

Validation of a Visual Perception Laboratory Using Field Data

by

Thomas Meitzler, Euijung Sohn, and Darryl Bryk
US Army TACOM
Survivability Technology Center
Warren, MI 48397-5000

OBJECTIVE

The purpose of this test was to compare the human visual detection of military targets in the TARDEC Visual Perception laboratory (VPL) with human detection performance in the field. The data used were slides that were taken as part of a laser protection test. This is an example of dual-use data, a good way to save resources.

VPL PROCEDURAL SETUP

The test subjects were positioned in front of the rear projection screen in the car buck that we used for the first phase CRDA with GM. The Kodak Ekta-Pro slide projector was placed behind the screen.

The distance from the screen to the subject was 259cm. The AAV (Assault Amphibian Vehicle) in image 4-1 was used to check the distance from the projector to the screen. The actual length of the AAV is 7.943m and at a distance of 1 km, the vehicle is 0.0078 radians. With the subject to the screen distance of 259 cm, the AAV size was 2 cm high on the screen. The projector was placed so as to project the correct size of the AAV.

TESTING METHODOLOGY

Using the slide projector a total of 21 slides were arranged according to the field show number. The VPL was dimmed except the projector light and recording lamp light.

Subjects were instructed to point out the location of the target and name what type of vehicle he/she thought it was. Each slides was shown to the subjects with a 3 second time limit. If the subject wanted to proceed to the next slide within the time limit, the next image was shown.

Hard color copies of slides were prepared to record the subject responses. Each subject's response was recorded on the paper corresponding to each scene. The recording was done such that the position of the targets and the name of the targets that the subject pointed out were recorded.

SCORING METHOD

At the field location, the correct positioning of the target was considered an identification. In the VPL experiment, just pointing out the target and correctly naming the target was considered as identification. See appendix A for the scoring of individual responses.

	Field	LAB
ID	A target was considered identified if it was indicated in the correct position (grid square) and with the correct target name.	A target was considered identified if it was pointed out and named correctly.
DET	A target was considered detected if it was indicated in the correct position (grid square) but with the incorrect target name.	A target was considered detected if it was pointed out but named incorrectly.
UN	A target was considered undetected if it was not indicated at all.	A target was considered undetected if it was not pointed out at all.
FA	A target was considered a false alarm if it was indicated on the map, when actually, no target was there. An example of a FA is when sage brush, or bushes, are mistaken as vehicles.	A target was considered a false alarm if it was pointed out which is bush or junk pile actually.

Report Documentation Page

*Form Approved
OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 10 OCT 1998	2. REPORT TYPE Journal Article	3. DATES COVERED 10-10-1998 to 10-10-1998			
4. TITLE AND SUBTITLE Validation of a Visual Perception Laboratory Using Data		5a. CONTRACT NUMBER			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S) Thomas Meitzler; Euijung Sohn; Darryl Bryk		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army TARDEC, Survivability Technology Center, 6501 East Eleven Mile Rd, Warren, Mi, 48397-5000		8. PERFORMING ORGANIZATION REPORT NUMBER #19097			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army TARDEC, Survivability Technology Center, 6501 East Eleven Mile Rd, Warren, Mi, 48397-5000		10. SPONSOR/MONITOR'S ACRONYM(S) TARDEC			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S) #19097			
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The purpose of this test was to compare the human visual detection of military targets in the TARDEC Visual Perception Laboratory (VPL) with human detection performance in the field. The data used were slides that were taken as part of a laser protection test. This is an example of dual-use data, a good way to save resources.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Public Release	18. NUMBER OF PAGES 10	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

for a luminance plot. There were some images in which the target were located at the right or left edge of the slide. These may have been harder for the subjects to search.

DISTANCE definition

The target range was divided into bands of distance, each 300 meters deep. The entire target range was 3000 meters deep with the closest target at 600 meters and 500 meters wide. The distance variable is referred to as DIST-1 through DIST-8 and the specific ranges for each DIST are listed below.

- DIST-1: 600 - 900 meters
- DIST-2: 900 - 1200 meters
- DIST-3: 1200 - 1500 meters
- DIST-4: 1500 - 1800 meters
- DIST-5: 1800 - 2100 meters
- DIST-6: 2100 - 2400 meters
- DIST-7: 2400 - 2700 meters
- DIST-8: 2700 - 3000 meters

AVAILABLE DATA

The original primary purpose of the field test was to compare the performance of the laser eye protection systems (1). In the VPL, only the baseline, naked eye visual perception test was done. The ideal comparison is the naked eye (lens type x) field results with the VPL results.

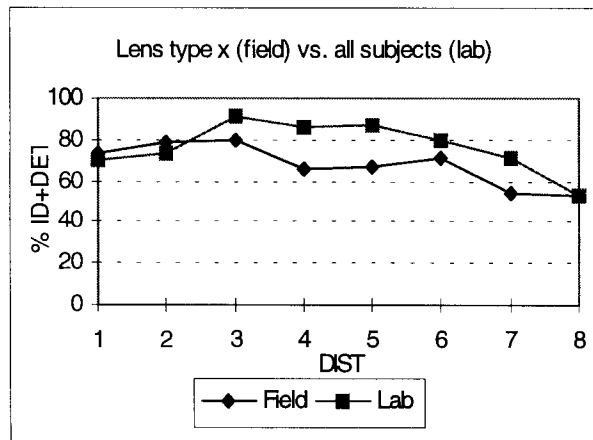
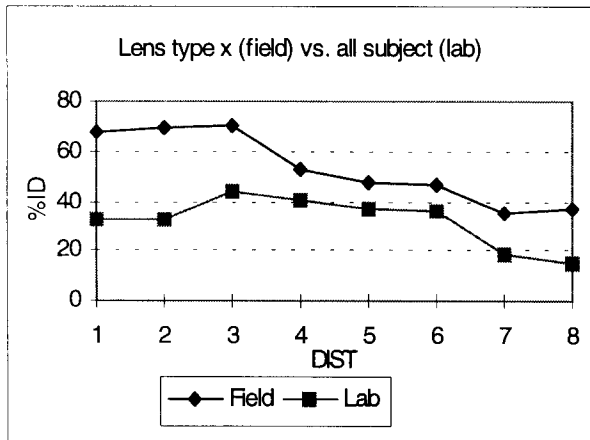
RESULTS

1) LAB DATA and NAKED EYE (Lens type X) result comparison

a) Lens X DIST for lens type x field test result vs. all subject lab data

Field	Lens		
Dist	%ID	%DET	%UN
1	67.4	5.8	26.8
2	69.2	9.1	21.7
3	70.5	9.4	20.1
4	53	12.8	34.2
5	47.7	19.5	32.9
6	46.3	24.8	28.9
7	35.3	19.3	45.3
8	37.1	16.1	46.9

LAB	All		
Dist	%ID	%DET	%UN
1	32.9	36.9	30.2
2	32.6	40.6	26.9
3	43.7	47.3	9.0
4	40.8	45.4	13.8
5	37.3	49.6	13.1
6	36.4	43.3	20.2
7	18.1	53.3	28.6
8	14.7	38.7	46.7



Correlation values

From dist-1 through dist-8: 0.67
 From dist-3 through dist-8: 0.85

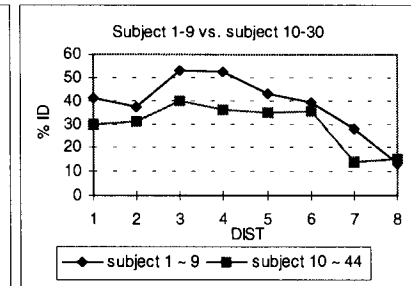
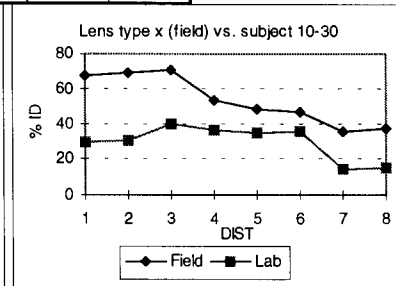
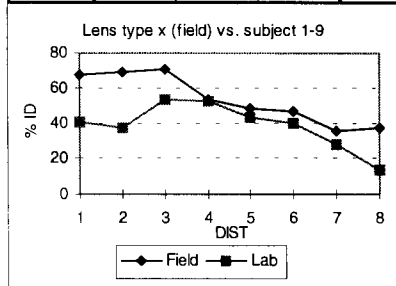
Correlation values

From dist-1 through dist-8: 0.58
 From dist-3 through dist-8: 0.84

b) Lens X DIST for lens type x field test result vs. lab data separated by scene size

Subject response was divided according to the projector distance setup. Subject 1-9 saw smaller target size than the actual size but in brighter image than the second setup (subject 10 through 30).

Lab	subject 1 ~ 9			subject 10 ~ 44		
Dist	%ID	%DET	%UN	%ID	%DET	%UN
1	40.7	31.1	28.1	29.5	39.4	31.1
2	37.0	37.0	25.9	30.7	42.1	27.2
3	52.9	41.2	5.9	39.8	49.9	10.4
4	52.1	35.0	12.8	35.9	49.8	14.3
5	43.1	40.3	16.7	34.8	53.6	11.6
6	39.3	38.5	22.2	35.2	45.4	19.4
7	27.8	43.7	28.6	13.9	57.5	28.6
8	13.3	37.8	48.9	15.2	39.0	45.7



Correlation value of % ID

From dist-1 through dist-8:
 From dist-3 through dist-8:

Subj. 1-9

0.64
 0.82

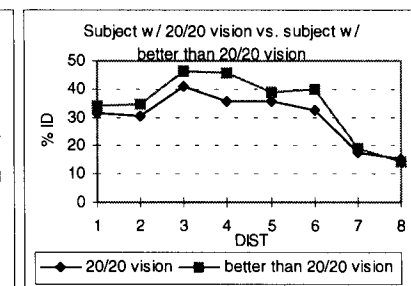
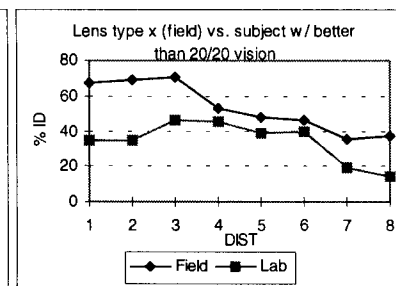
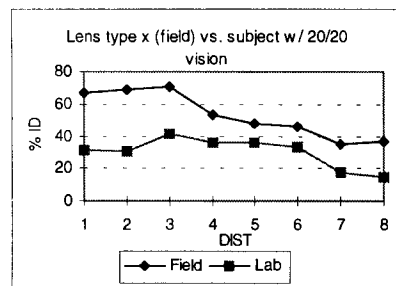
Subj. 10-30

0.66
 0.83

c) Lens X DIST for lens type x field test result vs. lab data separated by the 20/20 and higher vision

There are 15 subjects with 20/20 vision and 15 subjects with higher vision.

Lab	20/20 vision			better than 20/20 vision		
Dist	%ID	%DET	%UN	%ID	%DET	%UN
1	31.6	39.6	28.9	34.2	34.2	37.0
2	30.4	40.7	28.9	34.8	40.4	25.9
3	41.2	47.5	11.4	46.3	47.1	5.9
4	35.9	49.2	14.9	45.6	41.5	9.4
5	35.8	48.8	15.4	38.8	50.4	11.1
6	32.9	46.2	20.9	40.0	40.4	18.5
7	17.1	51.9	31.0	19.0	54.8	31.7
8	15.1	35.6	49.3	14.2	41.8	45.2



Correlation value of % ID

From dist-1 through dist-8:
 From dist-3 through dist-8:

Subj. 20/20

0.7
 0.87

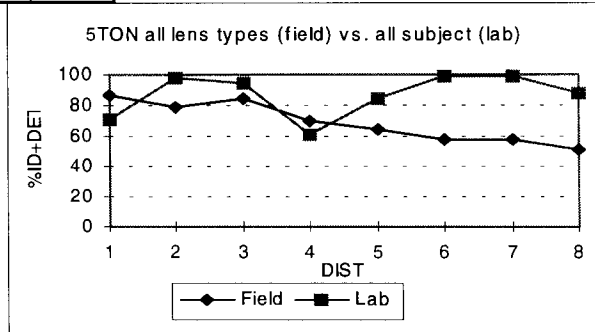
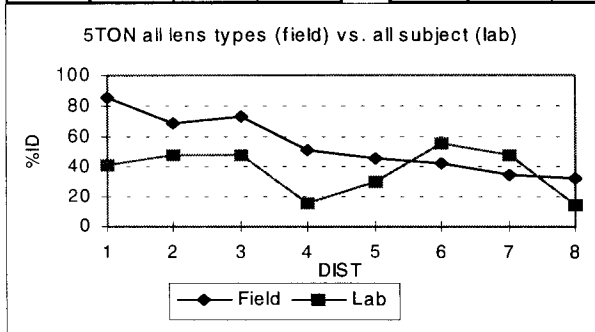
Subj. better than 20/20

0.64
 0.82

5TON truck

5TON		Field			
Dist	%ID	%DET	%UN		
1	85.1	1.2	13.7		
2	69.3	10.1	20.6		
3	73.2	10.7	16.1		
4	51.4	18.1	30.6		
5	45.7	18.3	36.0		
6	41.8	16.4	41.8		
7	34.8	23.2	42.0		
8	32.7	18.2	49.1		

5TON		Lab			
Dist	%ID	%DET	%UN		
1	40.8	30.8	28.3		
2	47.5	50.0	2.5		
3	47.3	47.3	5.3		
4	15.6	45.6	38.9		
5	30.0	54.0	16.0		
6	55.3	44.0	0.7		
7	47.5	51.7	0.8		
8	14.0	73.3	12.7		



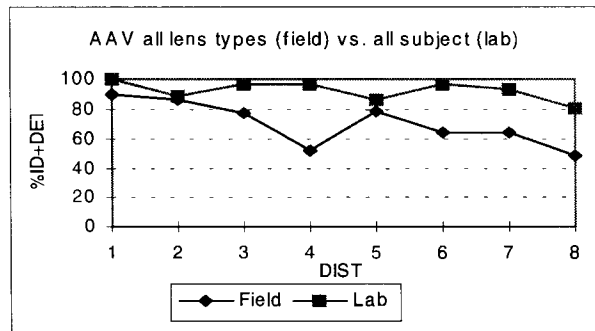
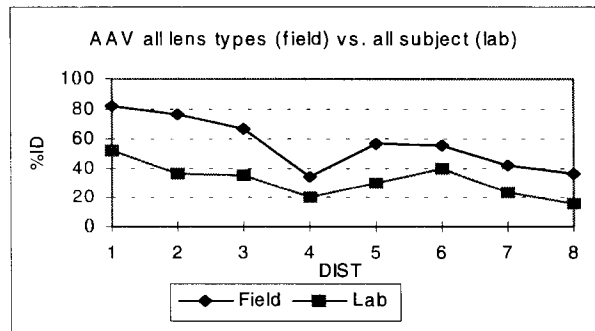
Correlation values: 0.3

-0.2

AAV

AAV		Field			
Dist	%ID	%DET	%UN		
1	81.9	7.6	10.4		
2	76.4	10.4	13.2		
3	66.7	10.9	22.4		
4	35.0	16.8	48.3		
5	57.1	21.5	21.5		
6	55.7	8.9	35.4		
7	41.7	22.2	36.1		
8	37.0	12.0	51.0		

AAV		Lab			
Dist	%ID	%DET	%UN		
1	52.2	47.8	0.0		
2	36.7	52.2	11.1		
3	35.6	61.1	3.3		
4	20.0	76.7	3.3		
5	30.0	56.7	13.3		
6	40.0	56.7	3.3		
7	23.3	70.0	6.7		
8	15.6	65.6	18.9		



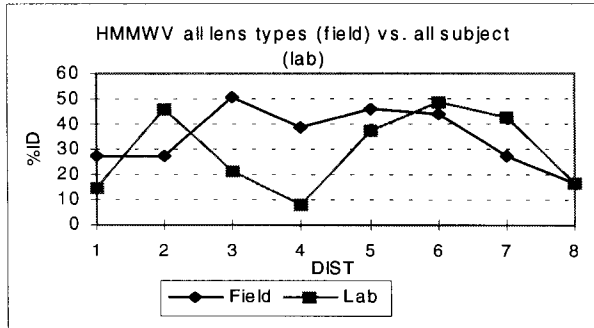
Correlation value: 0.9

0.3

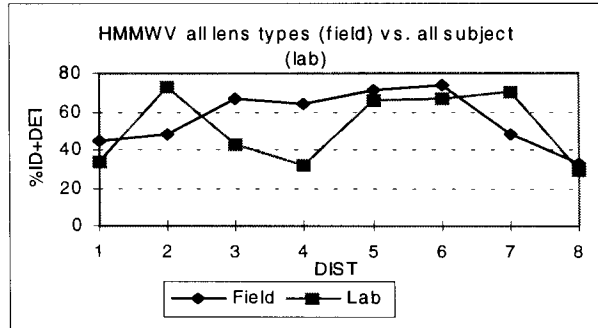
HMMWV

HMMWV		Field			
Dist	%ID	%DET	%UN		
1	27.4	16.7	56.0		
2	27.1	20.5	52.4		
3	50.9	15.5	33.6		
4	38.6	25.6	35.8		
5	45.8	25.3	28.9		
6	43.8	30.1	26.2		
7	27.2	21.2	51.6		
8	16.4	16.4	67.2		

HMMWV		Lab			
Dist	%ID	%DET	%UN		
1	15.0	19.2	65.8		
2	46.1	26.7	27.2		
3	21.7	20.8	57.5		
4	8.3	23.3	68.3		
5	37.3	28.0	34.7		
6	48.9	17.8	33.3		
7	42.7	28.0	29.3		
8	16.7	12.5	70.8		



Correlation value: 0.1



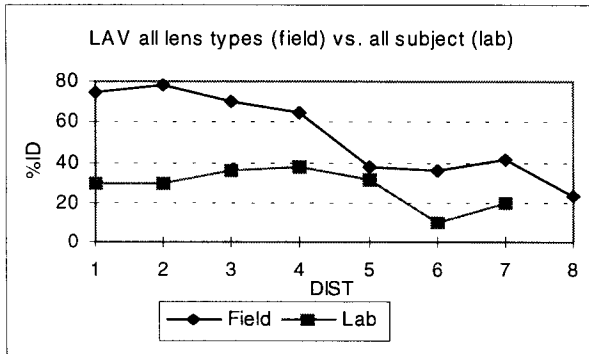
0.3

LAV

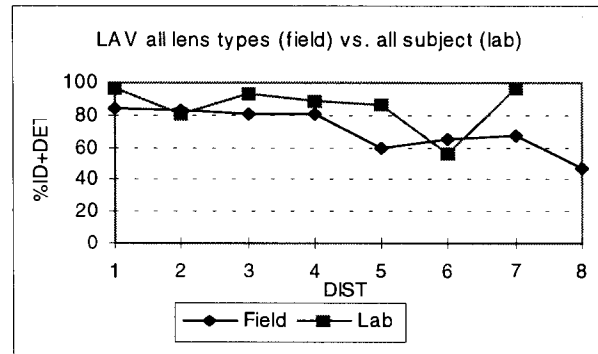
LAV	Field		
Dist	%ID	%DET	%UN
1	74.3	9.7	16.0
2	78.6	4.7	16.7
3	70.1	11.1	18.8
4	64.6	16.7	18.8
5	38.2	21.5	40.3
6	35.6	29.8	34.6
7	41.4	26.2	32.5
8	23.6	23.6	52.8

LAV	Lab		
Dist	%ID	%DET	%UN
1	30.0	66.7	3.3
2	30.0	50.8	19.2
3	35.6	57.8	6.7
4	37.5	50.8	11.7
5	31.7	55.0	13.3
6	10.0	46.7	43.3
7	20.0	76.7	3.3
8			

Empty data at distance 8 represents no data available from the lab.



Correlation value: 0.6



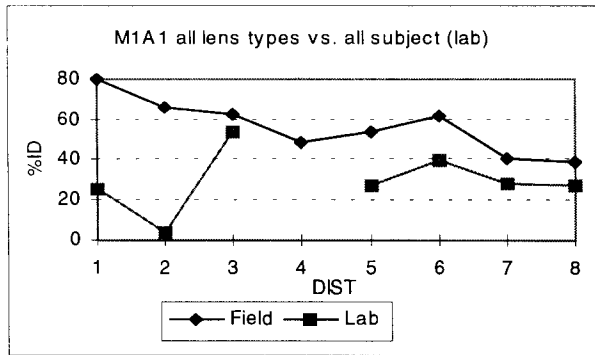
0.4

MIA1

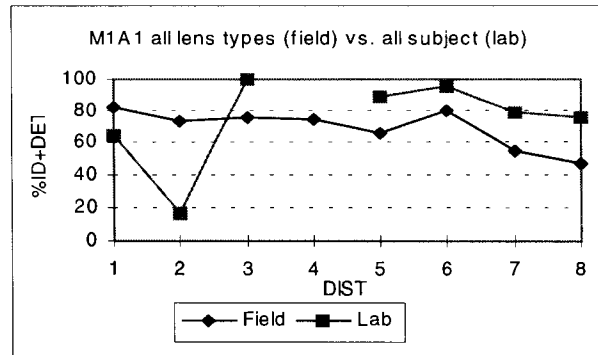
MIA1	Field		
Dist	%ID	%DET	%UN
1	79.9	2.1	18.1
2	65.4	8.4	26.2
3	62.3	13.1	2.6
4	48.4	26.6	25.0
5	53.5	12.5	34.0
6	61.1	19.4	19.4
7	40.1	14.6	45.3
8	38.2	8.3	53.5

MIA1	Lab		
Dist	%ID	%DET	%UN
1	25.0	40.0	35.0
2	3.3	13.3	83.3
3	53.3	46.7	0.0
4			
5	26.7	62.2	11.1
6	38.9	56.7	4.4
7	27.5	50.8	21.7
8	26.7	48.9	24.4

Empty data set at distance 4 at the lab represents no data availability.



Correlation value: 0.0

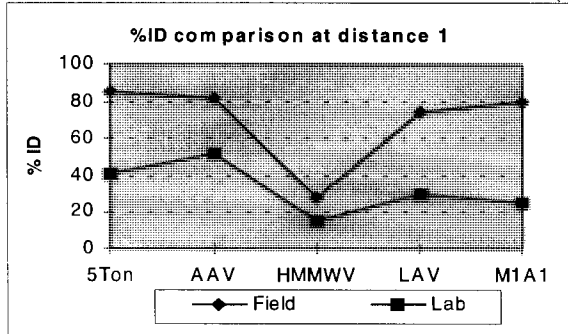


0.0

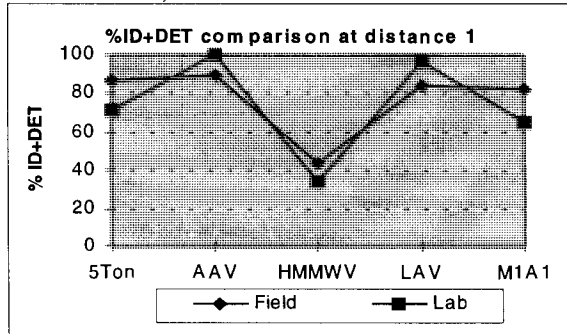
3) Vehicle ID rate comparison at different distance

		% ID								%ID + DET							
		DIST								DIST							
	Target	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Field	5Ton	85.1	69.3	73.2	51.4	45.7	41.8	34.8	32.7	86.3	79.4	83.9	69.5	64.0	58.2	58.0	50.9
	AAV	81.9	76.4	66.7	35.0	57.1	55.7	41.7	37.0	89.5	86.8	77.6	51.8	78.6	64.6	63.9	49.0
	HMMWV	27.4	27.1	50.9	38.6	45.8	43.8	27.2	16.4	44.1	47.6	66.4	64.2	71.1	73.9	48.4	32.8
	LAV	74.3	78.6	70.1	64.6	38.2	35.6	41.4	23.6	84.0	83.3	81.2	81.3	59.7	65.4	67.6	47.2
	M1A1	79.9	65.4	62.3	48.4	53.5	61.1	40.1	38.2	82.0	73.8	75.4	75.0	66.0	80.5	54.7	46.5
Lab	5Ton	40.8	47.5	47.3	15.6	30.0	55.3	47.5	14.0	71.7	97.5	94.7	61.1	84.0	99.3	99.2	87.3
	AAV	52.2	36.7	35.6	20.0	30.0	40.0	23.3	15.6	100.0	88.9	96.7	96.7	86.7	96.7	93.3	81.1
	HMMWV	15.0	46.1	21.7	8.3	37.3	48.9	42.7	16.7	34.2	72.8	42.5	31.7	65.3	66.7	70.7	29.2
	LAV	30.0	30.0	35.6	37.5	31.7	10.0	20.0		96.7	80.8	93.3	88.3	86.7	56.7	96.7	
	M1A1	25.0	3.3	53.3		26.7	38.9	27.5	26.7	65.0	16.7	100.0		88.9	95.6	78.3	75.6
Correlation (field vs. lab)		0.7	-0.3	0.6	0.8	-0.4	0.3	-0.8	0.3	0.9	0.2	0.8	-0.1	-0.2	-0.1	0.8	1.0

The one with best correlation value is at distance 1 (600 - 900 meters)



Correlation value: % ID - 0.7

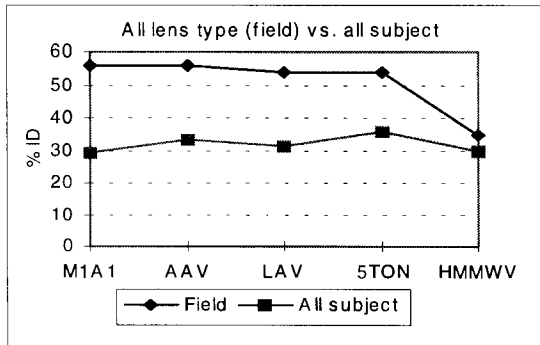


%ID+DET - 0.9

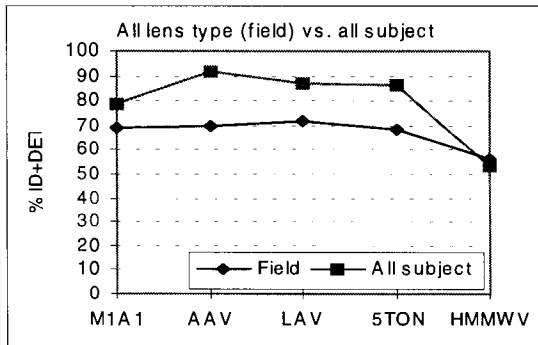
5) ID rate comparison of different vehicles

a) Comparison with all subject data

Vehicle	Field			All subject		
	%ID	%DET	%UN	%ID	%DET	%UN
M1A1	55.8	13.5	30.7	29.0	49.8	21.2
AAV	56.1	13.7	30.2	33.3	58.8	7.9
LAV	53.6	18.1	28.3	31.2	55.7	13.1
5TON	54.1	14.5	31.3	36.1	49.9	14.0
HMMWV	34.9	21.5	43.6	29.8	23.3	46.9

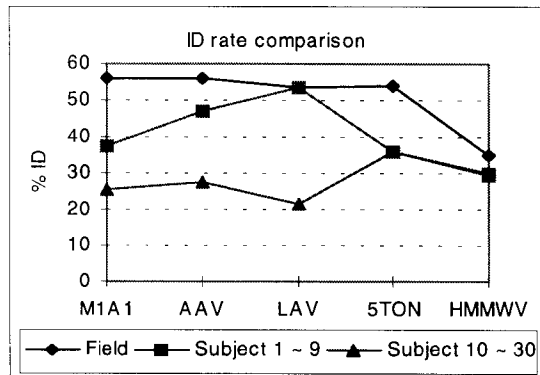
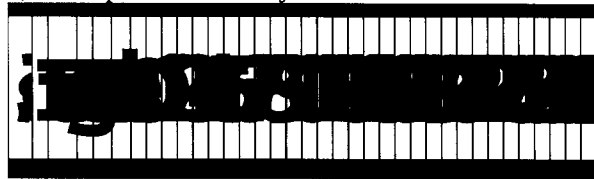


Correlation value: %ID only - 0.37



%ID + DET - 0.95

b) Comparison with subject 1-9 and 10 - 30



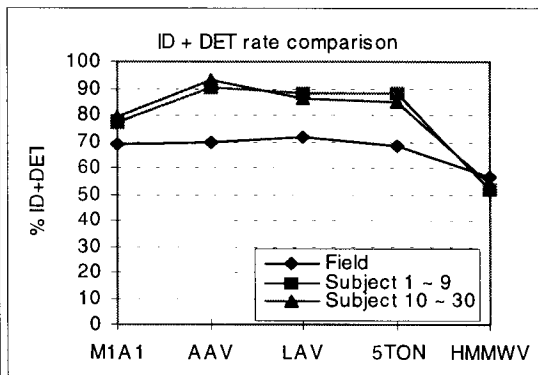
Correlation value:

Subj. 1 -9 : % ID - 0.61

%ID + DET - 0.95

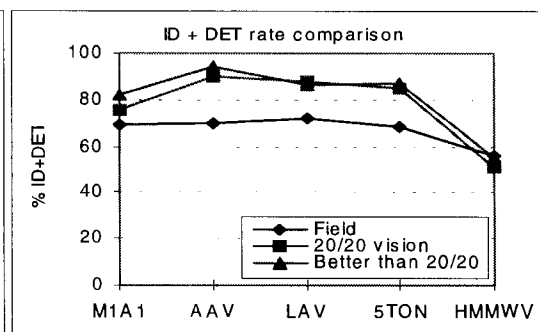
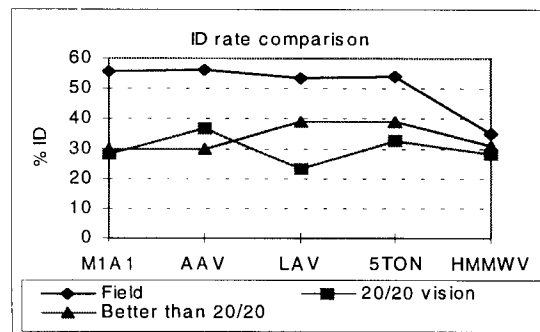
Subj. 10 - 30 : % ID - 0.17

%ID + DET - 0.95



c) Comparison with 20/20 vision and better than 20/20 vision

Vehicle	20/20 vision			Better than 20/20		
	%ID	%DET	%UN	%ID	%DET	%UN
M1A1	28.2	47.5	24.3	29.8	52.2	18.0
AAV	36.7	52.9	10.4	30.0	64.6	5.4
LAV	23.5	63.9	12.5	38.8	47.5	13.7
5TON	33.0	52.1	14.9	39.1	47.7	13.2
HMMWV	28.6	22.5	49.0	31.0	24.2	44.8

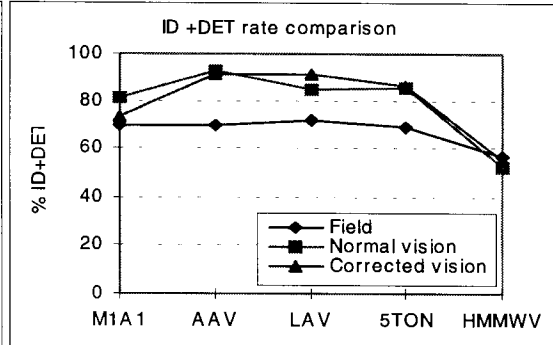
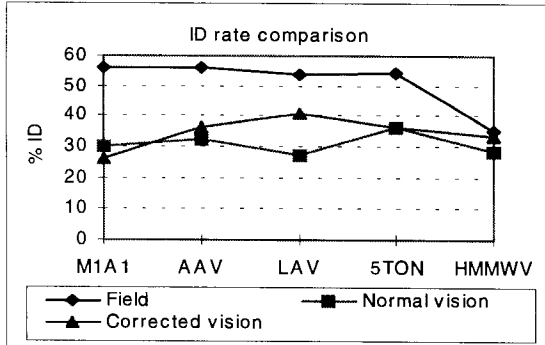


Correlation value:

Subj. 20/20 : % ID - 0.23 %ID + DET - 0.95
 Subj. better than 20/20 : % ID - 0.21 %ID + DET - 0.94

d) Comparison with normal vision and corrected vision

Vehicle	Normal vision			Corrected vision		
	%ID	%DET	%UN	%ID	%DET	%UN
M1A1	30.3	51.0	18.8	26.1	47.1	26.8
AAV	32.1	60.4	7.4	36.1	54.9	9.0
LAV	27.2	57.7	15.1	40.5	51.0	8.5
5TON	36.1	49.6	14.3	36.0	50.6	13.5
HMMWV	28.2	24.1	47.8	33.7	21.6	44.8



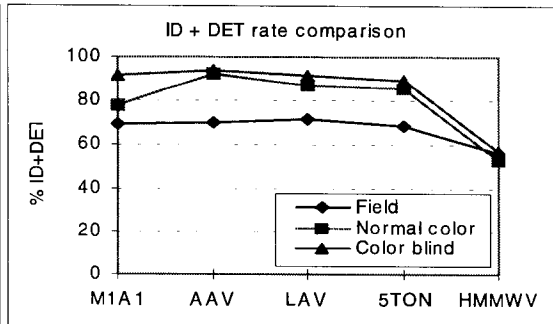
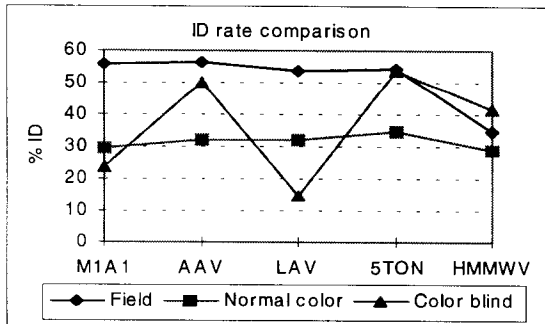
Correlation value:

Subj. normal vision : % ID - 0.42 %ID + DET - 0.95
 Subj. corrected vision : % ID - 0.01 %ID + DET - 0.91

e) Comparison with normal color vision and color blindness

(note: only 2 data sets are available for the colorblind data)

Vehicle	Normal color			Color blind		
	%ID	%DET	%UN	%ID	%DET	%UN
M1A1	29.4	48.5	22.1	23.5	67.6	8.8
AAV	32.1	59.8	8.0	50.0	43.8	6.3
LAV	32.4	54.2	13.4	14.7	76.5	8.8
5TON	34.8	50.9	14.3	53.9	35.5	10.5
HMMWV	29.0	23.9	47.1	41.4	15.7	42.9



Correlation value:

Subj. normal color vision : % ID - 0.54 %ID + DET - 0.94
 Subj. color blindness: % ID - -0.12 %ID + DET - 0.98

CONCLUSIONS

35mm color slides were used from another field test to help validate the overall test procedures used in the Visual Perception Laboratory (VPL). The color slides were of seven military vehicles positioned at tactical range in the desert. The correlation of the laboratory to the field ranged from 0.5 to 0.95 depending on the

variables analyzed and questions asked of the subjects. The highest correlation, 09.5, was obtained when comparing identification rates of the vehicles between the field and the lab. This is understandable in light of the fact that detection is strongly controlled by local luminance conditions, which are hard to replicate in the lab, and identification rates are more a function of the target size, shape, texture and target/background color differences, which are easily replicated in the lab using various projection techniques. Bottom line, the VPL can give results that correlate almost perfectly to the field if the correct questions are asked.

Overall, the lower luminance in the VPL of the projected image resulted in a lower identification rate and higher detection rate than the field test. This study shows that the vehicle identification rate aggregated by the distance gives the best correlation.

REFERENCE

1) Ground Laser Eye Protection System (GLEPS) for Armored Vehicle Crews test report, United States Marine Corps, Marine Corps Systems Command Quantico, VA. 22134-5080; January 25, 1994