIELD ELMT
ATTN AMSRL HR MJ
(R ARMSTRONG)
PO BOX 620716 BUILDING 514
FT RUCKER AL 36362-0716

1 C ARL HRED STRICOM FIELD ELMT
ATTN AMSRL HR MT (A GALBAVY)
12350 RESEARCH PARKWAY
ORLANDO FL 32826-3276

1 C ARL HRED FT HOOD FIELD ELMT
ATTN AMSRL HR MA (E SMOOTZ)
HQ TEXCOM BLDG 91012 RM 134
FT HOOD TX 76544-5065

1 USARL HRED FIELD ELMT
USAADASCH
ATTN ATSA CD
ATTN AMSRL HR ME (K REYNOLDS)
5800 CARTER ROAD
FORT BLISS TX 79916-3802

1 C ARL HRED ARMC FIELD ELMT
ATTN AMSRL HR MH (M BENEDICT)
BUILDING 1109D (BASEMENT)
FT KNOX KY 40121-5215

1 C ARL HRED USAFAS FIELD ELMT
ATTN AMSRL HR MF (L PIERCE)
BLDG 3040 ROOM 220
FORT SILL OK 73503-5600

1 C ARL HRED USAIC FIELD ELMT
ATTN AMSRL HR MW (E REDDEN)
BUILDING 4 ROOM 349
FT BENNING GA 31905-5400

1 C ARL HRED SC&FG FIELD ELMT
ATTN AMSRL HR MS (L BUCKALEW)
SIGNAL TOWERS ROOM 207
FORT GORDON GA 30905-5233

1 ARL HRED USASOC FIELD ELMT
ATTN AMSRL HR MN (F MALKIN)
BUILDING D3206 ROOM 503
FORT BRAGG NC 28307-5000

1 ARL HRED OPTEC FIELD ELMT
ATTN AMSRL HR MR (S BOLIN)
PARK CENTER IV RM 1450
4501 FORD AVENUE
ALEXANDRIA VA 22302-1458

1 ARL HRED VHFS FIELD ELMT
ATTN AMSRL HR MX (T CLARK)
BLDG 181 STOP 5
VINT HILL FARMS STA
WARRENTON VA 22186-5116

1 C ARL HRED FT HUACHUCA
FIELD ELEMENT
ATTN AMSRL HR MY (J HOPSON)
BUILDING 84017
FORT HUACHUCA AZ 85613-7000

ABERDEEN PROVING GROUND

1 C ARL HRED ERDEC FIELD ELMT
ATTN AMSRL HR MM (D HARRAH)
BLDG 459
APG-AA

1 ARL SLAD
ATTN AMSRL BS (DR JT KLOPCIC)
BLDG 328 APG-AA

5 DIRECTOR
US ARMY RESEARCH LAB
ATTN AMSRL OP CI B (TECH LIB)
BLDG 305 APG-AA

1 USATECOM
RYAN BUILDING
APG-AA

1 USMC LIAISON OFFICE
ATTN AMST ML
RYAN BUILDING APG-AA

1 LIBRARY
ARL BUILDING 459
APG-AA