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PERCEPTIBILITY OF MILITARY VEHICLE SILHOUETTES

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A series of experiments was conducted to assess human performance measures of the perceptibility of four current and proposed tracked vehicle designs as viewed through a simulated sensor system. Subjects were trained to identify silhouettes of four tracked and four wheeled military vehicles. Each of these targets was embedded in one of 12 levels of white noise, that is, the signal-to-noise (SNR) ratio. Subjects' identification responses were analyzed to produce three SNRs for each target at which targets were barely detectable, recognizable as to target type, or identificable as a specific target. Analyses of the data indicated that the relative perceptibility of each target depended largely upon the number of features that it shared in common with other targets in the expected target set.

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A second experiment explored whether eye movement behavior could determine which target silhouette features appeared to be most critical to target discrimination. The forced choice responses of 22 subjects from the first experiment were analyzed to determine for each individual the specific SNR for detection, recognition, and identification for each of the eight targets. These 24 images were again shown for 5 seconds each, and eye movements were recorded during the examination. Subjects were then asked to discuss target images in terms of what they thought were important to them in the identification process. Results indicated that the pattern of visual attention for the Bradley differed from the other tracked vehicles. Additionally, there did not appear to be any systematic match between strategies that subjects indicated they were using to identify targets and where they might have actually looked. These results were interpreted to mean that the pattern of visual attention is perceptually driven, whereas target identification per se is a cognitive function.

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EXECUTIVE SUMMARY

It is of interest to designers of military tracked vehicles to ascertain what, if any, particular design features are more or less perceptible when viewed through electronic imaging devices. Electronic sensing devices may enable an observer to detect a target that may not be apparent through a direct visual system. The target signature (i.e., those specific characteristics of the target that are used for target identification) may be degraded or modified by the imaging process, however. A series of experiments was conducted to assess several human performance measures of the perceptibility of four current and proposed tracked vehicle designs as viewed through a simulated sensor system.

Subjects were trained to identify silhouettes of four different tracked and four different wheeled military vehicles. After training to criterion, each subject was shown 96 slides in random order. Each slide contained one of the eight target silhouettes embedded in one of twelve different levels of white noise, that is, the signal-to-noise ratio (SNR). Subjects' responses were analyzed to produce three SNRs for each target at which targets were just barely detectable or recognizable as to target type (i.e., tracked versus wheeled) or identifiable as a specific target (e.g., Abrams). Analyses of the data indicated that the relative perceptibility of each target depended largely upon the number of features that a target shared in common with other targets in the expected target set.

A second experiment was performed to ascertain whether eye movement behavior could be useful in determining which target silhouette features appeared to be the most critical to the target discrimination task. In addition, Experiment II also explored how well observers' verbal descriptions of which target features they thought were most critical for target identification agreed with the features indicated by their eye movements.

The forced choice responses of 22 subjects from the first experiment were analyzed to determine for each individual the specific SNR for detection, recognition, and identification for each of the eight targets. These 24 slides were shown for 5 seconds each in random order, and subjects were again required to locate and identify the targets. The subjects' eye movements were recorded during their examination of these slides. Following this identification task, subjects were asked to discuss target slides in terms of the target features that they thought were important to them in the identification process.

The results indicated that the pattern of visual attention for the Bradley differed from the other tracked vehicles both as a function of threshold level and as a function of cellular distribution. In addition, there did not appear to be any systematic match between the strategies that subjects indicated they were using to identify targets and where they might have actually looked. These results were interpreted to mean that the pattern of visual attention is perceptually driven, whereas target identification per se is a cognitive function.

PERCEPTIBILITY OF MILITARY VEHICLE SILHOUETTES

INTRODUCTION

Some electronic imaging devices are used to scan or search areas for targets of potential interest. These devices may enable an observer to detect a target that may not be apparent through a direct visual system. For example, forward looking infrared (FLIR) sensors allow target search and acquisition activities during periods of low light levels as occur on dark nights and in areas where smoke obscurants have been used. In addition, proposed Army systems such as aided or automatic target recognition devices require the use of electronic imaging devices. The target signature (i.e., those specific characteristics of the target that are used by an observer for target identification) may be degraded or modified by the imaging process, however. Therefore, it was of interest to designers of military tracked vehicles to ascertain what, if any, particular design features were more or less perceptible when viewed through electronic imaging devices.

To that end, Gerhart, Graziano, and Carter (1983) of the U.S. Army Tank-Automotive Command (TACOM) reported a methodology they developed for embedding a prepared image of a vehicle silhouette in a background of digitally generated noise which could be quantitatively measured and would simulate a sensor system. To assist in this program of vehicle design optimization, experiments were conducted by the Visual Performance Team of the U.S. Army Human Engineering Laboratory (HEL) to assess several human performance measures of the perceptibility of four current and proposed tracked vehicle designs under varying noise levels.

OBJECTIVES

The primary objective of the first experiment was to determine the relative levels of detection, recognition, and identification of these four vehicle designs when embedded in a field of gaussian noise as generated by the TACOM methodology. It was assumed that the cognitive processes of detection, recognition, and identification of a target followed a continuum. Detection was defined as the perception of a possible target before recognition of the target type. Recognition was defined as perception of the target type or category (i.e., a tracked vehicle versus a wheeled vehicle). Finally, identification was defined as the determination of the specific target name (e.g., Abrams).

A second experiment was performed to ascertain if eye movement behavior could be useful in determining what, if any, target silhouette features appeared to be the most critical to the target discrimination task. Further, Experiment 2 tried to explore how well observers' verbal descriptions of which target features they thought were the most critical for target identification agreed with the features indicated by their eye movement recordings.

EXPERIMENT 1

Method

Subjects

Forty-two military personnel in the United States Army were selected as subjects in the experiment. All subjects were assigned to the Ordnance Center and School for training courses. The subjects were between the ages of 17 and 32 with a mean age of 20.7 years. Their educational levels ranged from completion of 10th grade to completion of a 4-year college program. The time in service ranged from 2 months to 6 years with a mean of 17.1 months. All subjects had normal acuity for near vision. Data from 10 of the original population of 42 were eventually excluded from the data analyses because they could not successfully learn all the names of the target vehicles used in the experiment.

Materials

Target images were combined in real time on a video monitor with digitally generated gaussian noise to produce images of vehicle silhouettes embedded in static, homogeneous white noise. The target silhouettes had a gray level value of 180 and a background gray level of 150 in which 0 is black and 255 is white. Twelve distinct signal-to-noise ratios (SNRs) were chosen from a continuum of values ranging from 0.111 to 0.902 in increments of 0.072. These 12 levels of signal to noise were determined during a pilot investigation to cover the entire range within which targets are not detectable to targets being identifiable. Eight different target silhouettes were combined with each of the 12 SNRs for a total of 96 video images which were then copied onto 35-mm Kodak Ektachrome film. The resulting 2- by 2-inch transparencies became the stimulus slide set used for the experiment.

The eight target silhouettes used were all side views of each of four tracked vehicles and four wheeled vehicles and are shown in Figure 1. The tracked set consisted of (a) the Abrams tank, (b) the Bradley fighting vehicle, (c) a tank test bed, and (d) a concept vehicle, the last two of which were currently being designed at TACOM. The wheeled set consisted of (e) a carrier vehicle for a Vulcan missile system, (f) a high mobility multi-purpose wheeled vehicle (HMMWV), (g) a heavy-duty forklift, and (h) an armored personnel carrier. Image sizes of the vehicle silhouettes were normalized so that when projected, they would subtend identical viewing angles.

There were eight fixed random target locations uniformly distributed within each quadrant of the viewing area, giving a total of 32 possible target locations. In addition, individual targets appeared equally often in each quadrant, and each of the 12 SNRs was used equally often in each quadrant. Eight different static noise pattern images, which were initially combined with the target vehicle images, were also used equally often for each target image and in each quadrant.

Apparatus

Stimulus slides were rear-projected onto a viewing screen by two Kodak Carousel projectors fitted with shutters linked to an experimenter's control unit. Each subject sat alone in a semi-darkened viewing studio at a

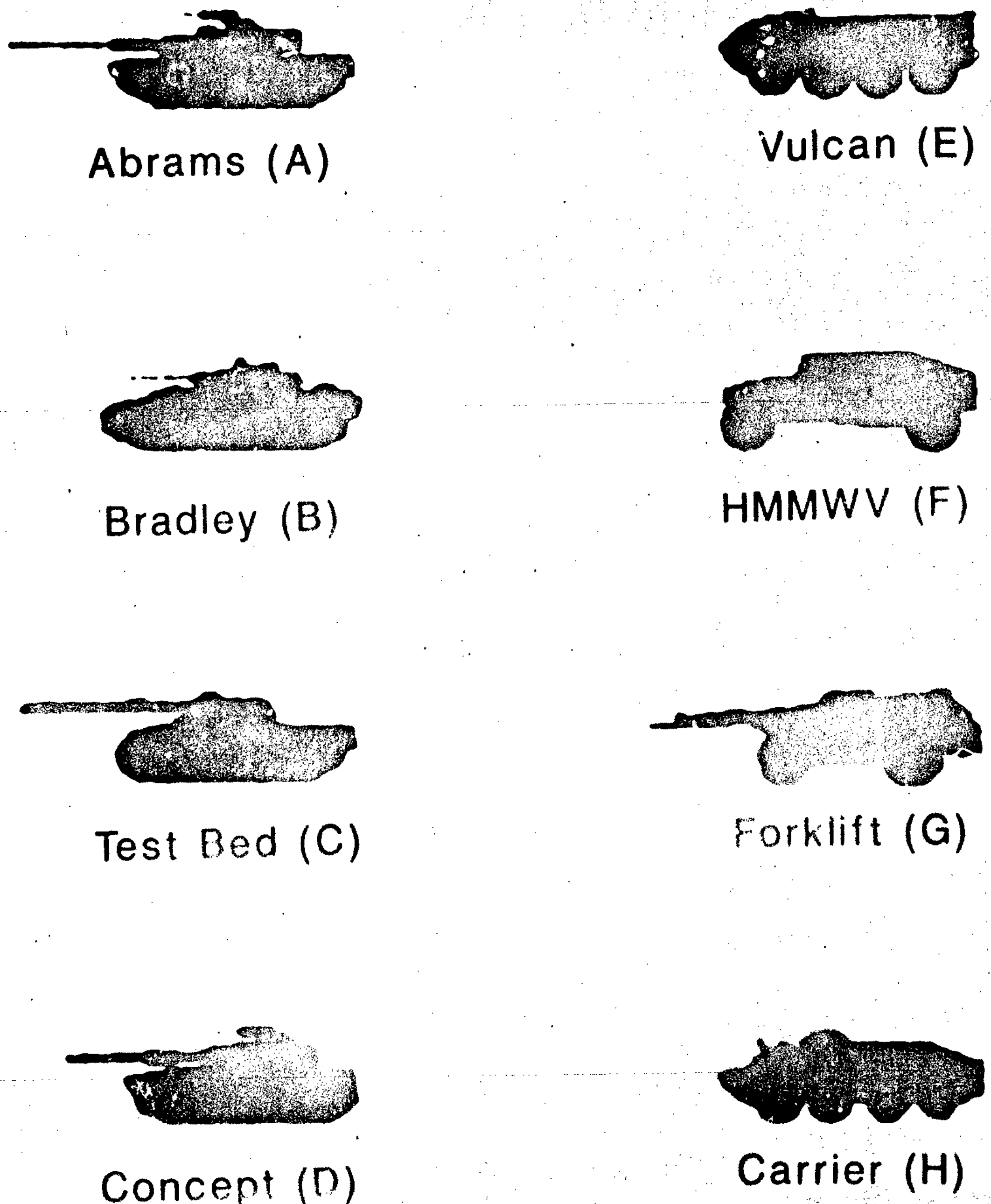

Figure 1. Target silhouettes of four tracked and four wheeled vehicles.

distance of 1.75 meters from the screen. The total viewing area of the screen subtended a visual angle of 20° horizontally and 20° vertically. The size of any given target vehicle silhouette subtended visual angles of 3.3° horizontally and 1° vertically. The subject indicated various responses to the stimuli via a hand-held response button and an audio communication link with the experimenter.

Procedure

Subjects were first briefed about the nature of the experiment and how they were to participate in it. They then filled out a questionnaire requesting demographic information such as age, educational level, military occupational specialty (MOS), time in service, and visual acuity, and subsequently were seated individually in the viewing studio.

Training was in three parts. For the familiarization phase, the experimenter showed each subject the complete set of targets that would be used, pointing out which targets were tracked and which were wheeled. In addition, the subjects were shown some of the silhouettes embedded in different levels of noise.

The learning phase occurred during the next 10 minutes and was devoted to teaching each subject the names of each of the eight target vehicles used in the experiment. Half the subjects learned the names of the tracked vehicles first, followed by the names of the wheeled vehicles, while the order was reversed for the remaining half of the subject population. During this training phase, all target images were shown without visual noise. First, each target was shown alone and the subject was required to repeatedly verbalize the target name. Second, all four tracked or wheeled vehicles were shown together while the subject correctly named each target. Incorrect responses were immediately corrected by the experimenter, and the set of targets was shown again in a different order. This procedure was repeated until the targets could all be successfully named quickly and without prompting by the experimenter. Third, after learning the target names, the subjects were given a recall test consisting of a total of 24 slides (three slides of each of the eight targets) in random order. As a criterion for further participation in this experiment, subjects had to score at least 13 correct of the 24 slides. Thirty-two of 42 subjects met this criterion with a mean score of 19 correct. After this pre-test, two more target reviews were given, in which the subjects were required to identify the targets by name with correction by the experimenter until all targets could be correctly identified.

During the final training phase, instructions about the response procedures were given. This was then followed by a third review of the target names. A practice test was given about eight target silhouettes embedded in different levels of visual noise. The subjects' task was defined to be simply, "when shown a target slide, find the target, identify it as quickly and accurately as possible, then press a response button, and verbally report the target's identity and quadrant location." The subjects were instructed to respond "not visible" if absolutely no target could be discerned and to make a best estimate of the identity of the target if the information was insufficient to positively identify the target.

After the practice session, each subject was shown the 96 test slides (i.e., the eight targets each embedded in 12 levels of noise) in a different random order. A maximum of 25 seconds was allowed for subjects to respond to any given test slide.

After the experimental session was completed, each subject was given approximately a 1-hour rest period before being used as a participant in a second experiment.

Results

All target name and location responses were recorded. Although 25 seconds were allowed for response time to a target slide, it was noted that the mean response time for the 96 slides for the 32 subjects was 4.5 seconds, with a standard deviation (SD) of 1.6 seconds.

Table 1 shows the response selection frequency across the 12 slides of each of the eight targets. For 32 subjects, the frequencies are expressed as the percent of 384 total possible responses per target. Although "do not know" was not a valid response in the forced choice paradigm, this occurred primarily for SNRs just following SNRs that received "not visible" responses and were accompanied by correct location responses making them equivalent to nonspecific target responses.

Table 2 shows the category response selection frequency across the 12 slides of each of the eight targets. Again, for the 32 subjects, the frequencies are expressed as the percent of 384 total possible responses per target.

After a subject completed the experimental session, the 96 verbal responses were sorted by target type. The 12 responses obtained for each target were then ordered from the lowest to the highest SNR, and the three threshold SNRs were determined from the responses received.

The detection threshold slide was defined as the slide with the lowest SNR where the subject response changed from "not visible" to any target response with a correctly reported location. The recognition threshold slide was defined as the lowest SNR slide where the response changed from incorrect target responses in an incorrect category (i.e., tracked or wheeled vehicle categories) to incorrect target responses in the correct category. The criterion for deciding where the response change occurred was that when proceeding through increasing SNRs, the consecutive number of correct category responses had to be at least two and be followed by (if at all) no more than one less than the same number of consecutive incorrect responses. If such was the case, the lowest SNR slide of the string of correct category responses was defined as the recognition threshold slide.

The identification threshold slide was defined as the lowest SNR slide where the response changed from incorrectly identified targets to correctly identified targets. Determination of where the change occurred employed the same rules used in determination of the recognition threshold.

The SNR for the detection, recognition, and identification slides was averaged across 32 subjects for each of the eight targets and is shown in Table 3.

Table 1

Response Selection Frequency as Percent (N=384) of Possible Responses Given any Target Slide

Target presented	Not visible	Do not know	Abrams	Bradley	Test Bed	Concept	Vulcan	HMMWV	Fork-lift	Carrier
	Percent of Responses									
	Response									
Abrams	19.0	1.8	28.6	15.1	12.8	18.2	1.0	0.3	1.8	1.3
Bradley	26.3	2.9	9.1	36.2	2.3	8.1	4.7	1.3	0.8	8.3
Test Bed	22.4	2.3	8.1	3.6	48.7	6.8	1.6	0.5	2.9	3.1
Concept	24.0	3.4	21.9	18.0	4.9	22.4	0.5	0.0	1.8	3.1
Vulcan	21.4	2.6	2.6	6.5	1.8	1.0	38.3	1.6	0.5	23.7
HMMWV	24.5	2.3	0.3	1.3	0.3	0.5	1.8	59.4	3.9	5.7
Forklift	21.6	2.3	1.8	1.3	2.9	2.3	3.1	2.1	57.3	5.2
Carrier	19.0	2.1	3.1	7.0	1.0	2.1	14.6	6.3	1.0	43.8

Note. Underlined values are correct responses.

Table 2

Category Response Selection Frequency as Percent (N=384) of all Possible Responses

	Percent of Responses	
	Target Response	
Target presented	Tracked vehicle	Wheeled vehicle
Abrams	74.7	4.4
Bradley	55.7	15.1
Test Bed	67.2	8.1
Concept	67.2	5.5
Mean tracked	66.2	8.3
Vulcan	11.9	64.1
HMMWV	2.4	70.8
Forklift	8.3	67.7
Carrier	13.2	65.7
Mean wheeled	9.0	67.1
Mean tracked and wheeled	37.6	37.7

Note. The percentages do not total 100% because "not visible" and "do not know" responses were not included.

Table 3

Mean Signal-to-Noise Ratio Threshold

Target	Threshold					
	Detection		Recognition		Identification	
	Mean SNR	SD	Mean SNR	SD	Mean SNR	SD
Abrams	3.3	0.75	4.2	0.58	11.0	2.67
Bradley	4.1	0.80	7.0	2.00	9.8	2.42
Test Bed	3.3	0.80	5.8	1.19	7.3	2.12
Concept	3.9	1.01	4.8	1.39	11.8	2.10
Total tracked	3.7	0.84	5.8	1.54	10.0	2.33
Vulcan	3.5	0.79	5.7	2.48	10.0	2.27
HMMWV	3.9	0.86	4.5	0.75	6.0	1.90
Forklift	3.3	0.81	5.8	2.56	7.0	2.29
Carrier	3.2	0.44	5.8	2.02	8.5	3.07
Total wheeled	3.5	0.73	5.2	1.95	7.9	2.39

Discussion

It can be seen in Table 2 that the general distribution of responses to tracked vehicles (66.2% and 8.3%, correct and incorrect category responses, respectively) is essentially identical to that for wheeled vehicles (67.1% and 9.0%, correct and incorrect category responses, respectively). Any differences pertaining to the two groups exist only within each category. For example, in Table 1, there is a mean of approximately 34% correct identifications for tracked vehicles (mean correct response = 28.6%, 36.2%, 48.7%, and 22.4%, for Abrams, Bradley, Test Bed, and Concept, respectively), whereas for wheeled vehicles, there is a mean of approximately 50% correct identifications (mean correct response = 38.3%, 59.4%, 57.3%, and 43.8%, for Vulcan, HMMWV, Forklift, and Carrier, respectively) showing that as a group, the wheeled targets were more easily identified. The reason for this is probably because of much greater similarity between targets in the tracked group giving rise to greater confusion than in the wheeled group. The reason for confusion between two targets in a set depends not only upon the amount of features they jointly share, but also upon how the features are being shared with other targets in the set. One might normally think that if two targets look alike, presenting either one will elicit response frequencies equally distributed between the two. This is not necessarily the case. In the data in Table 1, when the Abrams was shown, many more responses of Abrams were elicited than Concept responses (mean correct responses = 28.6% and 18.2%, for Abrams and Concept, respectively). However, when the Concept was shown, Abrams and Concept responses were equally elicited (mean correct responses = 22.4% and 21.9%, for the Abrams and Concept, respectively). The reason for this is that in the context of the entire set of tracked vehicles, the Abrams' confusion is primarily shared with three other targets, whereas the confusion concerning the Concept is primarily shared with only two other targets. Basically, the distribution of confusions within a set of stimuli must be interpreted in terms of the entire stimulus context.

To further demonstrate the nature of target confusions and to show how the distributions of all responses to each target change across SNRs, Figures 2 and 3 were plotted. The curves shown are based on the means of the response frequency data for each of six pairs of SNRs (1+2, 3+4, 5+6,...,11+12), so that the resultant smoothing process would illustrate the global changes of the relative response frequencies and minimize the masking effect of slides that exhibited anomalous response frequencies. The curve labels A through G refer to targets A through G. For a tracked vehicle, the curve labeled O represents the total number of wheeled vehicle responses given. Conversely, for a wheeled vehicle, the curve labeled O represents the total number of tracked vehicle responses given.

It can be seen from Figures 2 and 3 that in general, as SNRs increase, correct identification responses increase continually, while most incorrect identification responses increase to a point and then decrease. The multimodal appearance of some of the response frequency curves may be partly attributable to response frequency anomalies. It should be noted that in general, at the higher SNRs, finer details of the target silhouettes become more perceptible, whereas at the lower SNRs, gross target features such as basic mass and shape are the only perceptible features. Consequently, as the SNR increases, the nature of the target feature competition changes as well. More specifically, it can easily be seen in Figures 2 and 3 that the Test Bed, HMMWV, and Forklift are the least frequently confused with the other targets and that the confusion is primarily at the lower SNRs. In contrast, confusion between Abrams and Concept can be seen at all SNRs.

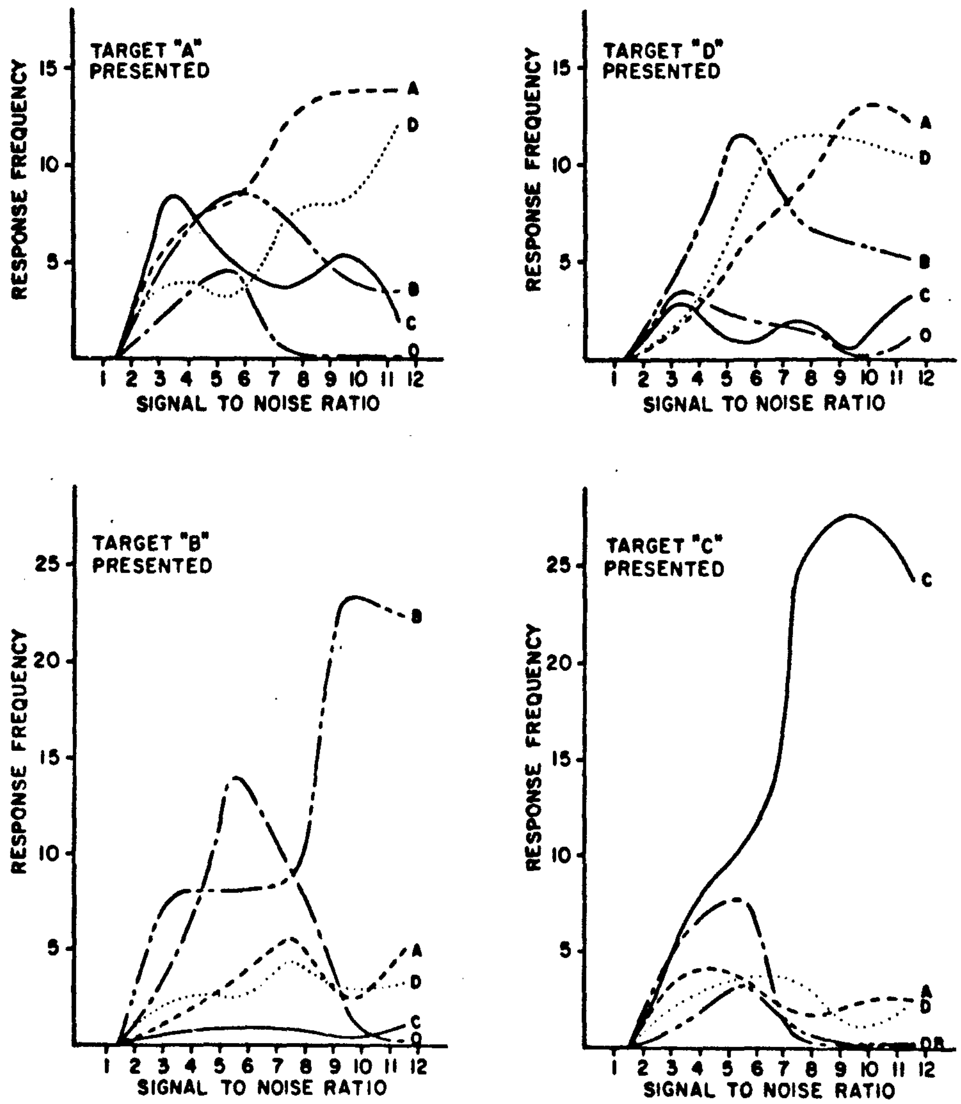

Figure 2. Approximated curves of correct and incorrect target identification responses for all SNRs (N=32 Ss) of tracked vehicles (targets A through D).

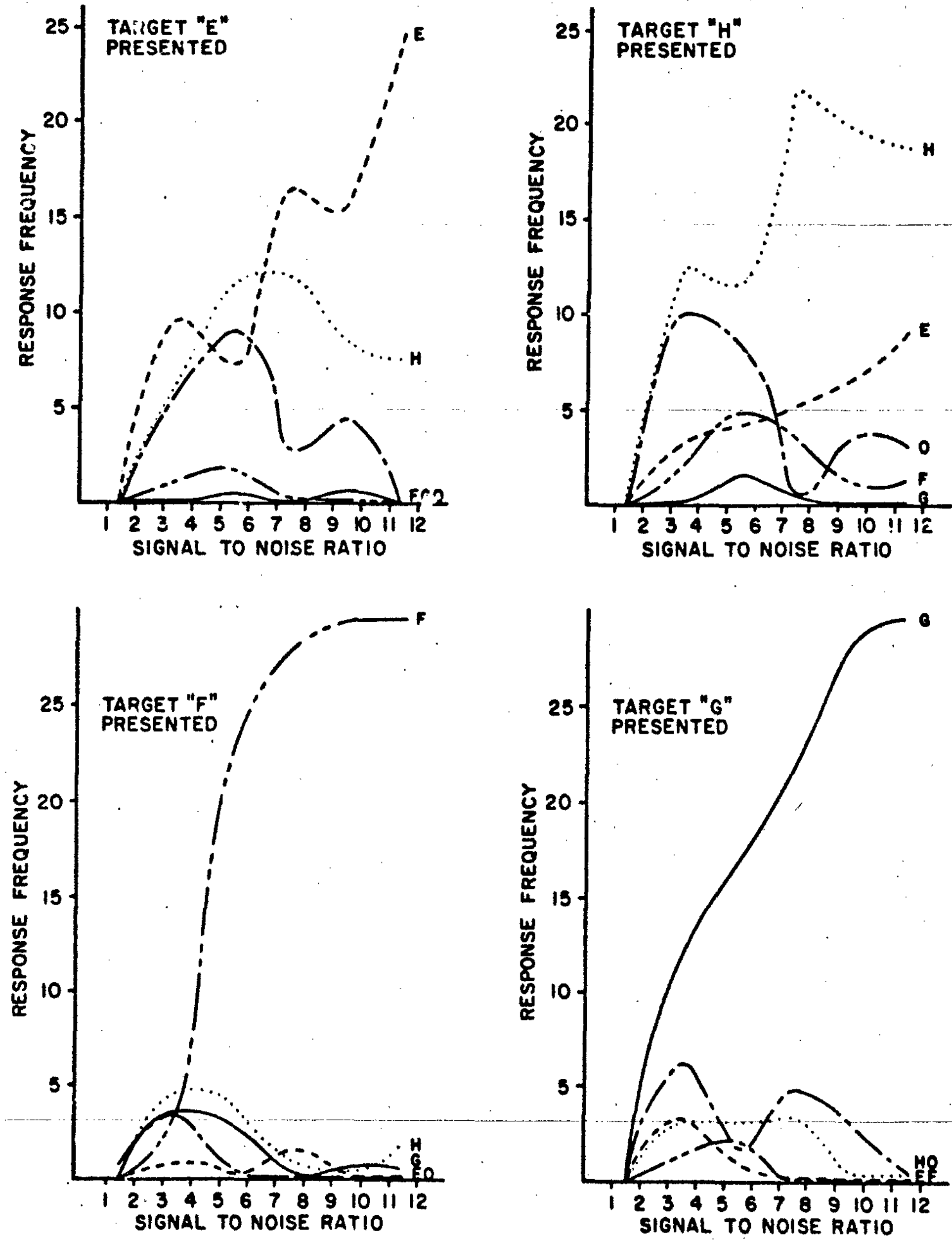

Figure 3. Approximated curves of correct and incorrect target identification responses for all SNRs (N=32 Ss) of wheeled vehicles (targets E through H).

The need to smooth the data as shown in Figures 2 and 3 comes from the presence of slides in the stimulus set that elicit anomalous response frequencies. An anomalous stimulus slide was defined as one for which the frequency of identically correct or identically incorrect responses to that slide is extremely high or extremely low when compared to the frequencies of responses to higher and lower SNR slides of the same target. A label of "anomalous" data is, of course, a consideration of context and is based on the assumption that data will generally align themselves as shown in Figures 2 and 3. But if, for example, a large percentage of the subject population agrees on the correct identity of a target when the next lower SNR or next higher SNR slides elicit little or no agreement on the correct identity, then the response frequencies for that slide would be considered anomalous.

On average, two anomalous slides per target set were found. Thirteen of the 16 slides defined as anomalous elicited extremely high response frequencies for primarily one incorrect response to any particular slide. Three of the anomalous slides elicited extremely high correct response frequencies seemingly out of context with neighboring tallies. The anomalies were found between SNRs 3 and 11 with more than 50% of them between SNRs 4 and 6. The actual slides where very high percentages of agreement occurred among subjects on the same incorrect response were examined. It was concluded that if a large number of independent observers agree on the identity of a target, even if they are wrong, it is probably because the target really does look like the agreed-upon identity and not because of some error of perception.

The main source of the anomalous response frequencies appears to be the white noise field and its relationship to the angular extent of the targets. There is a direct relationship between the apparent grain size (comprised of random pixel clusters in a video image) of the white noise texture and the size of the silhouette edge details that are critical to their discrimination. This relationship, when combined with the fact that the noise background of the stimuli is static in nature, thus producing a fixed image of the granular texture, generates a condition in which on a "micro" level, the noise itself provides images that may compete with portions of the target image. One of the most surprising aspects of the power of this effect is that qualities of the static noise not only mask target features by occluding them, but can also add apparent features to a target, thereby making it look like another target in the set. It is counter-intuitive for an observer to allow for the possibility that a gun tube seen on a vehicle silhouette is an effect of the background noise and not a part of the target at all. This finding may have some relevance to camouflage techniques. With respect to reduction in target identification thresholds, it may be much more effective under certain conditions to make the target appear to be something else by adding features of other targets to it, than to try to mask its distinguishing features by simply covering them or breaking up their outlines.

Table 3 needs to be explained in light of the previous discussion of the nature of confusions between targets and the occurrence of anomalies. As previously mentioned, the bulk of the anomalous slides were found at SNRs 4 through 6. Since this range is also the range of all the recognition thresholds shown in Table 3, we must be quite conservative in our interpretation of them. As we have defined it, a recognition threshold is solely determined by the quantity and primarily the distribution of the cross-category responses to a target. Any confusions between targets of different categories sharing similar features will, by definition, increase the incorrect category response frequency of those targets, and hence, tend to inflate their recognition thresholds. Such is the case with the Bradley which exhibits the highest recognition threshold. Table 2 indicates that when the

Bradley is presented, an extremely high cross-category response frequency is elicited. In Figure 2, it can be seen that the peak of the cross-category confusion occurs at SNRs 5 + 6, and Table 1 indicates that the cross-category responses are primarily Vulcan and Carrier. The implication is that the Bradley's gross features of mass and shape are seen to be confused with those features of Vulcan and Carrier to SNR 6 where supposedly, enough finer details of the Bradley are visible to make a more positive identification. The occurrence of anomalous response frequencies at those signal-to-noise levels probably contributed greatly to the inflated recognition threshold of the Bradley, however. The lowest recognition thresholds as found for the Abrams, the Concept, and the HMMWV are conversely a result of very low confusions with their incorrect categories. This factor is also echoed in Table 2 showing summary percentages within targets for incorrect category responses.

The identification thresholds shown in Table 3 primarily exhibit the effects of target confusions within the same category, although there is a small effect arising from cross-category responses. The Abrams and the Concept share more features than do any other target pairs resulting in thresholds that are almost off scale. Similar comments may be made about the Vulcan and the Carrier, although their confusion with each other is much less than the level of confusion of the Abrams with the Concept. The lowest identification thresholds of the Test Bed, the HMMWV, and the Forklift may be associated with the most unique target images, that is, those that share few or no features with the others.

The detection thresholds for all targets appear to be no different from each other. Apparently, being able to discriminate a target presence from the noise requires only the most minimal signal that any of the targets can supply. However, it is interesting to note that for the Abrams, the Concept, and the HMMWV, a mean of approximately 60% of the subjects had recognition thresholds that were identical to their detection thresholds for each of those targets. The implication is that even at the very lowest visibilities, category discrimination within the context of our target set is quite strong. More important considerations concerning detection thresholds ought to be examined in a context where non-targets may elicit competing responses.

One of the findings, albeit serendipitous, of this experiment is that a real problem could exist in stimuli that use static images of real scenes. In a visually degraded scene, the fixed nature of a noise background can create an apparent field of artifactual objects that may compete (depending on their size) with critical objects or features related to the identity of a target. The nature of the interaction between noise and target details, such as edges, can be quite subtle or very dramatic in their effect. The locale of the interaction within a viewing area is random and can probably occur at any SNR. The data variance introduced by such a highly specific interactive effect can be very detrimental to attempts to model target identification processes for aided target recognition systems, especially when the mean global statistical properties of an image are used to characterize its simulation. Some types of target sighting systems that require capturing and freezing a video frame of a real terrain for "off-line" analysis, as has been occasionally proposed, could also experience serious problems resulting from using frozen images of certain kinds of visual contexts.

EXPERIMENT 2

A second experiment was performed to ascertain if eye movement behavior could be useful in determining what, if any, target silhouette features appeared to be the most critical to the target discrimination task. Further, Experiment 2 tried to explore how well observers' verbal descriptions of which target features they thought were the most critical for target identification agreed with the features indicated by their eye movement recordings.

Method

Subjects

Thirty-two military personnel whose data were used in Experiment 1 participated in Experiment 2. The data from 10 of the Experiment 1 population were excluded from the final data analyses because of scheduling problems which did not allow the subjects time to complete the session or because of equipment problems.

The 22 subjects ranged in age from 17 to 32 with a mean age of 20.7 years. Their educational backgrounds ranged from completion of high school or a general equivalency diploma (GED) to a 4-year college program. Their time in service ranged from 2 months to 6 years with a mean of 19 25 months.

Materials

The set of stimulus slides used in this experiment was chosen from the entire set of stimulus slides used in Experiment 1. The forced choice responses of each subject were analyzed from Experiment 1 to determine for that individual the specific threshold slides for detection, recognition, and identification for each vehicle as described in the Results section for Experiment 1. Therefore, subjects were shown a set of 24 slides determined by their own detection, recognition, and identification levels for each vehicle.

Apparatus

Stimulus slides were projected using the same equipment as described in Experiment 1.

Eye movement recordings were made with an Applied Science Laboratories (ASL) corneal reflection system Model 1998. The system is video-based, sampling at a rate of 60 Hz. The accuracy of the system is $\pm 0.75°$, which is the largest expected difference or error between true eye position and mean computed eye position when the eye is stationary. In use, the subject's eye is illuminated with a filtered near-infrared (IR) light source producing a video image of a backlighted pupil. The point of gaze for each subject's eye is continually determined by the measurement of the center of the pupil with respect to the center of the corneal reflection of the IR source and the distance of the eye to the viewing screen. No physical constraints were imposed on the subject nor was s/he aware that the eye's point of gaze was being recorded. Except for the IR source, no portion of the ASL apparatus was visible to the subject.

Design

The design of the experiment incorporated three within-subject factors, as follows: (a) the threshold levels for target detection, recognition, and identification; (b) the target type (i.e., the Abrams, the Bradley, the Test Bed, and the Concept vehicles); and (c) the cell (i.e., one of nine specific sections of any given target area). The sections were determined by overlaying a nine-cell grid on the rectangular area a target occupied. All target areas were the same size.

Four dependent variables were measured, as follows: (a) the proportion of fixation time spent in the entire target area that was spent in each cell; (b) the verbal identification of vehicle type (i.e., Abrams, Bradley, Test Bed, or Concept); (c) the verbal reports of specific features that were thought to be most critical to the identification of each target; and (d) the frequency of fixations in each cell. Conceptually, the fixation is simply the period of time during which the point of regard of the eye is relatively stationary. Karsh and Breitenbach (1983) report a detailed description of the fixation algorithm used for this experiment.

Procedure

Approximately 1 hour after completing Experiment 1, each subject was again individually seated in the viewing studio. During the first 1 to 2 minutes of the experimental session, subjects performed various search tasks during which time, the eye position was calibrated.

After the calibration procedure, a review of the target silhouettes was given. Each subject was shown two slides of all eight target silhouettes in different orders and was asked to name each target. Following this review, instructions for the next phase of Experiment 2 were given. The subjects were told that they would be shown a series of slides which they had seen previously in the first experiment. Each slide was to be shown for 5 seconds, and the subject's task was to silently examine the slide and to identify the target. After this slide was viewed, another slide of a cross in the center of a blank screen would automatically appear. During the time that the cross was on the screen, the subject was instructed to verbally identify the target to the experimenter. When the subject indicated that the directions were understood, the set of 24 slides representing that subject's detection, recognition, and identification threshold slides for each target was shown in random order following the described procedures.

When identification of the 24 slides was completed, verbal reports of specific features that the subjects thought they used to identify each target were elicited by the experimenter. For this, the 24 slides previously viewed were shown again. As each slide was shown to the subjects, they were asked specific questions to ascertain their opinion about features they personally thought were the most important ones that they had used to correctly identify that target. The questions were

1. What target do you think this image looks like?

2. Why? What is there about this image that makes you think it may be a _____?

3. What do you think is the most unique characteristic of this target?

4. What do you think is the most prominent feature?

5. How would you rate the ease or difficulty of identifying this target on a scale of 1 to 5?

Each subject's responses were recorded on audio tape.

Results

Eye Movements

The raw eye movement data were first processed into fixation locations and durations for each target slide and then plotted along two dimensions, as well as the known location of the target. Visual inspection revealed that fixations appeared to be generally grouped or "clustered" near the target. The fixations comprising these clusters were recorded as "target cluster" fixations and represented the location of the maximum accumulation of attention associated with the task of identifying the target. The distance of the target clusters from the target generally varied between 1.7° and 3.0° of visual angle. This would not have been an unusually large distance if the task involved searching for these pre-attentively discriminable targets. Search was not a factor in this task, however, because all the targets were above threshold as previously determined by the subject's own performance in Experiment I. For this simple target identification task, the magnitude and variability of these distances made the precise mapping of each fixation to a specific location on a target problematic. Since the area that each target covered was normalized for size, and mapping precision for this particular task was of low confidence, it was decided to examine the dynamics of a target cluster without mapping the fixations to the target silhouette. Thus, the target cluster was considered a self-contained unit of visual behavior, and factors such as the distribution of the number of fixations and their durations relative to the center of the cluster were the measures used to determine if stimulus field manipulations (i.e., the target differences) could be said to systematically affect the cluster dynamics. In other words, each target cluster was analyzed as though it were centered over the target area and that center were the spatial reference point for all measures of visual behavior.

Number of Fixations

The fixation frequencies were distributed in a 3 (Threshold) x 4 (Target) x 9 (Cell) completely crossed factorial. The threshold levels represented the SNR at which a target was detected, recognized, or identified. The target or vehicle type was the Abrams, the Bradley, the Test Bed, or the Concept. Only the eye movement data for the tracked vehicles were examined because of their specific research interest. Data pertaining to verbal target identification responses are included in other analyses, however. The cell levels were determined by superimposing a nine-cell grid over the fixation clusters. The grid size approximated the area of the normalized target silhouette areas. The nine cells were the top left, top center, top right, middle left, center, middle right, bottom left, bottom center, and bottom right (see Figure 4).

The data were analyzed using multivariate techniques on a repeated measures design. In the analyses, *a priori* contrasts between the various cell means, which represented the effects in an analysis of variance (ANOVA) model, were specified as the parameters to be entered in the analyses (SPSS-X, 1988). The description of main effects and interactions reported here identifies statistically significant differences between levels of an effect (see Appendix A). The F statistics are approximate based on Wilk's λ. Only those results pertaining to the research questions being investigated are discussed in detail.

The only main effect to reach statistical significance was for cell, $F(8, 14) = 46.11$, $p < .001$. The mean number of fixations in each cell is displayed in Table 4. Examination of the pattern of means shows that the largest number of fixations is in the center cell of the fixation clusters. Therefore, the more interesting contrasts to test appeared to be between cells on the periphery of the clusters. Statistically significant *a priori* contrasts are shown in Table 5. In general, more fixations appear to be in the center and middle cells than in the corner cells.

Table 4

Mean and Standard Deviation of the Number of Fixations in Each Cell

Top left	Top center	Top right	Top
0.14 (0.36)	0.62 (0.84)	0.27 (0.46)	1.03 (1.05)
Middle left	Center	Middle right	Middle (horizontal)
0.98 (0.89)	2.63 (1.48)	0.94 (0.98)	4.55 (2.27)
Bottom left	Bottom center	Bottom right	Bottom
0.24 (0.52)	0.63 (0.84)	0.17 (0.41)	1.04 (1.04)
Left	Middle (vertical)	Right	
1.36 (1.04)	3.88 (1.90)	1.38 (1.04)	

Note. Standard deviations appear in parentheses.

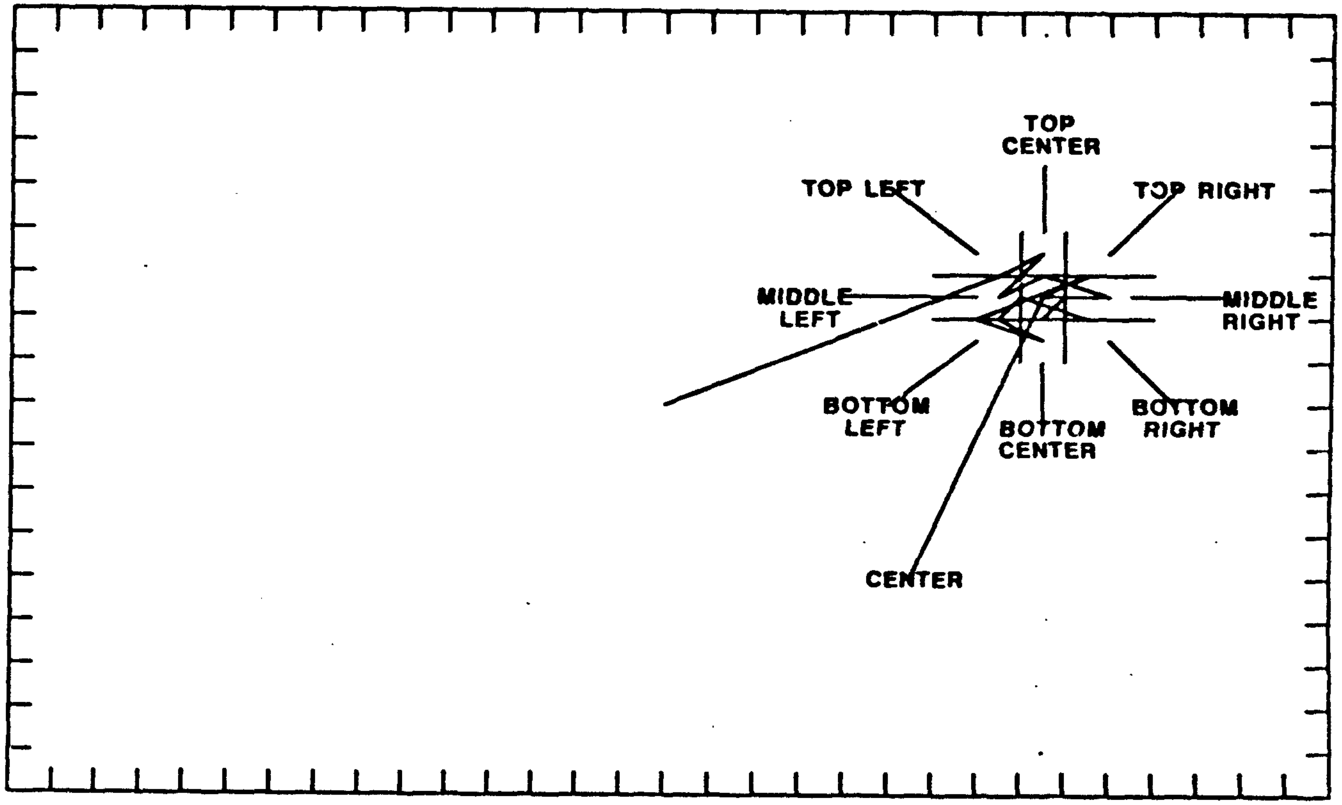

Figure 4. Distribution of nine cells in a cluster.

Table 5

Statistically Significant *a Priori* Contrasts Between Target Cluster Cells

A priori contrast	Significance test
Bottom left < Bottom center	$F(1,21) = 21.51, p<.001$
Top left < Bottom left	$F(1,21) = 4.77, p<.05$
Top left< Middle left	$F(1,21) = 100.00, p<.001$
Top left < Top center	$F(1,21) = 34.46, p<.001$
Top left < Top right	$F(1,21) = 15.87 = p<.001$
Bottom right < Top right	$F(1,21) = 6.33, p<.05$
Top right < Middle right	$F(1,21) = 18.56, p<.001$
Top < Middle (horizontal)	$F(1,21) = 168.06, p<.001$
Left < Middle (vertical)	$F(1,21) = 165.94, p<.001$

There was a statistically significant Threshold x Target interaction, $F(6,16) = 2.82, p<.05$. Figure 5 shows a plot of the mean number of fixations for each target for each threshold. Tables of statistically significant *a priori* contrasts are shown in Appendix B. The pattern of fixations for the threshold levels is very similar for the Abrams and the Concept. The Bradley appears to have the most dissimilar pattern of fixation frequencies when compared to the other vehicles. At both the detection and identification levels, fewer fixations are recorded for the Bradley than for the other vehicles. At the recognition threshold, however, a larger number of fixations is shown for the Bradley than for the other vehicles.

There was also a Target x Cell interaction, $F(24,504) = 4.01, p<.001$. The mean number of fixations for each cluster cell for each target are plotted in Figure 6. Tables of statistically significant *a priori* contrasts are shown in Appendix C. In general, it can again be seen that the greatest fixation frequencies occur in the center cells of the target clusters, while smaller frequencies occur in the top and bottom center cells with the corner cells receiving still smaller frequencies. Generally, the patterns of fixation frequencies show that they seem to be mostly directed along a horizontal axis through the middle cells of the cluster. The one exception to this pattern is the cluster associated with the Bradley. The distribution of fixations here appears to have attention directed mostly along a vertical axis in the middle center cells of the cluster.

Fixation Duration Time

The measure of fixation duration time as the proportion of the total fixation duration time for the entire target area that was allocated to

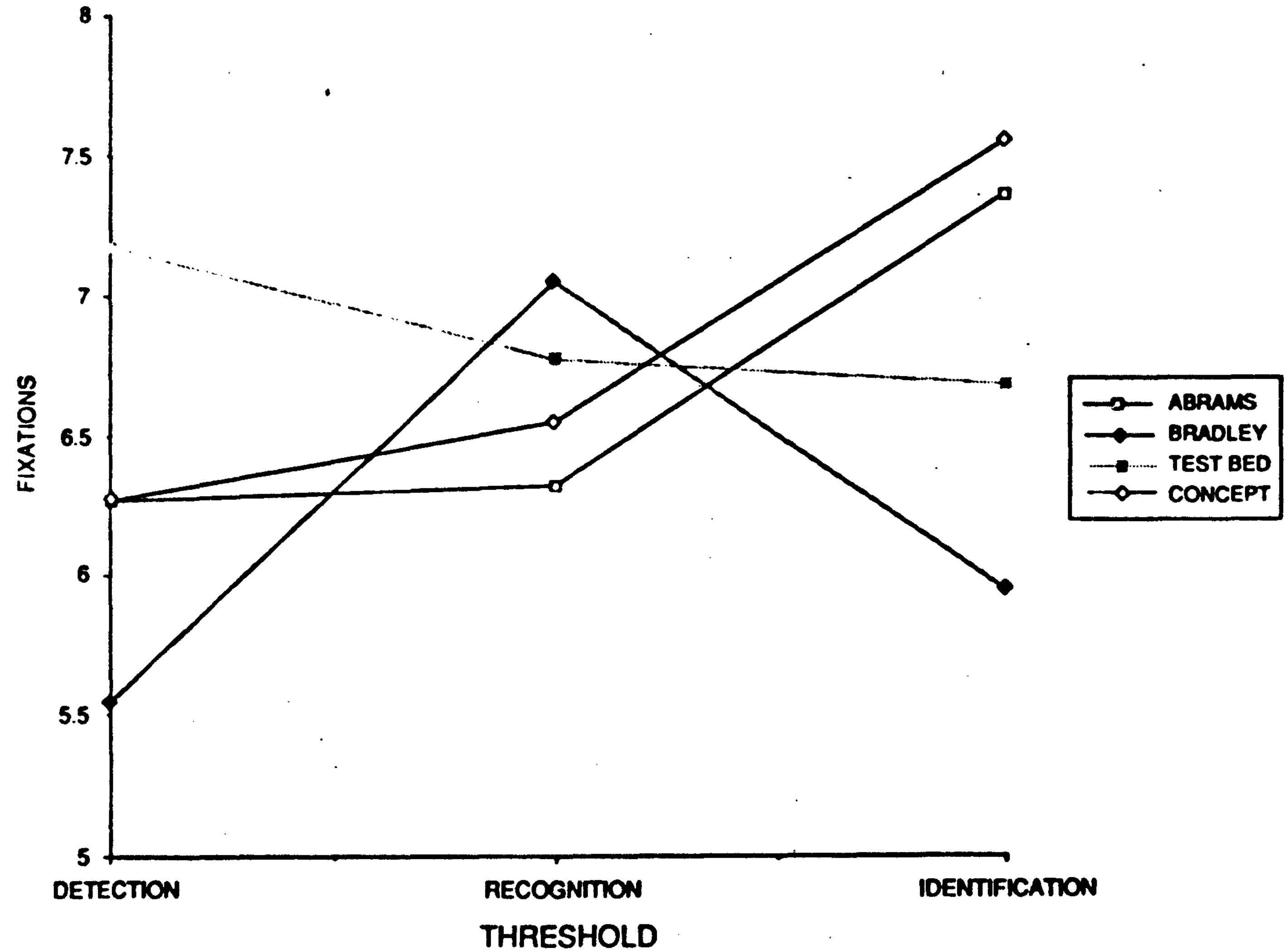

Figure 5. Mean number of fixations by target by threshold.

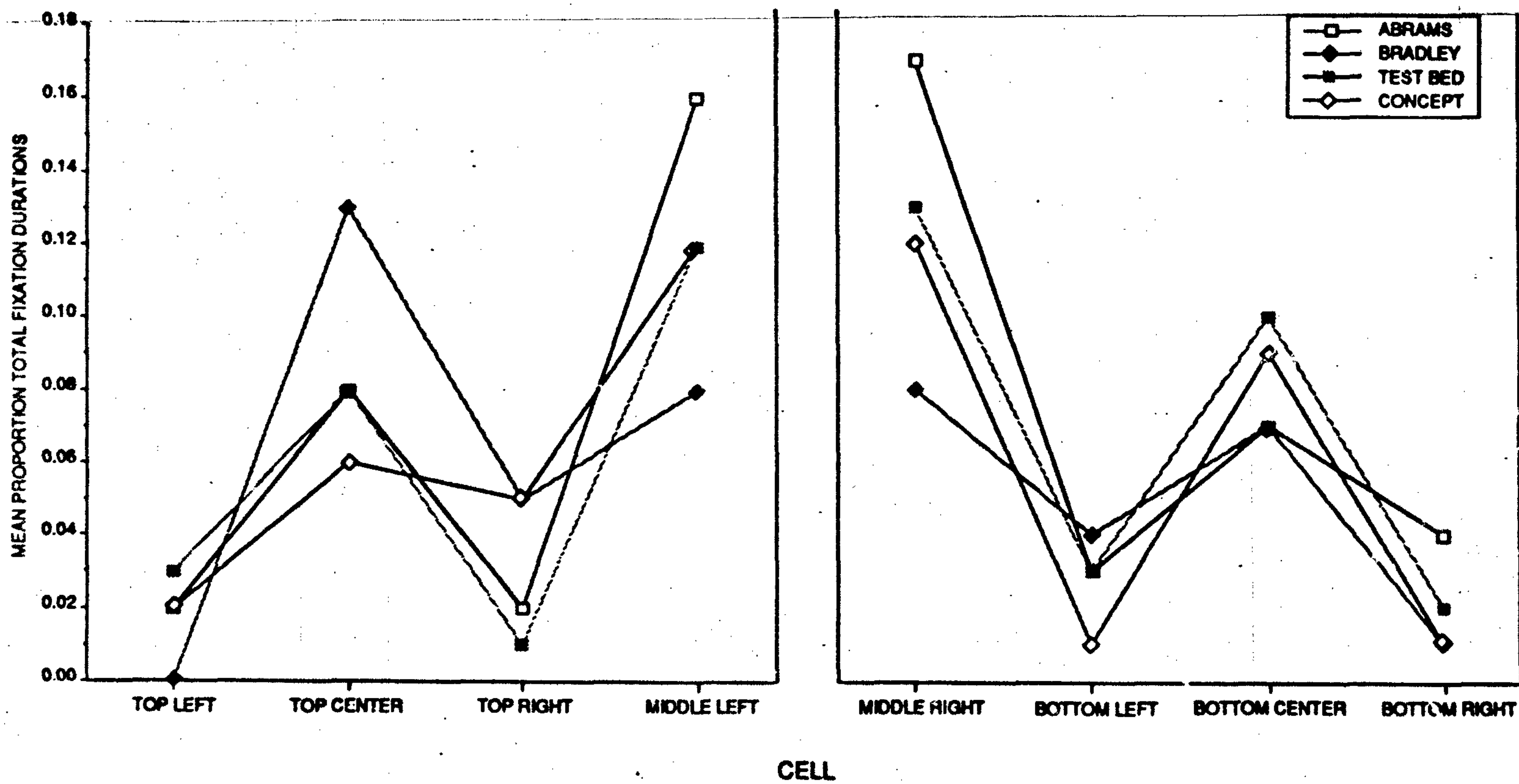

Figure 6. Mean number of fixations by target by cell.

each cell was distributed in the same 3 (Threshold) x 4 (Target) x 9 (Cell) completely crossed factorial as were the number of fixations. This measure was analyzed using multivariate techniques on a repeated measures design. Again, *a priori* contrasts between the various cell means, representing the effects in an ANOVA model, were specified as the parameters to be entered in the analyses (SPSS-X, 1988). As with the analysis of the number of fixations, the description of main effects and interactions reported here identifies statistically significant differences between levels of an effect (see Appendix D). Again, the F statistics are approximate based on Wilk's λ. Only those results pertaining to the research questions being investigated are discussed in detail.

The only main effect to reach statistical significance was for cell, $F(8,14)=100.00$, $p<.001$. The mean proportion of total fixation duration time allocated to each cell is displayed in Table 6. The distribution of proportion of total fixation duration time paralleled the distribution of the number of fixations. The largest proportion of time was devoted to the center cell of the cluster. Therefore, the *a priori* contrasts specified compared cells on the periphery of the cluster. Statistically significant *a priori* contrasts are displayed in Table 7. Again, similar to the pattern of number of fixations, more time proportionally appears to be devoted to the center and middle cells on the periphery than to the corner cells.

Table 6

Mean and Standard Deviation of the Proportion of Total Fixation Duration Time in Each Cell

Top left	Top center	Top right	Top
0.02 (0.04)	0.09 (0.14)	0.03 (0.09)	0.14 (0.17)
Middle left	Center	Middle right	Middle (horizontal)
0.12 (0.13)	0.46 (0.28)	0.13 (0.14)	0.70 (0.29)
Bottom left	Bottom center	Bottom right	Bottom
0.03 (0.08)	0.08 (0.15)	0.02 (0.07)	0.13 (0.18)
Left	Middle (vertical)	Right	
0.17 (0.15)	0.63 (0.26)	0.18 (0.16)	

Note. Standard deviations appear in parentheses.

Table 7

Statistically Significant *a Priori* Contrasts Between Target Cluster Cells

A priori contrast	Significance test
Bottom left < Bottom center	$F(1,21)=20.95$, $p<.001$
Top left < Bottom left	$F(1,21)=5.32$, $p<.05$
Top left < Middle left	$F(1,21)=93.35$, $p<.001$
Top right < Middle right	$F(1,21)=37.30$, $p<.001$
Top left < Top center	$F(1,21)=27.90$, $p<.001$
Top left < Top right	$F(1,21)=5.80$, $p<.05$
Top right < Top center	$F(1,21)=11.40$, $p<.01$
Top < Middle (horizontal)	$F(1,21)=198.74$, $p<.001$
Left < Middle (vertical)	$F(1,21)=142.58$, $p<.001$

Interpretation of this main effect is attenuated by the presence of a statistically significant Target x Cell interaction, however ($F(24, 504)=2.68$, $p<.005$). The mean proportion of total duration time for each cluster cell for each target is plotted in Figure 7. Tables of statistically significant *a priori* contrasts are shown in Appendix E. The distribution of visual attention by proportion fixation duration time parallels distribution of number of fixations. Again, the pattern of visual attention for the clusters associated with the Bradley appears to show the greatest differences when compared to the patterns associated with the other vehicles. Visual attention for the Bradley clusters seems to be along a vertical axis through the center of the clusters with more attention devoted toward the top of the clusters, whereas visual attention for the clusters of the other vehicles seems to be along a horizontal axis through the middle of the clusters.

Target Identification Responses

Target identification responses were collected from the subject population (N=22) after each of their 24 threshold slides was exposed for 5 seconds. The number of correct responses made to each of the slides is displayed in Table 8.

In Table 8, it may be seen that the wheeled targets, as a group, are identified correctly more often than the tracked targets. It should also be noted, however, that the Bradley was the single target most frequently identified correctly in both the tracked and wheeled categories.

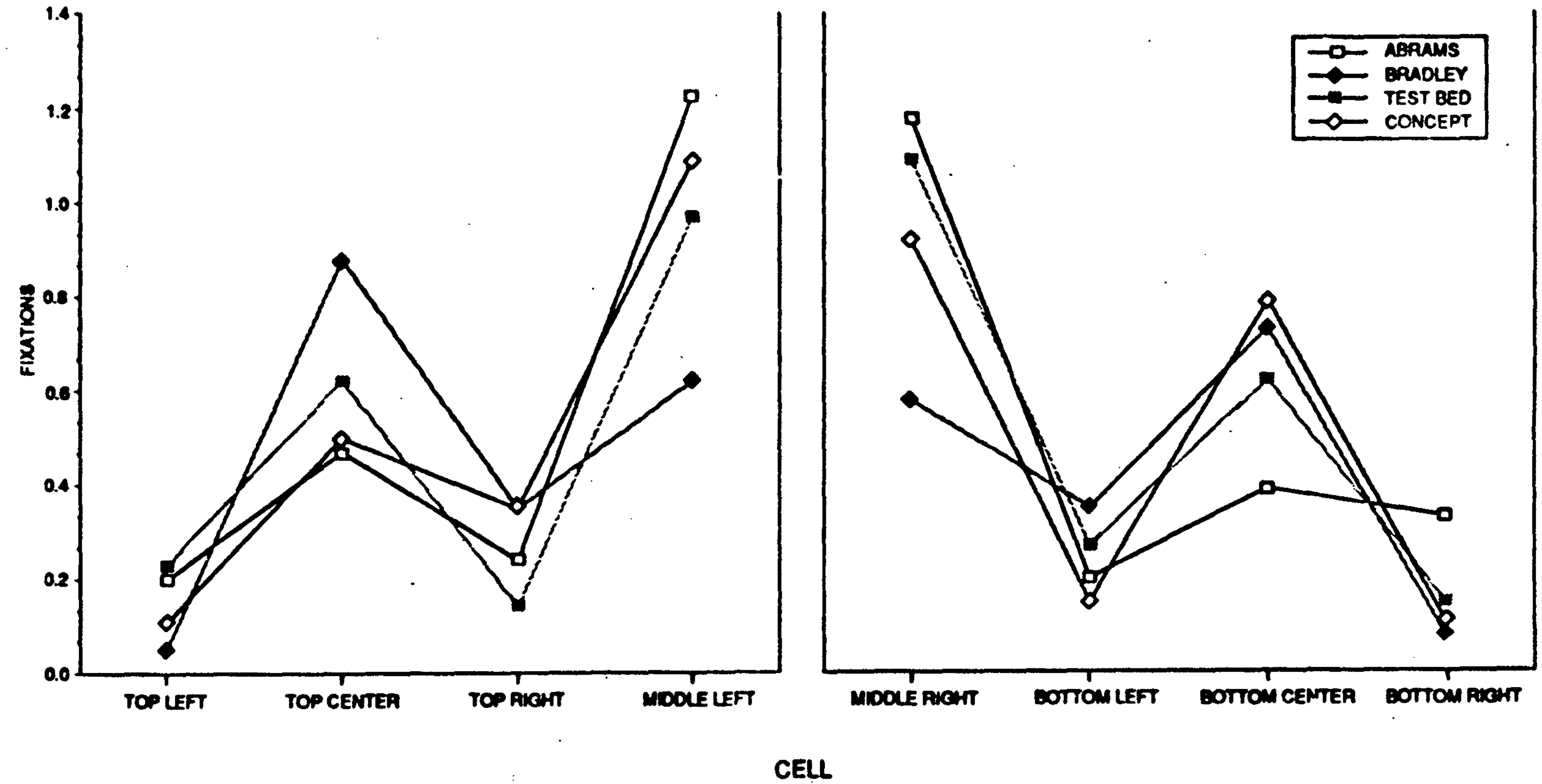

Figure 7. Mean proportion of total fixation durations by target by cell.

Table 8

Correct Identification Responses After a 5-second Viewing Time by Target by Threshold: Number and Percent of Total Possible Responses

	Threshold							
	Detection		Recognition		Identification		Total	
Target	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Abrams[a]	2	9	4	18	17	77	23	35
Bradley[a]	14	64	17	77	17	77	48	73
Test Bed[a]	7	32	6	27	18	82	31	47
Concept[a]	6	27	6	27	10	45	22	33
Total tracked[b]	29	33	38	38	62	70	124	47
Vulcan[a]	7	32	15	68	18	82	40	61
HMMWV[a]	6	27	14	64	20	91	40	61
Forklift[a]	15	68	14	64	16	73	45	68
Carrier[a]	14	64	8	36	19	86	41	62
Total wheeled[b]	42	48	51	58	73	83	166	63
Total[c]	71	40	84	48	135	77	290	55

[a]N=22 [b]N=88 [c]N=176

It should be remembered that correct identification of a target was not the criterion used to select SNRs for the detection and recognition thresholds. The detection threshold was simply the SNR at which a target could be correctly located on the slide, and the recognition threshold was simply the correct naming of the target's category (i.e., tracked or wheeled). Given these criteria, it is interesting to note that correct identification of the Bradley, Forklift, and Carrier was made quite frequently at the detection level, whereas the Abrams, Test Bed, and Concept were often not identified correctly until at the identification threshold level.

Verbal Reports

The recorded verbal responses of 20 subjects were transcribed and analyzed for the occurrence of descriptive words or phrases pertaining to specific target features or lack of features, as well as to more global target characteristics. Equipment failure prevented the recording of responses from two of the original 22 subjects. A list of coded notes on the verbal descriptions of the subjects viewing slides of the four tracked vehicles at each of the three threshold values is given in Appendix F.

To discriminate any systematic relationship between the verbal responses and the targets within the tracked vehicle set, a verbal descriptor analysis was devised. The verbal responses were coded for specific phrases referring to the guns on the targets, in addition to references to target shape or proportion. Specifically, each subject's responses at each of the three threshold levels were scored for the following mutually exclusive categories of responses: (a) mention of a nonspecific gun present, (b) specific reference to a long gun, (c) specific reference to a short gun, (d) specific absence of a gun, and (e) no reference to any gun. The frequency of each of these responses is displayed in Table 9.

In general, it appears that the Abrams, Test Bed, and Concept, rather than the Bradley are most frequently referred to in terms of the presence of a gun. Specifically, for the Abrams and the Concept, those references mostly occur in the identification threshold, while for the Test Bed they occur mostly in the detection threshold. Generally, a long gun is most frequently mentioned for the Abrams and the Concept, while a short gun is most frequently mentioned for the Bradley. Specifically, the mention of a long gun occurs mostly in the identification threshold for the Test Bed. Further, the mention of the inability to perceive a gun is primarily found for the Bradley within all thresholds, while no mention of a gun at all occurs almost equally for all targets. It may be interesting to note that across all targets, references to an inability to see a gun or no reference to any gun occurs mostly within the recognition threshold, while subjects having the most difficulty to respond (no data) occurs primarily within the detection threshold.

Table 9

Frequency of Verbal References to Guns on Four Tracked Vehicles

		Verbal Reference					
Target	Threshold	Gun present	Long gun	Short gun	Cannot see gun	No mention of gun	No data
Abrams	Detection	5	6	0	4	2	3
	Recognition	5	4	0	5	6	0
	Identification	8	4	0	1	6	1
Bradley	Detection	2	0	1	9	5	3
	Recognition	0	0	2	10	8	0
	Identification	4	0	2	9	4	1
Test Bed	Detection	8	1	0	3	2	6
	Recognition	4	2	0	3	7	4
	Identification	2	15	1	0	2	0
Concept	Detection	4	1	1	0	5	9
	Recognition	4	0	0	9	6	1
	Identification	14	3	0	0	3	0
Total	Detection	19	8	2	16	14	21
	Recognition	18	6	2	27	27	5
	Identification	28	22	3	10	15	2

The frequencies of occurrences of verbal descriptors referring to global properties of targets such as shape, proportion, or mass relating to target identity for the three thresholds are displayed in Table 10. It can easily be seen that "global" descriptors were used more frequently for the Bradley than for the other targets. Also, "global" descriptors were used more frequently for the recognition thresholds of the Abrams and the Concept than for their detection and identification thresholds, while distribution of those descriptors for the Bradley is equal across all thresholds.

Table 10

Frequency of Verbal References to Global Target Characteristics on Four Tracked Vehicles by Threshold

	Threshold			
Target	Detection	Recognition	Identification	Total
Abrams	5	10	5	20
Bradley	14	12	14	40
Test Bed	8	5	9	22
Concept	6	13	9	28
Total	33	40	37	110

An examination of all verbal responses showed no particular biases of any individual subject toward the use of references to either specific target features or to global characteristics exclusively.

Discussion

The results of the eye movement data from this investigation are consistent with the target identification data obtained in Experiment 1. The strongest finding is that the pattern of visual attention for the Bradley differed from the other tracked vehicles both as a function of threshold level and as a function of cellular distribution. The lowest frequencies of fixations needed for detection and identification were associated with the Bradley. The greatest frequency of fixations at the recognition threshold was also associated with the Bradley. This interaction may possibly be a result of the task demands. The recognition threshold was determined solely on the basis of a correct category discrimination (i.e., wheeled versus tracked). In the first experiment, the Bradley showed more category interference from wheeled targets than did the other tracked vehicles. That is, the Bradley was identified as a wheeled vehicle much more frequently than were any of the other tracked targets. It is possible that, at that degree of visual degradation, a discrimination problem of category is more prevalent with the Bradley than with the other tracked vehicles, leading to a need for more fixations. Further, fewer fixations may be necessary at the identification threshold because of the BRADLEY's conspicuous lack of such prominent details. Among the tracked vehicles, the Bradley had the shortest gun and the fewest large indentations on its top surface, particularly the long deck on its top rear. This silhouette would require fewer fixations for identification than would silhouettes of either the Abrams or the Concept which have many more details that require examination. This explanation is also consistent with the subjects' verbal descriptions of their examination strategies.

In addition, it can be seen that the Bradley had much lower fixation frequencies in the left and right middle cells and a higher fixation frequency in the top center cell as compared to the other tracked targets. This gives the general impression that visual attention for the Bradley is more heavily weighted vertically while the other tracked targets are more heavily weighted horizontally. Visual inspection of the target silhouettes reveals the obvious horizontal extension given to the Abrams, Test Bed, and Concept by their long gun tubes. Another important feature of these targets is made apparent in the verbal descriptions of examination strategies given by the subjects. The appearance of a flat deck or "step" where the rear of the turret drops down to the body of the vehicle is a feature frequently mentioned as apparently a useful discriminator. Again, visual inspection of the silhouettes shows that the gun tube and rear deck both fall in the same horizontal plane of the Abrams, Test Bed, and Concept. The Bradley shows neither of these features. Not unexpectedly, the pattern of results for the fixation duration data parallels the findings of the fixation frequency data.

There was no apparent method to correlate the pattern of eye movements and the verbal responses quantitatively. However, an informal examination of some individual visual behavior paired with the corresponding individual verbal responses did not reveal any systematic match between the strategies that subjects indicated they were using to identify the targets and where they might have actually looked. It seems most likely that the pattern of eye movements is perceptually driven, whereas target identification per se is a cognitive function. That is, visual attention will be directed to those areas that require the greatest amount of examination to discern specific features. This is especially true when those features are not perceptually clear or are occluded. Such features may or may not necessarily be the most important determinant for target identification. Also, more critical features necessary for identification may be more obvious or visible, and therefore, not require much visual attention.

CONCLUSIONS

The original intent of this research was to determine which features of several tracked vehicle silhouettes were critical to accurate target identification by analyzing a viewer's eye movements recorded during a target identification task. An additional purpose was to compare those features examined visually with the viewer's opinions about which target features were thought to be the most critical. Knowledge of such information would aid in applications using vehicle identification signatures.

In summary, it was found that

1. Target features critical to accurate target identification are not necessarily absolute properties of the target but are relative to the entire set of possible targets expected and their attributes being accessed in the identification task. If the target set is changed, the relative criticality of a given feature will change as well.

2. Similarly, recognition and identification thresholds are not absolute properties of targets, but are relative to the context in which they appear.

3. The distribution of eye movements measured as a response to a target identification task may only be indirectly indicative of broad

differences between coarsely dissimilar targets and is probably more directly affected by local visual noise in the perceptual field. This particular conclusion has implications as well for problems encountered in the current development of automatic systems of target identifiers that try to employ eye movement measurements.

4. Verbal reports of observers' opinions of what, for them, constitutes important features to identify specific targets in a set, display much agreement between individual viewers but little agreement with their eye fixation distributions. Verbal reports give some indication of cognitive strategies that may be in use, but are not necessarily reflected in the visual response measures.

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APPENDIX A

M/NOVA SOURCE TABLE FOR NUMBER OF FIXATIONS

MANOVA SOURCE TABLE FOR NUMBER OF FIXATIONS

Table A-1

MANOVA Summary Table for Number of Fixations

Source	Bartlett's test of sphericity	DF	*p*	Exact F	Hypothesis DF	Error DF	Significance of F
Threshold	19.37	1	0.000	0.86	2	20	0.437
Target	30.89	3	0.000	0.82	3	19	0.500
Cell	54.04	28	0.002	46.11	8	14	0.000
Threshold x Target	63.15	15	0.000	2.82	6	16	0.046
Threshold x Cell	170.37	120	0.002	0.51	16	6	0.867
Target x Cell				3.03[a]	24	504	0.000
Threshold x Target x Cell				0.72[a]	48	1008	0.962

[a]Note. The within-cell error matrices for these interactions were singular because of a linear dependency among dependent variables. Therefore, multivariate statistics could not be calculated. The F statistics reported here were from a univariate mixed model analysis of variance.

APPENDIX B

TABLES OF MEANS FOR SIGNIFICANT *A PRIORI* CONTRASTS FOR THE THRESHOLD X TARGET INTERACTION

TABLES OF MEANS FOR SIGNIFICANT *A PRIORI* CONTRASTS
FOR THE THRESHOLD X TARGET INTERACTION

Table B-1

Mean Number of Fixations for Abrams Versus
Bradley x Detection Versus Recognition, $F(1,21)=12.62$, $p<.01$

	Threshold	
Target	Detection	Recognition
Abrams	6.27 (2.49)	6.32 (2.25)
Bradley	5.55 (3.38)	7.05 (2.75)

Table B-2

Mean Number of Fixations for Bradley Versus
Test Bed x Detection Versus Recognition, $F(1,21)=4.81$, $p<.05$

	Threshold	
Target	Detection	Recognition
Bradley	5.55 (3.38)	7.05 (2.75)
Test Bed	7.18 (2.86)	6.77 (2.51)

Table B-3

Mean Number of Fixations for Abrams Versus Bradley x
Recognition Versus Identification, $F(1,21)=5.66$, $p<.05$

	Threshold	
Target	Recognition	Identification
Abrams	6.32 (2.25)	7.36 (1.94)
Bradley	7.05 (2.75)	5.95 (2.61)

APPENDIX C

TABLES OF MEANS FOR SIGNIFICANT *A PRIORI* CONTRASTS
FOR THE TARGET X CELL INTERACTION

TABLES OF MEANS FOR SIGNIFICANT A *PRIORI* CONTRASTS FOR THE TARGET X CELL INTERACTION

Table C-1

Mean Number of Fixations for Abrams Versus Bradley x Bottom Left Versus Bottom Right, $F(1,21)=4.91$, $p<.05$

	Cell	
Target	Bottom left	Bottom right
Abrams	0.20 (0.40)	0.33 (0.59)
Bradley	0.35 (0.71)	0.08 (0.27)

Table C-2

Mean Number of Fixations for Abrams Versus Bradley x Top Left Versus Top Center, $F(1,21)=7.23$, $p<.01$

	Cell	
Target	Top left	Top center
Abrams	0.20 (0.40)	0.47 (0.68)
Bradley	0.05 (0.21)	0.88 (0.98)

Table C-3

Mean Number of Fixations for Abrams Versus Bradley x Top Left Versus Top Right, $F(1,21)=5.76$, $p<.05$

	Cell	
Target	Top left	Top right
Abrams	0.20 (0.40)	0.24 (0.43)
Bradley	0.05 (0.21)	0.35 (0.48)

Table C-4

Mean Number of Fixations for Abrams Versus Bradley x Middle (Horizontal) Versus Top, $F(1,21)=7.01$, $p<.05$

	Cell	
Target	Middle (horizontal)	Top
Abrams	4.82 (2.20)	0.91 (0.89)
Bradley	3.76 (2.08)	1.27 (1.23)

Table C-5

Mean Number of Fixations for Abrams Versus Bradley x Left Versus Middle (Vertical), $F(1,21)=9.57$, $p<.01$

	Cell	
Target	Left	Middle (vertical)
Abrams	1.62 (1.08)	3.27 (1.45)
Bradley	1.02 (0.90)	4.17 (2.27)

Table C-6

Mean Number of Fixations for Bradley Versus Test Bed x Top Left Versus Top Center, $F(1,21)=5.96$, $p<.05$

	Cell	
Target	Top left	Top center
Bradley	0.05 (0.21)	0.88 (0.98)
Test Bed	0.23 (0.46)	0.62 (0.80)

Table C-7

Mean Number of Fixations for Bradley Versus Test Bed x Top Left Versus Top Right, $F(1,21)=18.29$, $p<.001$

	Cell	
Target	Top left	Top right
Bradley	0.05 (0.21)	0.35 (0.48)
Test Bed	0.23 (0.46)	0.14 (0.35)

Table C-8

Mean Number of Fixations for Bradley Versus Test Bed x Middle (Horizontal) Versus Top, $F(1,21)=6.10$, $p<.05$

	Cell	
Target	Middle (horizontal)	Top
Bradley	3.76 (2.08)	1.27 (1.23)
Test Bed	4.85 (2.37)	0.98 (1.09)

Table C-9

Mean Number of Fixations for Test Bed Versus Concept x Top Left Versus Top Right, $F(1,21)=7.22$, $p<.01$

	Cell	
Target	Top left	Top right
Test Bed	0.23 (0.46)	0.14 (0.35)
Concept	0.11 (0.31)	0.35 (0.54)

Table C-10

Mean Number of Fixations for Abrams Versus Test Bed x Left Versus Middle (Vertical), $F(1,21)=5.56$, $p<.05$

	Cell	
Target	Left	Middle (vertical)
Abrams	1.62 (1.08)	3.27 (1.45)
Test Bed	1.47 (1.04)	4.03 (1.64)

Table C-11

Mean Number of Fixations for Abrams Versus Concept x Bottom Right Versus Top Right, $F(1,21)=5.78$, $p<.05$

	Cell	
Target	Bottom right	Top right
Abrams	0.33 (0.59)	0.24 (0.43)
Concept	0.11 (0.31)	0.35 (0.54)

Table C-12

Mean Number of Fixations for Abrams Versus Concept x Middle Right Versus Top Right, $F(1,21)=4.24$, $p<.05$

	Cell	
Target	Middle right	Top right
Abrams	1.18 (0.99)	0.24 (0.43)
Concept	0.92 (0.86)	0.35 (0.54)

Table C-13

Mean Number of Fixations for Abrams Versus Concept x Left Versus Middle (Vertical), $F(1,21)=9.64$, $p<.01$

	Cell	
Target	Left	Middle (vertical)
Abrams	1.62 (1.08)	3.27 (1.45)
Concept	1.35 (1.07)	4.06 (2.04)

Table C-14

Mean Number of Fixations for Bradley Versus Concept x Bottom Left Versus Top Left, $F(1,21)=5.12$, $p<.05$

	Cell	
Target	Bottom left	Top left
Bradley	0.35 (0.71)	0.05 (0.21)
Concept	0.15 (0.40)	0.11 (0.31)

Table C-15

Mean Number of Fixations for Bradley Versus Concept x Middle Left Versus Top Left, $F(1,21)=6.70$, $p<.05$

	Cell	
Target	Middle left	Top left
Bradley	0.62 (0.76)	0.05 (0.21)
Concept	1.09 (0.96)	0.11 (0.31)

APPENDIX D

MANOVA SOURCE TABLE FOR PROPORTION TOTAL FIXATION DURATION TIME

MANOVA SOURCE TABLE FOR PROPORTION TOTAL FIXATION DURATION TIME

Table D-1

MANOVA Summary Table for Total Fixation Duration Time

Source	Bartlett's test of sphericity	DF	*p*	Exact F	Hypothesis DF	Error DF	Significance of F
Threshold	196.09	1	0.000	1.46	2	20	0.256
Target	55.78	3	0.000	0.99	3	19	0.417
Cell	62.39	28	0.000	100.00	8	14	0.000
Threshold x Target	417.27	15	0.000	0.51	6	16	0.794
Threshold x Cell	228.307	120	0.000	0.56	16	6	0.838
Target x Cell				2.56[a]	24	504	0.001
Threshold x Target x Cell				1.20[a]	48	1008	0.224

[a]Note. The within-cell error matrices for these interactions were singular because of a linear dependency among dependent variables. Therefore, multivariate statistics could not be calculated. The F statistics reported here were from a univariate mixed model ANOVA.

APPENDIX E

TABLES OF MEAN PROPORTION OF TOTAL FIXATION DURATION TIME FOR SIGNIFICANT *A PRIORI* CONTRASTS FOR THE TARGET X CELL INTERACTION

TABLES OF MEAN PROPORTION OF TOTAL FIXATION DURATION TIME
FOR SIGNIFICANT *A PRIORI* CONTRASTS FOR THE TARGET X CELL INTERACTION

Table E-1

Mean Proportion of Total Fixation Duration Time for Abrams Versus Bradley x Bottom Left Versus Bottom Right, $F(1,21)=4.75$, $p<.05$

	Cell	
Target	Bottom left	Bottom right
Abrams	0.30 (0.06)	0.04 (0.10)
Bradley	0.04 (0.11)	0.01 (0.05)

Table E-2

Mean Proportion of Total Fixation Duration Time for Bradley Versus Test Bed x Top Left Versus Top Center, $F(1,21)=4.75$, $p<.05$

	Cell	
Target	Top left	Top center
Bradley	0.00 (0.02)	0.13 (0.17)
Test Bed	0.03 (0.05)	0.08 (0.12)

Table E-3

Mean Proportion of Total Fixation Duration Time for Bradley Versus x Test Bed x Top Left Versus Top Right, $F(1,21)=13.76$, $p<.001$

	Cell	
Target	Top left	Top right
Bradley	0.00 (0.02)	0.05 (0.12)
Test Bed	0.03 (0.05)	0.01 (0.03)

Table E-4

Mean Proportion of Total Fixation Duration Time for Abrams Versus Concept x Bottom Right Versus Top Right, $F(1,21)=6.15$, $p<.05$

	Cell	
Target	Bottom right	Top right
Abrams	0.04 (0.10)	0.02 (0.04)
Concept	0.01 (0.04)	0.05 (0.11)

Table E-5

Mean Proportion of Total Fixation Duration Time for Abrams Versus Concept x Middle Right Versus Top Right, $F(1,21)=4.64$, $p<.05$

	Cell	
Target	Middle right	Top right
Abrams	0.17 (0.16)	0.02 (0.04)
Concept	0.12 (0.12)	0.05 (0.11)

Table E-6

Mean Proportion of Total Fixation Duration Time for Bradley Versus Concept x Bottom Left Versus Top Left, $F(1,21)=5.18$, $p<.05$

	Cell	
Target	Bottom left	Top left
Bradley	0.04 (0.11)	0.00 (0.02)
Concept	0.01 (0.04)	0.02 (0.05)

Table E-7

Mean Proportion of Total Fixation Duration Time for Abrams Versus Bradley Test Bed x Left Versus Middle (Vertical), $F(1,21)=14.33$, $p<.001$

	Cell	
Target	Left	Middle (vertical)
Abrams	0.20 (0.16)	0.54 (0.28)
Bradley	0.05 (0.21)	0.35 (0.48)

Table E-8

Mean Proportion of Total Fixation Duration Time for Bradley Versus Test Bed x Left Versus Middle (Horizontal), $F(1,21)=9.03$, $p<.001$

	Cell	
Target	Left	Middle (horizontal)
Bradley	0.13 (0.14)	0.71 (0.25)
Test Bed	0.18 (0.13)	0.64 (0.22)

Table E-9

Mean Proportion of Total Fixation Duration Time for Abrams Versus Test Bed x Left Versus Middle (Vertical), $F(1,21)=7.48$, $p<.01$

	Cell	
Target	Left	Middle (vertical)
Abrams	0.20 (0.16)	0.54 (0.28)
Test Bed	0.18 (0.13)	0.64 (0.22)

Table E-10

Mean Proportion of Total Fixation Duration Time for Abrams Versus Concept x Left Versus Middle (Vertical), $F(1,21)=7.35$, $p<.01$

	Cell	
Target	Left	Middle (vertical)
Abrams	0.20 (0.16)	0.54 (0.28)
Concept	0.15 (0.15)	0.62 (0.25)

APPENDIX F

TRANSCRIPTIONS OF VERBAL RESPONSES

TRANSCRIPTIONS OF VERBAL RESPONSES

Verbal notes of words and phrases used by 20 subjects (S) in response to specific questions asked of them about each of four tracked targets at three threshold levels. Responses (RSP) were Abrams (A), Bradley (B), Test Bed (C), Concept (D), Vulcan (E), HMMWV (F), Forklift (G), or Carrier (H). SNRs of slides were from 1 to 12. Coding (CAT) of responses were reference to a gun in general only (g), reference to a long gun (l) or a short gun (s) or a noise suppressor (n), reference to not being able to see a gun (x), reference to global characteristics such as shape, proportion, size of the target (*). In the text of the following notes, most words are abbreviated. The letter "X" means "cannot."

S#	SNR	RSP	CAT	Verbal Notes: Detection, Abrams (A) order: 18
3	3	G		forks in frnt
8	3	A	g	brrl/fading
10	3	C	l	lng gun/or D
11	3	C	l	lng gun
18	3	D	x	X see gun/could be H
22	3	C	g	hint of gun/not sure
25	3	NV		
31	3	NV		
40	3	C	*g	? gun/more frnt wt/trrt ht=C
42	4	B	*x	trckd/flat bttm up on ends/X see gun/tallr=B, othrwse D
36	3	A	*x	football at bttm/trcks to frnt/X see gun/it's got that look
6	3	B	x	X see gun
7	3	A	*l	lng brrl/hi in mddl/brrl most prom
9	3	C	g	X make out/maybe gun tube/maybe C
12		ND		
13	3	D	g	gun/frnt of trck most prom
19	3	C	l	stair step/lng brrl/flat srfce on top
27	4	G		whls/fork comes out
34	3	C	l	lng gun
41	3	C	*l	lng gun/maybe trrt far fwrd/partl trck

Verbal Notes: Recognition, Abrams (A)
order: 04

S#	SNR	RSP	CAT	Verbal Notes
3	6	B	*	smll/hi mddl/frnt most prom
8	8	D	*g	tank because brrl/genl shpe=D/X rememb if D or A has skinny brrl
10	4	G	*	like whled/bttm/frnt most prom
11	4	B	x	trrt on top/X see brrl
18	4	D	*	has outsde shpe/maybe whl
22	4	C	*1	C off-balance/lng brrl/littl body
25	4	B	x	tank because bttm/X see gun=B
31	4	A	x	mach. gun on top/X see brrl
40	4	A	*1	gun lngr/gun on top/D gun more propor.to body than A's/C has flat bck
42	5	A	g	gun tube/tallr than whled/lngr/spce in bck diff=def.trckd
36	5	G		attendng to frnt and top/not base so much/2 pieces comng out,C has only 1 piece
6	8	A	*g	shpe of trrt/gun/wthout trrt look like C
7	4	A	g	like blob/sqrd off top/wthout top look like D
9	4	ND		
12	4	B	g	cannon/mach. gun
13	4	D	g	fire thing/trckd vehcl shpe on top/whl bttm
19	4	G	x	like whls but too close/whls,fork most prom/ X see brrl
27	5	A	*1	lng brrl most prom/angl up on both ends
34	4	C	1	lng gun/no othr info
41	4	F	*x	shpe/bttm uneven/2 whls ?/X see gun

S#	SNR	RSP	CAT	Verbal Notes: Identification, Abrams (A) order: 22
3	12	A		lip in bck top/would be D wthout step in bck
8	12	A	l	gun on top/lng brrl/sqd rear/angl frnt/trrt
10	10	A	*	shpe/top gun/trcks/mach.gun on top most prom
11	12	D	l	lrgr gun tube in mddl=maybe A/has lngr,flattr trrt
18	12	C		but looks like A/bck shrtr than C=A/just saw gun on top
22	10	A	*l	lngr brrl/more rnd than D/not B,not C
25	7	A	g	trckd/gun on frnt/trrt shpe/X see noise suprsr/can be D also
31	12	B	*	X see top gun/hvy/low/cab in cntr/=B
40	8	A	g	trckd/gun/not C,no flat bck/same,except D has shrtr,wider gun
42	7	E,C	*g	lngth+ht=E or H/flat bck+maybe gun=C/lngth and ht most prom/if flat bck shrtr=A or D
36	12	B	g	mach. gun/if X see mach.gun, X tell
6	12	A	*g	gun/frnt shpe/top gun
7	12	C	l	lng brrl/bed on bck
9	8	C		sees sprckts/bck sprckt/doesn't show on A
12	8	D	*g	cannon/bed in bck/not much trrt/D has bggr trrt
13	12	A	x	see evrythng=A,excpt end of brrl
19	9	A	g	has gun on top/no fat brrl/ could be G
27	12	D	g	fattr brrl/most prom
34	10	D	g	top flat/most prom/gun
41		ND		

S#	SNR	RSP	CAT	Verbal Notes: Detection, Bradley (B) order: 02
3	5	B	*B	smll/hi at top/compactd
8	3	H,E	x	flat/X see brrl/X see tank head
10	4	D	*	rnd shpe/almost like A,diff on bck of trcks
11	4	H,E	*	X see nose/H has dip in nose/bascly rectng/ht most prom
18	4	B	*	littl bill or mound/rnd body shpe/slopes up to point
22	4	ND		
25	4	B	*x	outline like tank/X see brrl= A,D/ht most prom/short+tall
31	4	ND		
40	3	NV		
42	3	H,E	*x	lngth/X thng out frnt/lngr than othrs/shrtr than tank
36	4	B	*s	shpe/lng pyrmid/shrt/strtchd out/shrt gun/ prom shpe
6	4	B	*x	X see gun as much as A,D/compct/gun not stckng out
7	4	B	*	rnded top
9	6	D	g	X have flatbed/nas mzzl sprsr
12	4	A	*g	slightly see cannon/shpe most prom
13	4	B	*x	shpe/rocker bttm/X see gun/sees trcks/like a triangl
19	4	B	x	lowr trck base/X brrl
27	4	B	*x	shpe/pointd more at frnt/X see gun
34	6	H	*x	shpe/whls/X see gun
41	4	B	*x	even base/uneven top/X see stckng out in frnt/ flat bttm most prom

S#	SNR	RSP CAT		Verbal Notes: Recognition, Bradley (B) order: 20
3	9	D	*x	shrt,hi/D has cap on top,must see brrl to tell D from B
8	8	B	x	X see gun/Vee angl on ends
10	5	B	*	rnd shpe/smllr than othrs
11	5	H	x	X see nose or gun/must see gun to see if B
18	5	D	*x	X see gun/bck shpe slopes up to point/looks like mashed potatos but shrtr than B
22	8	B		turned around
25	8	B	*	shpe of trrt/shpe most prom
31	8	B	*s	no top gun/looks hvier/lowr/strdier/cab in cntr/shrtr gun
40	8	B	x	flat bttm/no gun
42	8	B	x	X see gun/trrt to rear
36	8	D,B	*s	duck tail/littl gun
6	9	B	x	X see gun
7	8	D	*	hi in mddl
9	7	B	x	exhaust in bck/no lng gun tube
12	7	ND		
13	5	B	*	Vee shpe/rockng chair
19	5	B	*x	tank shpe/diamnd shpe like tank/X see brrl
27	5	F	*x	rnd bck/strght frnt/whls/X see gun
34	8	A	*	shpe of top
41	5	B	*	flat bttm/bulge on top/X see ends.

S#	SNR	RSP CAT		Verbal Notes: Identification, Bradley (B) order: 06
3	10	D		because bck end down and strght again
8	9	B	*x	trck/X see B brrl/other 3 have lng brrls/ shpe most prom
10	12	B	*g	gun/rnd shpe/like egg/shpe prom/shrt lngth
11	8	B	x	prom trrt/X see mzzl
18	8	B	*x	X see guns so must use shpe/mound mashed pot's on plate
22	11	B	*s	sml brrl/more rnded ends than D/ends most prom
25	9	C		lngr flat spot/trrt close to end/facng rt or=B
31	10	tkd	x	low to gnd/X gun/slntd frnt/X recog it
40	9	B	*x	trck/bttm even/no gun=B/wtd in cntr
42	9	B	*g	trret in mddl/X see gun,dsnt extnd/filld in bttm/tallr trrt thn othrs
36	10	D,B	g	both have mach.gun/confusn ovr brrl lngth/not sure if B has mach.gun
6	12	A	*	shpe of frnt is Vee
7	12	B	*s	shrt brrl/tail on bck stks out/most prom=shrt barrl
9	9	B	*x	fin on bck stcks up/exhst/20mmgun frnt/X see brl
12	12	B	*g	cannon/hump on bck/no bed/hump bck most prom
13	7	A,H	*	trnd bckwds/trcks/rnd on lft/sqrd on rt/stck off on top
19	6	H	*x	whls/blob look/X see brrl
27	10	B	*x	shpe/barely see brrl/frnt end has nose
34	12	ND		can't remem name
41	8	B	*x	flat bttm/trrt mound/ends angld/X see stck out frnt/shpe most prom

S#	RSP SNR	CAT	Verbal Notes: Detection, Test Bed (C) order: 15
3	5 C	*	high/low to rt
8	3 A	g	brrl=tckd/wild guess
10	3 C	g	gun=C/gun most prom/more to frnt of vehcl
11	3 A,D	g	trrt/av.lngth gun/has to see noise sprsr to dstnguish
18	5 H	*x	X see bttm flat or rnd/top slopes up/flat bck X see gun
22	6 C	*g	shpe/brrl more to frnt/like bckwrd tank/lowr in bck
25	5 H	*	size/lngth/genl shpe/X see trrt to see=C,not H
31	5 H	x	cab/trrt most prom/X see lng nose/gun
40	3 A,C	g	gun/too lng/not as wide=C/X see bck for cut/ shtr than A
42	3 C	*g	bck flat behnd trrt/lng flat/gun tube/ht prom
36	3 C	l	gun stcks out far/flat bck there
6	7 A	ND	
7	4 D	ND	
9	3 NV		
12	4		don't know
13	3 B,C	*g	bttm rockng chair=B/confusd about gun/guess C
19	4 NV		
27	3 C	*g	trrt at frnt/brrl/lngr than othr tanks
34	5 D		X verblize
41	5 B	*x	2 flat spots bttm/X see trck or whls/X see trrt positn/X see stckng out frnt/guess B

S#	SNR	RSP	CAT	Verbal Notes: Recognition, Test Bed (C) order: 23
3	7	D		because no lip in bck
8	4	E	x	X see trrt or brrl/rect shpe like H,E/whls might be covrd
10	5	G	*	frnt/X see whls/shpe/frnt most prom
11	6	D	*g	shrtr/highr trrt/has mzzl
18	6	C	*	because bck/lng frnt/like duck
22	7	C	*	off balnce/same reasons
25	6	C	g	flat on bck rt/X see trcks/see gun only lttle
31	6	C	l	flat in bck/lng gun
40	4			X tell
42	6	C		flat in bck/X see trrt/X be E, E has whls
36	5			X tell/dead copter
6	8	D	*g	trckd becse bck shpe/see gun/frnt of trrt
7	5	F		flat/gap betwn 2 tires
9	8	C	l	lngr gun/flat bck
12	5	C	g	tank/cannon/lng bck bed
13	4	B,F		don't see it/has hump/white/not visbl
19	5	C	x	trrt to frnt/trck/stairstep/X see gun/trrt in frnt most prom
27	5	F	x	rnd bck/X see guns
34	6	E	ND	
41	ND			

S#	SNR	RSP	CAT	Verbal Notes: Identification, Test Bed (C) order: 09
3	10	C	1	lng brrl in frnt
8	9	C	1	trrt up/sknny brrl blds out/brrl most prom/ if X see gun=B,and no top gun
10	6	A	1	shpe/no its D,no C/gun lngr/has sme A shpe in bck/lng gun
11	9	C	1	very lng mzzl/visbl trrt/no gun
18	12	C	*1	like duck shpe/lng in bck/lng nose/beak is gun/ body rndr than lng bck
22	8	C	*	no frnt/lot of bck/trrt more to frnt
25	7	C	1	lng gun/flat behnd trrt/only look at top
31	7	C	1	lng brrl/lttle cab/flat bck,lng gun most prom
40	9	C	1	lng gun/trck/bck/no mach.gun/flat bck mostly
42	7	C	*	frnt hvy/lrgr trrt/shelf in bck
36	7	C	*1	lng gun clsr to frnt/flat bck most prom
6	12	D	s	gun/lookd shrt first,not now
7	7	C	1	lng brrl/bed in bck most prom
9	9	C	1	bck end/lng brrl/bck most prom
12	6	C	g	bed in bck/cannon/big frnt,flat most prom
13	12	A	*g	X remem name/gun stcks out/bttm like ship/ flat top/nothng stcks out most prom
19	12	C	*1	stairstep/lng brrl/flat on top/lng base behnd/ trrt in frnt
27	6	C	*1	lng brrl/like truckbed/trrt in frnt most prom
34	7	C	*1	shpe/bck lngr than frnt/gun lngr/gun most prom
41	7	C	1	lng cannon/trrt/flat bttm/X see mzzl break/gun most prom/no mach.gun

S#	SNR	RSP CAT		Verbal Notes: Detection, Concept (D) order: 10
3	3	NV		
8	5	B	*1	trckd/B becse more compct/X see lng brrl/ not strtched out like othrs/blob
10	2	NV		
11	4	H,E,G		copter/lrge trrt at bck
18	6	D	*s	shpe of top/wdth/gun not lng/body not lng/bttm flat/trckd
22	4	F	*	not very visble/slght sqr shpe
25	4	E,H	*	shpe and size/X see trrt or top/size most prom
31	4	NV		
40	2	NV		
42	4	D	*	shrtr flat behnd trrt than all othrs/only way tell from A/1st notice trrt,ht
36	6	D	g	funny brrl/X see mach.gun
6	4	E	*	shpe of frnt/frnt most prom
7	4	F		hard to see
9	4			X see features
12	3	NV		
13	3	C,D	g	gun/trck/see all but top bck/frnt of trck most prom/end of brrl
19	7	A,D	n	50cal on top/D not have/D has suprsr/X see it
27	4	B	g	bttm trckd/could be F/B,can see brrl/dots runng tgethr
34	5	A	ND	
41	ND			

S#	SNR	RSP CAT		Verbal Notes: Recognition, Concept (D) order: 12
3	5	B	*	rear smll/hi/shrt lngth
8	6	A	x	X see brrl sze/always use brrl to tell tank
10	6	A		mach.gun on top/trcks
11	5	H	*x	becse of nose/X see mzzl/has ht excpt at nose
18	7	B,A	*	mound mshd pot's/shrtr thn B/less slope on end than B
22	5	A,B	*x	same shpe/if see brrl=A/dsnt know if sees brrl =not whld/not sqr/blob
25	5	B	x	trrt makes look like B/have to see gun to=D
31	5	B	x	flat on top/no gun stkng out/nthng prom
40	6	D	*g	flat bttm/no angl bck/gun shrtr thn B/easy to see/X see details/body most prom
42	5	B	*x	tckd becse ht/X see gun/flat bttm/tall/if gun=D
36	7	A	*	got that look/X see bck,A or D has ducktail bck
6	5	B	*x	X see lng gun/B is compct
7	5	A	*	rnd top in mddl most prom
9	6	A	n	X have big sprsr most prom
12	ND			
13	8	B,C	*g	ship on bttm/no its C/see frnt,bck,gun parts
19	8	B	x	X see brrl/has trck featr
27	5	E	*x	rnd frnt/X see brrl
34	6	A	*	shpe/rt side bgr thn lft side/flat trcks
41	7	D,A	*g	flat base/trrt/mzzl/trrt set bck/mzzl brk agnst trrt/spot for mzzl if on D not clear

S#	SNR	RSP	CAT	Verbal Notes: Identification, Concept (D) order: 16
3	12	A		[told D]bck lip hi on B/Astcks out more
8	12	D,A	g	X remem diff/can tell by brrl,gun on top
10	7	B	*g	becse rnd shpe/gun lngr
11	12	D	g	gun/cntr of guntube/trrt,mzzl most prom
18	12	A	g	also like C/gun most prom but fuzzy/so looks lngr than D gun
22	6	D	*g	more sqr than A/brrl diff lngth/more blocked off in bck than A
25	12	A	*ln	lge gun/shpe/looks like F,D/D has noise sprsr on gun,not A
31	11	D	gn	top gun/brrl has sleev on it
40	12	A,D	*g	not C/not B/trrt bck furthr/gun widr/more balncd in mddl
42	12	A	*	D is more stocky or chubby than this
36	12	B,A	l	lng brrl/mach.gun/no its A,no ducktail
6	12	A	*g	gun similr to A/also shpe frnt,bck,trrt
7	12	C	l	lng brrl most prom
9	8	D	n	see sprsr on tube/see sprckts,X see them if A
12	12	A	g	smll bed in bck/trrt/cannon/bed most prom
13	12	A	*g	gun/shpe like ship frnt/sqr bck/smthng on trrt
19	12	A	gn	50cal on top/could be D,has flat brrl/mach.gun most prom,brrl
27	12	A	gn	rnd frnt/brrl/gun on top/D looks like it,has fattr brrl
34	12	B	*	shpe of frnt/top rnded
41	12	D	*n	not C/mach.gun/trrt well bck/mzzl brck in mddl=D