BEHAVIORAL BASES FOR DETERMINING VEHICLE DETAILING IN SIMULATION DISPLAYS

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ABSTRACT

Effective representation of armored vehicles in simulation displays demands a careful evaluation of human perceptual capabilities. This holds especially true for computer generated target displays, which must provide sufficient detail to allow vehicle identification within limitations of computer processing time and display resolution. Even in image generation and display systems not incurring such limitations, the image detail need not exceed human perceptual and cognitive information processing capabilities. Providing excessive detailing of targets may, in fact, produce negative training by allowing those being trained to depend on information unavilable in combat for target identification. Results of research manipulating visible target detail in target identification training and its implications for target displays are discussed. Estimates are presented for the visibility of features of threat and friendly main battle tanks, based on analysis of past empirical research done under ideal visibility conditions and visibility data from past research.

INTRODUCTION

Picture yourself as a Tank Commander, moving in column along a road toward your forward battle position. Suddenly, you detect two tracked vehicles moving along a treeline about 2000 meters away. Do you engage them, or don't you? You have only split seconds to decide. If they are friendly and either simply lost or moving to a position near yours, engaging them would result in the death of US soldiers or your allies. If they are enemy, failing to engage them endangers your life, the lives of your men, and your tank. Are they *friend or foe? This question will recur frequently* given the fluid and "dirty" battlefield expected in most future European scenarios.

The situation described above clearly points out the need for effective target identification training. Simulation offers exciting opportunities for training many aspects of combat performance, including target identification, since it affords the capability to present a wide variety of realistic targets in highly realistic tactical settings. Troops can be trained to identify targets within the normal context of maneuver and combat engagement. However, the capability to train target identification as a matter of course raises the question of how much detail computer-generated vehicle representations or other target displays require to allow realistic target identification. The detail must be sufficient to represent a vehicle's critical features (those that differentiate it from other, similar vehicles), but the display should not represent features that would be unavailable in a combat setting and at the ranges a target would normally be identified. The danger with highly detailed representations is that troops might learn to depend on target details that are simply unavailable for target identification in combat.

METHOD

The US Army Research Institute (ARI) field unit at Fort Knox approached the target representation problem for tank gunnery by examining observers' performance in learning to identify slides of tank targets at different ranges, both before and after an experimental ARI target identification training program (see reference 2). Simulated training and test ranges of 4000 and 2000 meters through the 8x sight of the M60A1 were selected, because these two ranges encompass the ranges in which tank target identification would normally take place, assuming good visibility conditions and making two other reasonable assumptions. The first assumption is that few targets in a tactical setting will be detected beyond 4000m (with the exception of large armor formations, in which case target identification is a different task than for individual vehicles), and the second is that an *enemy should be identified at a range of 2000m or* more, given the engagement hit probabilities given in FM 71-1 (1). Examining observers' ability to learn target identification at these two ranges allows one to determine how much of a difference, if any, in target identification training occurs due to reduced visibility of target features at the farther compared to the nearer range. From these data one can infer the detail needed in displays to train target identification at ranges demanded in combat.

Subjects

Twenty OSUT (One Station Unit Training) armor crewmen (10 gunner/loaders and 10 drivers) served as observers. All had completed the standard block of instruction on Soviet Soldiers and Equipment, which includes basic target identification training, prior to the experimental target identification training program received as a part of this research. In this paper, however, references to training refer to training received through the experimental training program administered to subjects in this research.

Stimuli and Apparatus

Targets for training and tests of observers' learning were presented via slides. Slides of vehicles were taken from the ARI Combat Vehicle Identification (CVI) Program (2), as were the verbal descriptions of the vehicles that were presented during the training program. The training program itself was a modified version of one module of the ARI Combat Vehicle Identification Program, and lasted approximately two to two and one-half hours. Seven tanks were selected for training and testing, with the rationale that, first, tanks are the primary targets for tanks on the battlefield, and second, that they are highly confusable combat vehicles and therefore present some of the most difficult discriminations to be made in target identification in combat. The seven tanks used were the Soviet T-55, T-62, and T-72, the French AMX30, the US M60A1, the West German Leopard I, and the British Chieftain. The slides showed model vehicles on a terrain board. All vehicles were photographed on the same spot on the terrain board, and all vehicles were camouflage painted. These measures prevented observers from learning to identify vehicles based on extraneous cues from the terrain or vehicle markings. Frontal, flank, and oblique views of all vehicles were included. Slides of vehicles were rear-projected by a Kodak Ektagraphic slide projector, Model AF-1. Exposures of slides were timed by a hand-held stopwatch.

Procedure

Observers were tested and trained in groups of ten. Within each group of ten, five observers were selected to receive the experimental target identification training program at a simulated range of 2000m; the other five observers received the training program at a simulated range of 4000m. Ranges were simulated by seating the observers at different distances from the screen upon which slides were projected at a constant scale (for more detail see the instructions and discussion accompanying the CVI package). Five gunner/loaders received training at 2000m, and five at 4000m; the same held true for the drivers.

Before undergoing the experimental training program, each observer was given two tests (without feedback) on all views of all vehicles, with one pretest at each of the two ranges. Presentation of the slides of all seven vehicles in each of three views was randomized for each pretest. Each slide in each of the 21-item pretests was presented for ten seconds and followed by a ten second period with a blank screen to allow the observers more time to write down their answers. After the pretests, the vehicle identification program was presented. This program included verbal descriptions of vehicles accompanying the slides of the models, as well as slides of vehicles that observers were asked to name, and for which feedback was given following their responses. Specific details of the training program are presented in an ARI Report currently in preparation. After the instruction, all observers were given two final tests, with one test at 2000m and one at 4000m. As with the pretests, order of presentation was randomized over all vehicles and all views on both tests.

RESULTS AND DISCUSSION

Analysis of variance was applied to the number of correct vehicle identifications (corrected for guessing). The analysis revealed that performance improved significantly after the experimental training program ($p<.01$). Figure 1 shows this effect graphically in terms of percent correct, corrected for guessing. The difference between performance at simulated ranges of 2000m and 4000m was not statistically reliable either before or after subjects received the experimental training program. Similarly, the difference between

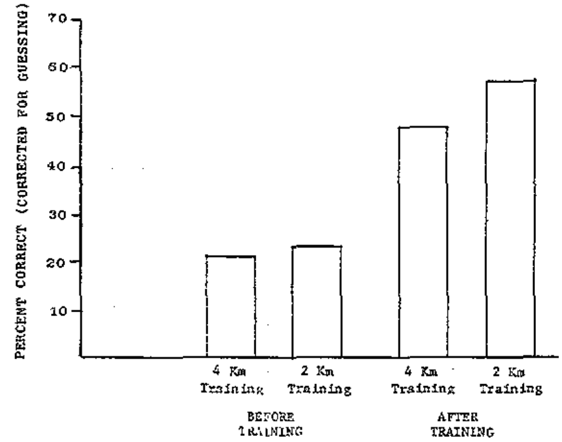

Figure 1. PERFORMANCE IMPROVEMENT WITH ARI COMBAT VEHICLE IDENTIFICATION PROGRAM

observers trained at 2000m and those trained at 4000m was insignificant, as was the interaction between training range and test range. The above results show that first, the ARI Combat Vehicle Identification Program raises target identification performance significantly over that provided by Armor OSUT training, regardless of some variation in training and testing range, and second, that there is still more room for improvement.

The analysis also showed that performance differed for different vehicle orientations ($p<.01$). Figure 2 shows this effect graphically, with results

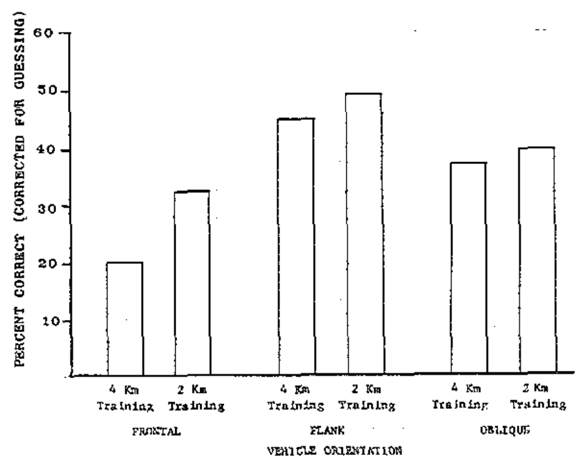

Figure 2. PERFORMANCE DIFFERENCES FOR DIFFERENT VEHICLE ORIENTATIONS

before and after the experimental training program combined. One must qualify statements about this effect, however, due to a significant interaction of vehicle orientation with training. Figure 3 shows this interaction. A test of simple main effects revealed first, that performance after training improved significantly over that before training for all three vehicle orientations ($p<.01$ in all three cases), and second, that performance differences among different vehicle views were significant only after training ($p<.01$). Pairwise comparisons using Tukey's HSD revealed that after training, observers identified flank views of vehicles significantly better than both frontal views ($p<.01$)

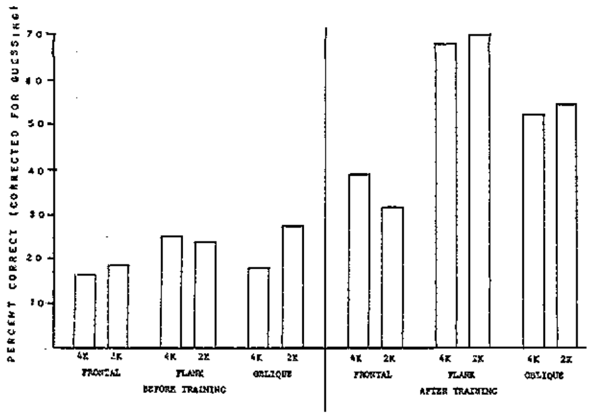

Figure 3. PERFORMANCE DIFFERENCES FOR DIFFERENT VEHICLE ORIENTATIONS BEFORE AND AFTER TRAINING

and oblique views ($p<.01$). These comparisons simply show that subjects in the present research learned the most about identifying flank views of vehicles, and the least about identifying frontal views of vehicles. The performance differences between different vehicle orientations simply reflects the differences in the number of critical features available in the three views. Training observers to identify frontal and oblique vehicles present a particular challenge for future target identification training research, since the tendency to fire at another vehicle without making a positive identification first will be greatest for vehicles in those orientations.

The striking aspect of these results is that, within practical limits, the effects of the range at which observers were trained and tested, as well as the interaction of these two factors, were extremely small relative to the large improvement of all observers over training, and were not even reliable enough to approach statistical significance. This implies that, for all practical purposes, observers learned to identify targets just as well with the details that could be seen at 4000m through an 8x sight as they could with the details that could be seen at 2000m through an 8x sight. Therefore, when considering training observers to identify tank targets through the 8x M60A1 sight under ideal visibility conditions, one need not have as much detail as can be seen normally at 2000m, although including that much detail will not harm training.

One might wonder why insignificant effects of training and test range were found in the above research. This question can be answered by first considering data collected by Foskett, et al. (4) on the detectability of features of armored vehicles. Figure 4, taken from their report, shows the detectabilities of the features they investigated. Consider that ranges of 2000 and 4000 meters through an 8x sight correspond approximately to 250 and 500m with unaided vision if the atmosphere is perfectly clear. One can see by Figure 4 that there is only a small difference between the detectability of features at 250 and 500 meters with unaided vision. Small features, such as the number of roadwheels (if the number is large) become dramatically less detectable over this increase in range, but the probability of detecting the largest features drops very little. Coupling this relatively small difference in detectability with the poor performance before training and the fact that the ARI program emphasizes identification using large, highly noticeable features (while de-emphasizing the importance of small features) it is probably not surprising that the effects of training or test range were insignificant.

In considering the results of the above research, however, there is a very definite caveat. Both our research and the research of Foskett et al. were conducted under scaled conditions. Hence, they apply specifically to an atmosphere of almost infinite visibility and do not consider effects of atmospheric attenuation. The results of the research reported here are an overestimate of the actual detectability of vehicle features in a normal outdoor environment. The impact of various levels of atmospheric attenuation on actual detection of armored vehicle features is yet to be thoroughly investigated. However, one can develop a crude estimate of the effects of atmospheric attenuation through data such as those presented by Middleton (5). Middleton presented a series of nomograms allowing one to predict the 95 percent detection level of objects of various sizes, given certain levels of background luminance, the target to background contrast prior to contrast extinction by the atmosphere, and meteorological range (that range at which atmospheric attenuation reduces target to background contrast to threshold). The data Middleton presented allows one to generate curves, such as those in Figure 5, from which one can estimate the amount of drop in visibility of a feature with reduced lighting and reduced meteorological range. For more detail on the derivation of Figure 5, the interested reader is referred to a forthcoming ARI Working Paper dealing with vehicle feature detectability (6). If one assumes that these curves can be considered a "pure" reduction in visibility, disregarding any interactions of visibility reduction with target background, one can rescale the abscissa of Figure 4 to reflect a certain proportion of drop in detection range. An example of this rescaling, showing the impact of reduced visibility and a reduced light level on the detection data of Foskett et al. is shown in Figure 6. It is, of course, only a very rough estimate, and actual likelihoods of detection in a tactical setting depend on a number of factors, including such things as the target background and observers' criteria.

One can see from Figure 6 that under very hazy and overcast conditions, features become much more difficult to see. Only gross features such as whether a vehicle is tracked or wheeled, whether or not it has fender skirts, its main gun, its turret position, and turret shape are readily available. Any difference in target identification at 4000m and 2000m under these conditions is yet to be determined. For a further discussion of the impact of atmospheric conditions on feature visibility, the interested reader is again referred to the forthcoming ARI paper on feature visibility (6).

What conclusions can be drawn from the research reported here? Since the lethality of modern weapons may easily make 2000m the minimum range by which an enemy tank must be identified under good viewing conditions, it seems impractical to conduct target identification training with a final goal of training people to identify tanks only within 2000 meters. Therefore, for practical purposes it seems

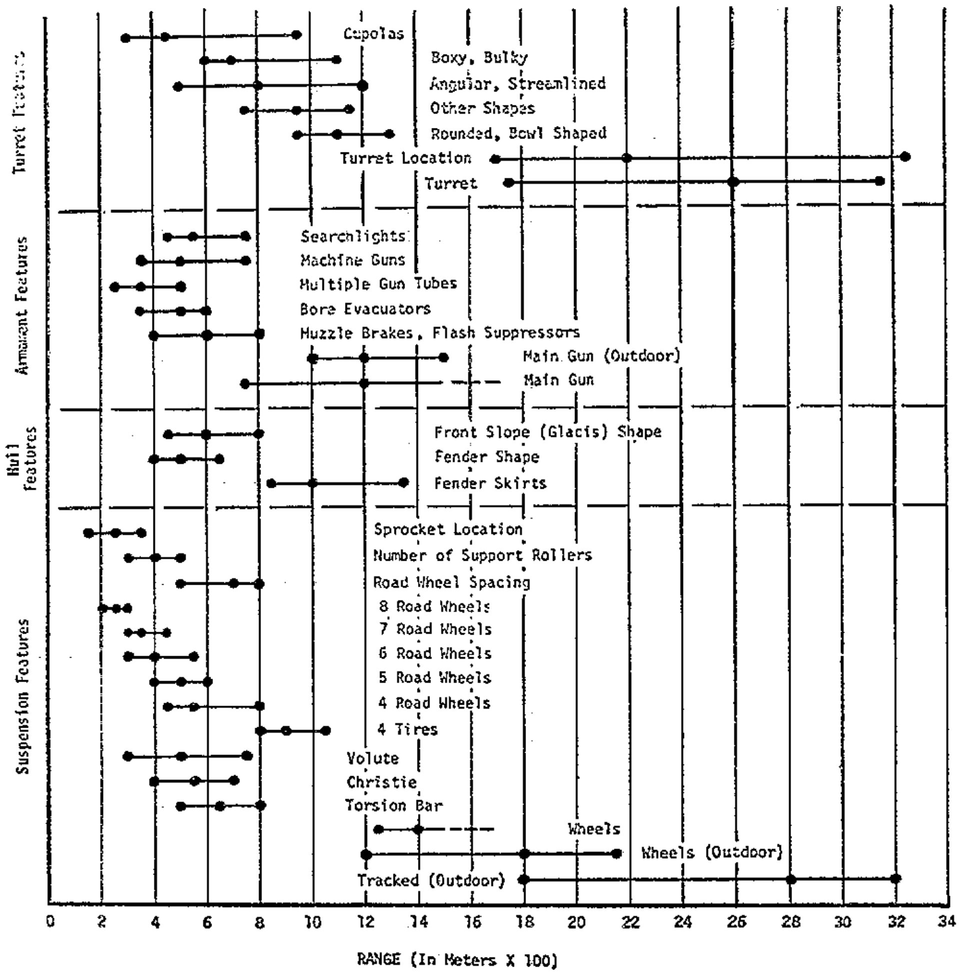

Figure 4. DETECTION RANGES FOR SELECTED VEHICLE FEATURES (FIGURE FROM FOSKETT, BALDWIN, AND KUBALA, 1978)

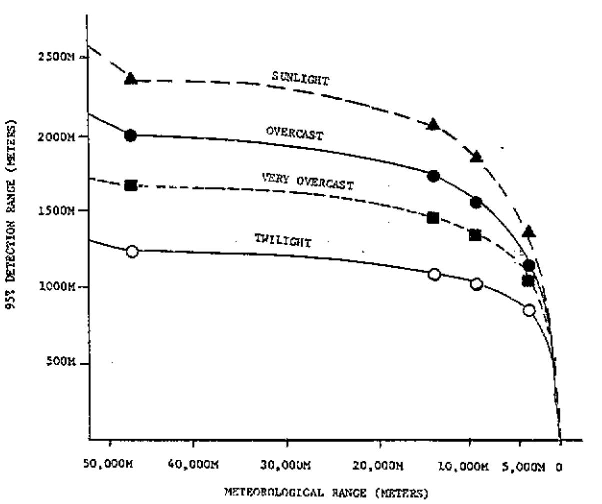

Figure 5. DETECTION RANGE AS A FUNCTION OF METEOROLOGICAL RANGE FOR CIRCULAR TARGET (AREA = 1 SQ. FT.) AGAINST SKY BACKGROUND. CURVES FIT BY HAND.

unnecessary to train target identification with more details than would be visible under ideal viewing conditions through an 8x sight at 2000m. Additionally, since any difference between target identification training at 2000 and 4000m proved to be small relative to other influences in the present research, only those that can be seen at 4000 meters with an 8x sight are necessary to include for practical training purposes. Since this research did not address training with even fewer features than those available at 4000 meters are necessary for reliable identification, until further research is conducted.

Several questions yet remain to be answered that may have an impact on future target identification training programs. What is the impact of including more features than are available at 2000m? Is it feasible to consider beginning target identification training with highly detailed vehicle representations, and systematically reduce the detailing until vehicles can be identified based on minimal information? Finally, a better understanding of the impact of time constraints during target

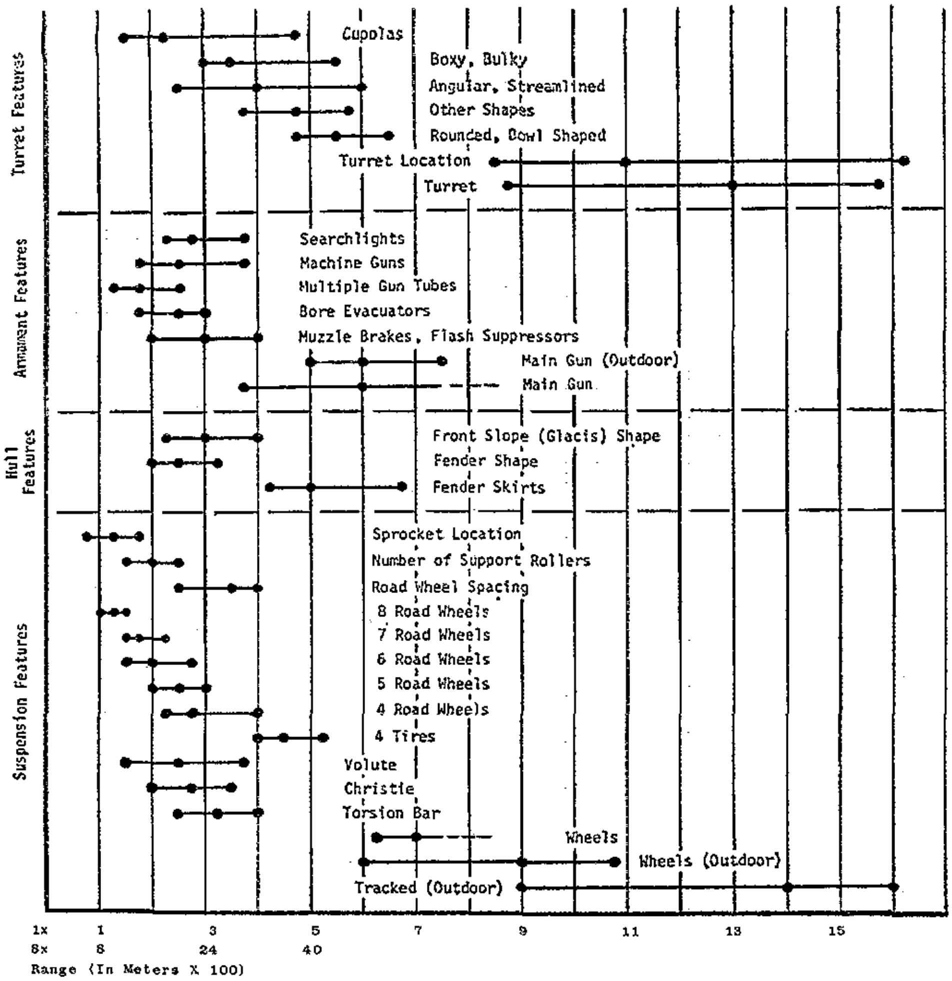

Figure 6. ESTIMATED DETECTION RANGES FOR VEHICLE FEATURES SELECTED BY FOSKETT ET AL. UNDER OVERCAST CONDITIONS, WITH 5 KM VISIBILITY

identification and the impact of observers' criteria may yield information about practical aspects of target identification that have yet to be considered.

REFERENCES

(1) US Army, The Tank and Mechanized Infantry Company Team Field Manual 71-1. Washington, DC: Headquarters, Department of the Army, June 1977.

(2) Combat Vehicle Identification Training Program. Alexandria, VA: US Army Research Institute (Ft. Hood Field Unit), 1979.

(3) Kirk, R. E. Experimental Design: Procedures for the Behavioral Sciences. Belmont, CA: Wadsworth Publishing Company, Inc., 1968.

(4) Foskett, R. J., Baldwin, R. D., and Kubala, A. L., The Detection Ranges of Features of Armored Vehicles (ARI Technical Report TR 78-837). Alexandria, VA: US Army Research Institute, November 1978.

(5) Middleton, W. E. K. Vision Through the Atmosphere. Toronto, Canada: University of Toronto Press, 1952.

(6) Kottas, B. L., and Bessemer, D. W. Detectability of Armored Vehicle Features, (ARI Working Paper, under review). Alexandria, VA: US Army Research Institute (Ft. Knox Field Unit).

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