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NAMRL 1314

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July 1985

NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY

PENSACOLA, FLORIDA

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Naval Medical Research and Development Command
63701N
A34030F/68C
2W1192000-0001

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July 1985

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SUMMARY PAGE

This report summarizes the development of a vision testing program currently being administered by the Naval Aerospace Medical Research Laboratory (NAMRL) at the Tactical Air Combat Training System, NAS Oceana, VA. The research program is designed to measure and suggest means of improving aircrew visual capabilities. This report describes the procedures used to identify and select vision tests that will be evaluated in field studies as predictors of an individual's ability to detect targets in air-to-air engagements.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Raymond Briggs and Dr. William Morey for their comments and review of the manuscript. Further, we would like to thank our sponsor at NAVAIRSYSCOM, who arranged, through contract support, the statistical consultative services of Dr. Marshall Jones. Also, the authors would like to thank Mrs. Nell Davis and Ms. Angelisa Stallworth for their secretarial assistance.

INTRODUCTION

A review of Vietnam combat data by Vice Admiral Weymouth, former Naval Director for Research, Development, Training, and Education, indicated that vision plays a major role in early target detection, even in radar-equipped aircraft. Youngling (1) summarized written comments from 100 American combat pilots, and noted that vision is frequently more important in combat than the selection and execution of the most appropriate flight maneuver. Despite the development of advanced electro-optical sensors in modern aircraft, the task of detecting adversary aircraft in combat operations still depends upon human visual skills. Furthermore, visual target identification is usually required before an attack can be initiated. Thus, Ginsberg's (2) statement, "He who detects the enemy first has by far the greatest chance of survival and combat success", is still applicable. Consequently, it is important to be able to accurately assess pilot performance in relation to visual ability.

Historically, the military has been concerned that existing vision tests may be too clinically oriented to assess pilot performance accurately in real-world situations. Since 1973, the Naval Aerospace Medical Research Laboratory (NAMRL) has been measuring and evaluating various aspects of visual performance and relating them to actual flying tasks. Whether or not specific vision tests can predict pilot performance is being studied by NAMRL investigators at the Naval Air Station, Oceana, Virginia.

The Tactical Air Combat Training System (TACTS) at Oceana is a computerized data communications and tracking network that records real time flight dynamics, weapons system status, and weapons firing of each aircraft performing air combat maneuvers (ACM). The TACTS was developed as a fleet-usable tool to quantify pilot performance and to aid aircrew debriefing. The NAMRL Vision Test Battery (VTB) enables detailed measurement of the visual capacities of pilots. In June 1983, the TACTS and the NAMRL VTB were linked in a field-based, research project to determine if visual skills are accurate predictors of performance in ACM.

There were two major steps involved in designing the research project. The first step was to study the flying tasks involved in ACM and to identify an accurate and meaningful measure of performance. The second step was to develop a streamlined battery of vision tests relevant to the visual requirements of the flying task identified.

Previous studies of TACTS data (3-6) were used as a guide in the current research project. The criterion measure of performance in ACM, slant range, is the distance between observer and adversary, inclusive of any altitude separation, at target acquistion. Slant range is recorded when a pilot gives a verbal response (usually "TALLYHO") indicating visual detection of a target. Hutchins and Jones (3) attempted to identify vision-based "situational" variables provided by the TACTS Display and Debriefing Subsystem (DDS), and to relate them to air-to-air target detection performance. In a subsequent study, Hutchins (4) recorded data on ACM engagements involving a single carrier air wing during a 10-day detachment to the TACTS range. Jones (5,6) attempted to determine the possible value of "peer ratings" as an estimate of an individuals's target detection performance. Peer ratings are based solely on personal impressions of squadron colleagues. Peer ratings were highly correlated (r=.83) with objective measures of target detection ability. Peer evaluation data, therefore, were included in the current project as a back-up performance estimate possibly correlated with vision test data.

Streamlining the battery of vision tests involved the deliberate aggregation of orthogonal measurements of visual performance, simplification of scaling and scoring, and deletion of vision tests which were redundant or inadequately correlated with the flying task involved. It was necessary to make the test battery short enough to accommodate the busy flight schedule of aircrewmen.

METHODS

VISION TESTS

In assembling the Vision Test Battery, over 100 individual tests were considered. The original series of 67 tests took 4 1/2 days to administer. Each subject was then retested, for a total test duration of 9 days. Initial tests (Table I) are summarized below.

A. Eyelane Tests

A wide range of clinical tests and measures were evaluated. Facilities were available for a complete "21 point" eye examination, including fundus photography, biomicroscopy, and tonometry.

B. Chart Tests

A variety of chart tests were used. Standard Snellen wall charts were used to measure acuity. The A. O. Project-O-Chart was used to assess the subjective refraction. Standard near point cards were used to measure visual acuity at 16 inches. Distant and near acuity charts of medium (+0.2 contrast ratio) and low (+0.1 contrast ratio) contrast were specially developed and constructed for clinical use in the battery of vision tests.

C. Vision Screening Tests

The Armed Forces Vision Tester, the Titmus Vision Tester, the Verhoeff Depth Perception Test, and the Farnsworth Lantern Color Perception Test were incorporated into the initial Vision Test Battery. This group of screening devices includes all of

Table 1. List of tests in NAMRL experimental Vision Test Battery

<u>Optometric Tests & Measures</u>

Retinoscopy OD, OS; central peripheral
Subjective Refraction OD, OS, OU; -0.9, -0.1 contrast
Distant Phoria Verhoff Lens
Distant Phoria-Maddox Rod horizontal, vertical
Adduction blur, break, recovery
Abduction blur, break, recovery
Supra Duction break, recovery
Infra Duction break, recovery
Accommodative Amplitude OD, OS, OU
Near Phoria horizontal, vertical
Gradient AC/A OD, OS, OU
Positive Relative Convergence blur, break, recovery
Negative Relative Convergence blur, break, recovery
Positive Relative Accommodation
Negative Relative Accommodation
Cover Test with prisms 5.8m, 0.4m
Ocular Version
Near Point of Convergence
Lensometer measures of Rx in use
Eye Color Identification

<u>Chart Tests</u>

Snellen Acuity 5.8m; -0.9, -0.2; -0.1 contrast
Snellen Acuity 0.4m; -0.9, -0.2; -0.1 contrast
Harrington Flocks Visual Field
Pseudo-Isochromatic Plates with Tritan Plate
Weston Visual Performance Test
Size Contrast Chart Test

<u>Vision Screener Tests</u>

Verhoff Depth Perception Test
FALANT Farnsworth Lantern, Color Perception Test
Titmus Vision Tester
- Far Central Acuity OD, OS, OU
- Near Central Acuity OD, OS, OU
- Color Vision
- Horizontal Phoria, Far
- Vertical Phoria, Far

Armed Forces Vision Tester
- Far Central Acuity OD, OS, OU
- Near Central Acuity OD, OS, OU
- Vertical Phoria Far, Near
- Horizontal Phoria Far, Near
- Depth Perception

<u>Psychometric Tests</u>

Central Detection 5.5m, +1.0 contrast (high)
Central Detection 5.5m, +0.1 contrast (low)
Peripheral Detection 5.5m, +1.0 contrast
Peripheral Detection 5.5m, +0.1 contrast

Central Acuity 5.5m, +1.0 contrast
Central Acuity 5.5m, +0.1 contrast
Peripheral Acuity 5.5m, +1.0 contrast
Peripheral Acuity 5.5m, +0.1 contrast

Central Acuity 0.457m, +1.0 contrast
Central Acuity 0.457m, +0.1 contrast
Peripheral Acuity 0.457m, +1.0 contrast
Peripheral Acuity 0.457m, +0.1 contrast

Central Lateral Movement 5.5m, +1.0 contrast
Central Lateral Movement 5.5m, +0.1 contrast
Peripheral Lateral Movement 5.5m, +1.0 contrast
Peripheral Lateral Movement 5.5m, +0.1 contrast

Central Size Change 5.5m, +1.0 contrast
Central Size Change 5.5m, +0.1 contrast
Peripheral Size Change 5.5m, +1.0 contrast
Peripheral Size Change 5.5m, +0.1 contrast

Lateral Detection/Acquisition/Identification 5.5m, +1.0 contrast
Lateral Detection/Acquisition/Identification 5.5m, +0.1 contrast

Detection/Acquisition In Depth 5.5 to 0.457m, +1.0 contrast
Detection/Acquisition In Depth 5.5 to 0.457m, +0.1 contrast

Detection/Acquisition In Depth 0.457 to 5.5m, +1.0 contrast
Detection/Acquisition In Depth 0.457 to 5.5m, +0.1 contrast

Signal Detection (central detection) 5.5m, +0.1 contrast
Glare Sensitivity (central acuity) 5.5m, +1.0 contrast
Glare Sensitivity (central acuity) 5.5m, +0.1 contrast
Glare Sensitivity (peripheral detection) 5.5m, +1.0 contrast
Glare Sensitivity (peripheral detection) 5.5m, +0.1 contrast

<u>Other Tests</u>

Dynamic Acuity 20°/sec, +1.0 contrast
Dynamic Acuity 20°/sec, +0.1 contrast
Dynamic Acuity 50°/sec, +1.0 contrast
Dynamic Acuity 50°/sec, +0.1 contrast
Dynamic Acuity 110°/sec, +1.0 contrast
Dynamic Acuity 110°/sec, +0.1 contrast

Contrast Sensitivity
Dark Focus
Visual Detection Simulator

the vision screening tests currently employed at Navy physical exam facilities.

D. Automated Vision Tests

Sixteen automated vision tests were developed at NAMRL to study central and peripheral visual function. Each test was performed under high contrast (+1.0 contrast ratio) and low contrast (+0.1 contrast ratio) conditions, at both far and near distances (18 feet and 18 inches). The tests determined threshold by staircase, signal detection, or a bracket method developed at NAMRL (7). The bracket method (8) resembles the conventional staircase method, except that the stimulus continuously varies and the observer's response dictates the subsequent stimulus size. Target size in practice trials was reduced until it could no longer be resolved, and then increased to the level where it could again be resolved. After 10 practice trials, 40 test trials were administered. During the test trials, two correct responses were required before the stimulus was reduced in size (.05 log unit steps corresponding to a factor of 1.122). Conversely, the target was increased in size when the observer responded incorrectly. Thresholds were then determined by means of linear regression.

SUBJECTS

Three groups of subjects were studied. Group 1 consisted of 15 men and 2 women, ages 19 to 57. Group 2 consisted of 22 men and 3 women, ages 22 to 67. Group 3 consisted of 50 men, ages 18 to 26. This report deals primarily with analysis of Groups 2 and 3 data.

PROCEDURES

After the test battery was assembled, studies were undertaken to determine which tests might be related to pilot visual performance in air-to-air target detection. Groups 1 and 2 were administered the most extensive battery of tests (4 1/2 days duration). Each subject was retested within one week of their original test. All tests of Groups 1 and 2 were conducted in the laboratory.

Group 3 subjects were also tested twice, once in the laboratory and once in a trailer . One-half of Group 3 was tested in the trailer first and the laboratory second, with the other half tested in the opposite sequence. This experimental design neutralized the potential effect of practice on results from laboratory and trailer test sites. This design also determined the trans-situational reliability of individual vision tests. If a test did not generalize from the laboratory to the trailer, then it could not be assummed that it would generalize from the trailer to the TACTS range, or to operational conditions.

Selection of tests for the revised VTB was based on test-site influences, and reliability. Since an additional criterion was the time constraint, test duration was restricted to a maximum of 3 hours. Professional best estimates of visual demands considered relevant to the aviation task (air-to-air target detection) also influenced test selection.

RESULTS

Threshold values were obtained for all vision tests, and reaction time values were obtained for all vision tests except contrast sensitivity. Tables II and III summarize the test-retest thresholds and reaction times, respectively, for Group 2. For any given test, a decline of 10% or more in mean threshold, coupled with a significant test-retest correlation coefficient, was interpreted as a significant positive influence of experience. A non-significant correlation coefficient, regardless of the size of the change in mean threshold, was interpreted as a low test-retest reliability. As expected, no tests showed a 10% or greater increase in mean threshold, and a significant correlation; such a result would indicate a significant negative influence of experience.

Results of Group 2 suggest that experience influenced the peripheral acuity, lateral movement (right), and peripheral size change (growing) tests. Furthermore, the peripheral detection, central size change (growing), and peripheral size change (shrinking) tests had poor test-retest correlations for threshold level. The remaining tests showed significant reliability without any obvious influence of experience.

Lab-trailer thresholds and reaction times for Group 3 are summarized in Tables IV and V respectively. Although 50 subjects were tested, the sample size for some tests was slightly less than 50 (see Tables IV and V) due to equipment failure and other problems. For any given test, a 10% or greater change in mean threshold, coupled with a significant lab-trailer correlation coefficient, was interpreted as a significant influence of test site. A non-significant correlation coefficient, regardless of the size of the change in mean threshold, was interpreted as low trans-situational reliability for that test.

The Group 3 results indicate that test site influenced the peripheral detection, peripheral detection with glare, and peripheral size change (shrinking) tests. Furthermore, the peripheral acuity, lateral movement (right), central size change (shrinking), central size change (growing), and peripheral size change (growing) tests had poor lab-trailer correlations for threshold level, suggesting poor trans-situational reliability. The remaining tests showed significant reliability without any obvious influence of test site.

The results of the 18 tests administered to Groups 2 and 3 are summarized qualitatively in Table VI. Tests showing acceptable reliability included central detection, central

TABLE II

Test-Retest Analysis for Thresholds for Group 2 (n = 25 for all tests).

TEST NAME	Threshold ($\bar{X} \pm sd$) Test	Retest	% Change Threshold $\bar{X}$	Test-Retest Correlation (r)
Central detection, 5.5m, 1.0 contrast	.588 ± .16	.599 ± .18	+1.9	.90*
Peripheral detection, 5.5m, 0.1 contrast	12.970 ± 2.98	12.230 ± 3.16	-5.7	.18
Central acuity, 5.5m, 1.0 contrast	.539 ± .15	.513 ± .13	-4.8	.81*
Peripheral acuity, 5.5m, 1.0 contrast	7.460 ± 2.23	6.500 ± 1.82	-12.8	.61*
Peripheral detection with glare, 5.5m, 0.1 contrast	20.030 ± 12.12	19.810 ± 7.64	-1.1	.58*
Accommodative Flexibility, 5.5m to 0.457m, 1.0 contrast	1.230 ± 1.10	1.150 ± 1.12	-6.6	.89*
Lateral Movement detection, 5.5m, 1.0 contrast (Left)	1.830 ± .78	1.680 ± .66	-8.4	.55*
Lateral Movement detection, 5.5m, 1.0 contrast (Right)	1.530 ± .87	1.350 ± .72	-11.8	.76*
Central size change, 5.5m, 0.1 contrast (Shrinking)	1.750 ± .69	1.740 ± .75	-0.6	.83*
Central size change, 5.5m, 0.1 contrast (Growing)	1.170 ± .21	1.110 ± .17	-4.6	.31
Peripheral size change, 5.5m, 1.0 contrast (Shrinking)	8.040 ± 5.37	8.730 ± 5.44	+8.6	.44
Peripheral size change, 5.5m, 1.0 contrast (Growing)	4.170 ± 4.79	2.840 ± 3.49	-32.0	.81*

TABLE II (Continued)

Test-Retest Analysis for Thresholds for Group 2 (n = 25 for all tests).

TEST NAME	Threshold ($\bar{X}\pm sd$) Test	Retest	% Change Threshold $\bar{X}$	Test-Retest Correlation (r)
Contrast sensitivity (.5 cycles/deg)	-1.530 ± .33	-1.540 ± .26	-0.7	.51*
Contrast sensitivity (1 cycle/deg)	-1.850 ± .23	-1.830 ± .28	+1.2	.66*
Contrast sensitivity (3 cycle/deg)	-2.200 ± .27	-2.180 ± .28	+1.1	.66*
Contrast sensitivity (6 cycle/deg)	-2.150 ± .29	-2.190 ± .31	-1.8	.71*
Contrast sensitivity (11.4 cycle/deg)	-1.880 ± .30	-1.910 ± .31	-1.6	.74*
Contrast sensitivity (22.8 cycle/deg)	-1.380 ± .41	-1.470 ± .41	-6.3	.80*

* = P < .01 (r crit. (2 tail, n = 25) = .487)

TABLE III

Test-Retest Analysis for Reaction Times for Group 2
(n = 25 for all tests).

TEST NAME	Test-Retest Correlation (r)
Central detection, 5.5m, 1.0 contrast	.42
Peripheral detection, 5.5m, 0.1 contrast	.46
Central acuity, 5.5m, 1.0 contrast	.65*
Peripheral acuity, 5.5m, 1.0 contrast	.72*
Peripheral detection with glare, 5.5m, 0.1 contrast	.83*
Accommodative Flexibility, 5.5m to 0.457m, 1.0 contrast	.59*
Lateral Movement detection, 5.5m, 1.0 contrast (Left)	.46
Lateral Movement detection, 5.5m, 1.0 contrast (Right)	.51*
Central size change, 5.5m, 0.1 contrast (Shrinking)	.48
Central size change, 5.5m, 0.1 contrast (Growing)	.39
Peripheral size change, 5.5m, 1.0 contrast (Shrinking)	.83*
Peripheral size change, 5.5m, 1.0 contrast (Growing)	.80*

* = P < .01 (r crit. (2 tail, n = 25) = .487)

TABLE IV

Laboratory-Trailer Analysis for Thresholds for Group 3 (n = 50, except where indicated).

TEST NAME	Threshold ($\bar{X}\pm sd$) Laboratory	Threshold ($\bar{X}\pm sd$) Trailer	% Difference[1] Threshold $\bar{X}$	Lab-Trailer Correlation (r)
Central detection, 5.5m, 1.0 contrast	.546 ± .197	.498 ± .160	-8.8	.92* (a)
Peripheral detection, 5.5m, 0.1 contrast	9.080 ± 5.100	6.950 ± 1.900	-23.5	.42*
Central acuity, 5.5m, 1.0 contrast	.469 ± .160	.442 ± .105	-5.8	.64*
Peripheral acuity, 5.5m, 1.0 contrast	6.290 ± 1.690	6.860 ± 3.170	+9.1	.34
Peripheral detection with glare, 5.5m, 0.1 contrast	11.[illegible]00 ± 3.750	9.750 ± 2.920	-15.2	.51* (a)
Accommodative Flexibility, 5.5m to 0.457, 1.0 contrast	.256 ± .039	.243 ± .064	-5.1	.41* (a)
Lateral Movement detection, 5.5m, 1.0 contrast (Left)	1.440 ± .670	1.450 ± .520	+0.7	.57* (a)
Lateral Movement detection, 5.5m, 1.0 contrast (Right)	1.200 ± .260	1.220 ± .280	+1.7	.31 (a)
Central size change, 5.5m, 0.1 contrast (Shrinking)	1.650 ± .680	2.400 ± .660	+45.5	.27
Central size change, 5.5m, 0.1 contrast (Growing)	1.150 ± .330	1.460 ± .470	+27.0	.14 (b)
Peripheral size change, 5.5m, 1.0 contrast (Shrinking)	6.480 ± 4.230	4.680 ± 2.390	-27.8	.45* (a)
Peripheral size change, 5.5m, 1.0 contrast (Growing)	2.690 ± 2.360	2.590 ± 2.050	-3.7	.28 (c)

TABLE IV (Continued)

Laboratory-Trailer Analysis for Thresholds for Group 3 (n = 50, except where indicated).

TEST NAME	Threshold ($\overline{X}$±sd) Laboratory	Trailer	% Difference[1] Threshold $\overline{X}$	Correlation (r)
Contrast sensitivity (.5 cycles/deg)	-1.590 ± .22	-1.750 ± .24	-9.7	.72*
Contrast sensitivity (1 cycle/deg)	-1.870 ± .17	-2.080 ± .21	-11.2	.65*
Contrast sensitivity (3 cycle/deg)	-2.230 ± .22	-2.460 ± .24	-10.3	.70*
Contrast sensitivity (6 cycle/deg)	-2.230 ± .27	-2.440 ± .26	-9.3	.77*
Contrast sensitivity (11.4 cycle/deg)	-1.960 ± .27	-2.200 ± .27	-12.0	.73*
Contrast sensitivity (22.8 cycle/deg)	-1.450 ± .31	-1.630 ± .28	-12.6	.53*

[1]Percent difference is relative to the mean laboratory threshold

* = $P < .01$ (r crit. (2 tail, n = 50) = .354). Sample size for (a) was 49, (b) was 48, (c) was 46.

TABLE V

Laboratory-Trailer Correlations for Reaction Times for Group 3

TEST NAME	Laboratory-Trailer Correlation (r)
Central detection, 5.5m, 1.0 contrast	.32 (a)
Peripheral detection 5.5m, 0.1 contrast	.43*
Central acuity, 5.5m, 1.0 contrast	.34
Peripheral acuity, 5.5m, 1.0 contrast	.21
Peripheral detection with glare, 5.5m, 0.1 contrast	.46* (a)
Accommodative Flexibility, 5.5m to 0.457m, 1.0 contrast	.63* (a)
Lateral Movement detection, 5.5m, 1.0 contrast (Left)	.45* (a)
Lateral Movement detection, 5.5m, 1.0 contrast (Right)	.45* (a)
Central size change, 5.5m, 0.1 contrast (Shrinking)	.62*
Central size change, 5.5m, 0.1 contrast (Growing)	.54* (b)
Peripheral size change, 5.5m, 1.0 contrast (Shrinking)	.36* (a)
Peripheral size change, 5.5m, 1.0 contrast (Growing)	.31 (c)

* = $P < .01$ (r crit. (2 tail, n = 50) = .354)
Sample size for (a) was 49, (b) was 48, (c) was 46.

TABLE VI

Qualitative Summary of Group 2 and Group 3 Results.

TEST	GROUP 2 Experience Influence – = NO X = YES	GROUP 2 Test-Retest Reliability – = GOOD X = BAD	GROUP 3 Test Site Influence – = NO X = YES	GROUP 3 Trans-Site Reliability – = GOOD X = BAD	NUMBER X
Central Detection	–	–	–	–	0
Peripheral Detection	–	X	X	–	2
Central Acuity	–	–	–	–	0
Peripheral Acuity	X	–	–	X	2
Peripheral Detection, Glare	–	–	X	–	1
Accommodative Flexibility	–	–	–	–	0
Lateral Movement, Left	–	–	–	–	0
Lateral Movement, Right	X	–	–	X	2
Central Size Change, Shrinking	–	–	–	X	1
Central Size Change, Growing	–	X	–	X	2
Peripheral Size Change, Shrinking	–	X	X	–	2
Peripheral Size Change, Growing	X	–	–	X	2
Contrast Sensitivity, .5 cpd	–	–	–	–	0
Contrast Sensitivity, 1 cpd	–	–	–	–	0
Contrast Sensitivity, 3 cpd	–	–	–	–	0
Contrast Sensitivity, 6 cpd	–	–	–	–	0
Contrast Sensitivity, 11.4 cpd	–	–	–	–	0
Contrast Sensitivity, 22.8 cpd	–	–	–	–	0

acuity, accommodative flexibility, lateral movement (left), and all six contrast sensitivity tests. Unacceptable tests included peripheral detection, peripheral acuity, peripheral detection (glare), lateral movement right, and all central and peripheral size change tests.

Intertest correlations for the laboratory and trailer data (Group 3) are given in Tables VII and VIII, respectively. Significant correlations which were consistent for both test sites include central detection with central acuity (.73,.71), central detection with lateral movement to the right (.72,.39), and peripheral detection with peripheral detection in glare (.54,.73).

DISCUSSION

Analyses of Group 2 and Group 3 data enabled identification of vision tests useful for inclusion in the revised Vision Test Battery (VTB) deployed to NAS Oceana. The four size change tests were rejected for inclusion because of poor reliability. The three peripheral detection and acuity tests were rejected because of poor reliability and apparent influences of experience and test site.

The central detection, central acuity (high contrast), accommodative flexibility, and contrast sensitivity tests were retained in the revised VTB because they were reliable and were not influenced by either experience or test site. Although highly correlated, both the central detection and central acuity tests were retained, because future tasking requirements insist on a measure of central visual acuity, and spot detection is most similar to the relevant task of target acquisition.

Poor results for the test of lateral movement to the right were attributed to a software error in the staircase method. The lateral movement to the left test, however, gave good results, so both tests of lateral movement were included in the revised VTB.

A test of glare sensitivity was considered necessary in the revised VTB. Such a measurement requires comparing the results from a test at low contrast without glare to results from a test at low contrast with glare. Because the peripheral acuity tests were generally unsatisfactory (see above), central acuity tests at low contrast, with and without glare were included in the revised VTB in their place.

Two additional tests relevant to aviation performance were added to the revised VTB, dynamic visual acuity (DVA) and dark focus (DF). The DVA test measures ability to see details of a target moving through a visual field at specified velocities (9). The DF test measures the resting point of accommodation when the visual field lacks detail (10). The former test is relevant to visual tasks associated with air combat maneuvers, and the latter test is relevant to visual tasks associated with night carrier

TABLE VII

Inter-test correlations for threshold in the laboratory, exclusive of contrast sensitivity.

TEST NAME	TEST CODE	B	C	D	E	F	G	H	I	J	K	L
Central detection, 5.5m, 1.0 contrast	A	-.20	.73*	-.27	-.07	.18	.72*	-.04	.31	-.03	-.10	.22
Peripheral detection, 5.5m, 0.1 contrast	B	-	-.08	.25	.54*	-.12	-.01	-.00	-.08	.21	.02	-.01
Central acuity, 5.5m, 1.0 contrast	C	-	-	-.10	-.06	.12	.50*	.15	.14	-.07	-.09	.28
Peripheral acuity, 5.5m, 1.0 contrast	D	-	-	-	.37*	-.02	-.06	-.17	-.15	.24	.36*	.01
Peripheral detection with glare, 5.5m, 0.1 contrast	E	-	-	-	-	-.04	.07	-.01	.21	.16	.04	-.02
Accommodative Flexibility, 5.5m to 0.457, 1.0 contrast	F	-	-	-	-	-	.06	.09	.06	-.07	.07	.02
Lateral Movement detection 5.5m, 1.0 contrast (Left)	G	-	-	-	-	-	-	-.33	.33	.03	-.01	.15
Lateral Movement detection 5.5m, 1.0 contrast (Right)	H	-	-	-	-	-	-	-	-.08	.03	.19	.21
Central size change, 5.5m, 0.1 contrast (Shrinking)	I	-	-	-	-	-	-	-	-	-.09	.21	-.00
Central size change, 5.5m, 1.0 contrast (Growing)	J	-	-	-	-	-	-	-	-	-	.03	.16
Peripheral size change, 5.5m, 1.0 contrast (Shrinking)	K	-	-	-	-	-	-	-	-	-	-	-.26
Peripheral size change, 5.5m, 1.0 contrast (Growing)	L	-	-	-	-	-	-	-	-	-	-	-

* = $P < .01$ (r crit. (2 tail, n = 50) =.354

TABLE VIII

Inter-test correlations for threshold in the trailer, exclusive fo contrast sensitivity

TEST NAME	TEST CODE	B	C	D	E	F	G	H	I	J	K	L
Central detection, 5.5m, 1.0 contrast	A	.13	.71*	-.03	-.01	.32	.39*	-.06	.25	-.03	-.41*	.38
Peripheral detection, 5.5m, 0.1 contrast	B	-	.01	.29	.73*	.04	-.05	-.01	-.17	.10	-.17	.13
Central acuity, 5.5m, 1.0 contrast	C	-	-	.05	.00	.34	.29	-.04	.16	.05	-.28	.23
Peripheral acuity, 5.5m, 1.0 contrast	D	-	-	-	.14	.00	-.04	.01	.06	.06	.02	-.15
Peripheral dectection with glare, 5.5m, 0.1 contrast	E	-	-	-	-	.02	-.12	.17	-.19	.19	-.00	.23
Accommodative Flexibility, 5.5m to 0.457, 1.0 contrast	F	-	-	-	-	-	.14	.31	.30	-.21	-.03	.14
Lateral Movement detection 5.5m, 1.0 contrast (Left)	G	-	-	-	-	-	-	-.10	.09	.21	-.16	.05
Lateral Movement detection 5.5m, 1.0 contrast (Right)	H	-	-	-	-	-	-	-	-.00	.02	.14	.01
Central size change, 5.5m, 0.1 contrast (Shrinking)	I	-	-	-	-	-	-	-	-	-.56*	-.20	.27
Central size change, 5.5m, 1.0 contrast (Growing)	J	-	-	-	-	-	-	-	-	-	-.02	.08
Peripheral size change, 5.5m, 1.0 contrast (Shrinking)	K	-	-	-	-	-	-	-	-	-	-	-.34
Peripheral size change, 5.5m, 1.0 contrast (Growing)	L	-	-	-	-	-	-	-	-	-	-	-

* = P < .01 (r crit. (2 tail, n = 50) = .354

landing, flying under instrument flight rules, and high altitude flight.

Comparison of Group 2 and Group 3 data revealed significant differences in threshold magnitude for the tests of accommodative flexibility and peripheral detection with glare (Tables II, IV). The differences in accommodative flexibility thresholds were attributed to differences in subject age between the two groups; Group 2 included a wider range of ages and many older subjects. The differences in glare sensitivity may also be age-related.

A revised VTB (Table IX), containing tests appropriate for quantifying visual capacities associated with the pilot task of target detection, was installed in the Mobile Field Laboratory (MFL). The VTB required approximately 3 hours to administer to each individual. The MFL was transported to the Naval Air Station, Oceana, Virginia, in May 1983, to begin validation of the vision tests.

Thus far, extensive data have been collected for over 700 TACTS engagements involving over 90 pilots from eight squadrons. Peer evaluations, detailed flight histories, and VTB measures of visual skill have been obtained for each pilot. Preliminary analyses of these data have been reported (11,12,13). Adjustments to the VTB and procedures of collecting TACTS data have been effected, and validation is continuing.

TABLE IX

Revised Vision Test Battery for NAS Oceana

1. Central Acuity, Far (5.5m), High Contrast (1.Ø)
2. Central Acuity, Far (5.5m), Low Contrast (Ø.1)
3. Central Acuity, Far (5.5m), Low Contrast (Ø.1), With Glare
4. Central Spot Detection, Far (5.5m), High Contrast (1.Ø)
5. Accommodative Flexibility, Far (5.5m) to Near (.46m), High Contrast (1.Ø)
6. Lateral Movement Detection, Far (5.5m), High Contrast (1.Ø), Left and Right
7. Contrast Sensitivity, Ø.5 cycles/degree
   1.Ø cycles/degree
   3.Ø cycles/degree
   6.Ø cycles/degree
   11.4 cycles/degree
   22.8 cycles/degree
8. Dynamic Visual Acuity, 2Ø degrees/sec
   5Ø degrees/sec
   11Ø degrees/sec
9. Dark Focus

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NAMRL Research Report 1314	2. GOVT ACCESSION NO.: AD-A168 309
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): DEVELOPMENT OF VISION TESTS FOR AIR-TO-AIR TARGET DETECTION	5. TYPE OF REPORT & PERIOD COVERED: Interim
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): W. A. Monaco, A. Morris, and P. V. Hamilton	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Aerospace Medical Research Laboratory, Naval Air Station, Pensacola, FL 32508-5700	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 63701N, A34030F/68C, 2W1192000-0001
11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Medical Research and Development Command, Naval Medical Command, National Capital Region, Bethesda, MD 20814	12. REPORT DATE: July 1985
	13. NUMBER OF PAGES: 22
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Air Combat	Visual Acuity	Dynamic Visual Acuity
Target Detection	Dark Focus	Contrast Sensitivity

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the accomplishments leading to the development of a vision testing program currently being administered by the Naval Aerospace Medical Research Laboratory (NAMRL) at the Tactical Air Combat Training System; NAS, Oceana, VA. The program is designed to measure and suggest means to improve aircrew visual capabilities. Included in this report is a description of the methods used to select vision tests appropriate for determining the relationship between an individual's visual skill and his ability to detect targets in air-to-air engagements. (Keywords: (eb.. (dots); visual acuity; contrast sensitivity; dark focus).

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S/N 0102-LF-014-6601

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