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EVALUATION OF NIGHT VISION GOGGLES IN THE DYNAMIC FLIGHT SIMULATOR

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Two aviator's night vision goggles were evaluated on the NAVAIRDEVCEN Dynamic Flight Simulator (Human Centrifuge) as part of a selection process to choose a system applicable to NAVY fixed wing flight operations. The helmet mounted sights under evaluation were "CATSEYES" and "ANVIS". The main objective of the centrifuge tests were to evaluate the acceleration induced head and neck loadings, and to subjectively compare the comfort and wearability of each system. Additional qualitative data were taken on helmet rotation and the ability to perform a visual tracking task. The six subjects found no difference in either system in term of neck strain, comfort, or the ability to keep their attention on the tracking task. Both goggles were less comfortable than the helmet alone, but no experimental run had to be aborted due to discomfort or strain and no long term physical effects were noted.

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INTRODUCTION

Two aviator's night vision goggle systems were evaluated on the NAVAIRDEVCEN Dynamic Flight Simulator (Human Centrifuge) as part of a selection process to choose a system applicable to NAVY fixed wing flight operations. The helmet mounted night vision systems under evaluation were "CATSEYES" (figure 4) and "ANVIS" (figure 5). The main objective of the centrifuge tests were to evaluate the acceleration induced head and neck loadings, and to subjectively compare the comfort and wearability of each system. Additional qualitative data were taken on helmet rotation and the ability to perform a visual tracking task.

METHOD OF TESTING

Six male volunteers, officers and enlisted personnel in the U.S.NAVY, were subjected to accelerations in the human centrifuge that simulated the G forces that could be encountered during naval fixed wing flight. The subjects wore helmets with and without the night vision goggles mounted, and were asked to perform a visual tracking task during all of the acceleration profiles. Question were asked so that the subjects could give a rating to the particular helmet/goggle combination. Standard centrifuge operating proceedures were used.

Each subject was fully clothed with flight overalls, socks, flight boots, CSU-15/P anti-G garment, MA-2 torso harness, PRK-37/P flight helmet with form fitting liner, and an MBU-15/P oxygen mask with the hose and inlet valve removed to allow free breathing. Each subject was medically instrumented with EKG electrodes, an ultrasonic Doppler flowmeter transducer located over the superficial temporal artery, and a remote reading blood pressure cuff. Medical supervision was provided to deal with any problems that could arise due to head/neck strain, unconsciousness, fatigue, nausea, etc.

The gondola of the human centrifuge was outfitted with the PALE seat fixed to a 15 degree seat back angle, a force control joystick mounted on the end of the right armrest of the seat, a video monitor approximately 40 inches in front of the subject, and two low light level video cameras. The video cameras were mounted on orthogonal axes, at approximately eye level, so that head/helmet rotation could be monitored.

The experimental protocol specified eight acceleration profiles with at least one plateau level per profile (table 1). The plateau profiles were run starting at a resting level of 1.03 Gz, then rising on a two second haversine curve to the specified plateau level, remaining at that level for 15 seconds, and finally returning to the starting level on another two second haversine curve. The subjects were given at least a one minute rest period between each successive plateau run. These runs were designed to test the night vision goggles in every possible axis of acceleration that a fixed wing aviator might experience. The Simulated Aerial Combat Maneuver (SACM) was chosen to expose the subject to an acceleration profile typical of that experienced during aerial combat. The peak acceleration of this profile reached +6Gz (figure 1). The SACM lasted for 90 seconds and was followed by a five minute rest period. All of the profiles were run during an insertion session that lasted at least one hour for all subjects. Three subjects also volunteered to repeat the entire schedule for a total insertion time of two hours. The reason for this length of time was to simulate mission length effects on head and neck strain. The two hour sessions were accomplished once for each set of goggles, the helmet only configuration was not given a two hour exposure.

The subjects performed visual tracking tasks during all of the profiles. These tasks were only used to keep the subjects alert during the experiment. The scores of these tasks were not used in the evaluation of the goggles, however one of the questions asked after each run evaluates the ability to keep a line-of-sight on the video monitor.

Any one of the three tracking tasks that were performed could be selected by the subject through switches on the joystick. Task 1 was a simulated Head-Up-Display (HUD) on which was displayed a pitch ladder, compass, altitude pointer, and an airspeed pointer. A "steering tee" symbol was also generated and moved around the screen by a summation of sinusoids motion generator. The motion of this symbol simulated the motion of a target. The task was to keep the target at the center of a reticle on the screen (figure 2a). Task 2 was an "eight ball" tracking task. The subject was presented with horizontal and verticle cross hairs, which were driven by a pseudo random motion generator, and they had to keep the cross hairs in the center of a fixed target. A score was displayed which indicated the percentage of time on target (figure 2b). In task 3, the subject was presented with the digits one through eight displayed at random positions on the screen. The task was to move a cross hair cursor over the numbers in ascending order to erase them from the screen. The score displayed was the time taken to complete the task (figure 2c).

METHOD OF EVALUATION

The objective portion of the evaluation of the night vision system was done using two low light level video cameras. These cameras were mounted at the eye level of a typical subject and were orthogonal to each other: camera 1 was mounter approximately 30 degrees to the left of the centerline, and camera two was mounted about 60 degrees to the right of the centerline. With the cameras in these postions, head/helmet movement under acceleration could be observed. Video tapes were recorded from these cameras for about half of the total runs in the project.

For the subjective evaluation, each subject was asked five questions about the comfort and wearability of the particular helmet/goggle combination after each profile (+Gz, +Gx, SACM, etc.). The subject's response to each question was a number from zero to ten along the rating scales outlined below.

1. How much effort was required to keep your head stationary?
   0- No Effort 10- Impossible
2. Give the helmet/goggle combination a comfort rating.
   0- Very Comfortable 10- Very Poor
3. How much strain was on your neck?
   0- None 10- Painful
4. Was there any disorientation due to extra helmet load?
   0- None 10- Trouble in task
5. How much helmet roatation was there?
   0- None 10- Lost line of sight

The ratings were then averaged together to get a subjective evaluation of the goggles.

Before the testing began with human subjects, a manikin was placed in the gondola, outfitted with the appropriate flight gear and goggles. Because the manikin's neck was not designed to model human neck response, these tests were done to test the mechanical integrity of each goggle system. The manikin was run through all of the profiles listed in table 1.

RESULTS

The ANVIS goggles were the first to be tested on the manikin. After insuring that the goggles were in the down and locked position and a safety lanyard tied on, the test began. The ANVIS system showed nothing notable until the -4Gx run. As soon as the centrifuge had reached the plateau level the goggles came out of the helmet mount. An inspection of the mount and goggles showed no catastrophic damage and seemed to work as before the test. The G level was reduced to -3Gx and the run repeated. Again the goggles were dislodged from the mount. A review of the video tape showed that the goggles were first flipped upward at about -2.5Gx and this position aligned the force vector with the channel in the mount that is used for removal. Therefore, the goggles were removed. For subsequent human testing, the locking mechanism on the mount was intentionally jammed to prevent the goggles from flipping upward.

The CATSEYES goggles went through the entire testing protocol with nothing notable to report. In human testing, however, the eye protection furnished with the catseyes could not be used. The protective plastic was attached to the oxygen mask and was formed to fit exactly into the opening in the front of the helmet. This fit did not allow adequate adjustment in the positioning of the mask to firmly secure the helmet. Excessive helmet rotation was observed when the eye protection was used. For most of the experiment, an alternate eye shield was used.

There were no chronic physical effects reported from any of the subjects. Head and neck strain was transient if present at all. None of the insertions was terminated due to discomfort of the helmet or goggles, including the two hour sessions.

Table four shows the results of the analysis of the questions averaged over all subjects and all runs. Each profile was performed twice for each goggle and once for the helmet only. The degrees of freedom for this analysis were 6 subjects x 8 profiles x 2 repititions = 96. The averages of the questions are presented in figure 3. The results of paired t-tests on the data show no significant difference between the two goggle systems for questions one through four and a mild difference for question five. The helmet only configuration was far supperior to either set of goggles for all questions. Averaging all of the data together (previous df x 5 questions = 480) shows no significant difference between the CATSEYES and ANVIS ($p > 0.05$). In table two, the questions were grouped together according to run type and averaged over all subjects and all questions. This was done to see if there was any significant difference in the goggle rating due to the orientation of the G vector. The validity of the subjective evaluations can be seen in the fact that runs #3 and #6 have very similar ratings and they correspond to the SACM profile. In table three, the questions were grouped according to subject and averaged over all questions and all runs. This was to see if there was any significant difference in subject preference.

CONCLUSION

Both CATSEYES and ANVIS night vision goggle systems were evaluated on the human centrifuge under G loadings and vectors chosen to simulate conditions found in naval fixed wing air operations. In the subjective evaluations, the six subjects found no significant difference in either system in terms of neck strain, comfort, or the ability to keep their attention on the tracking task. Both goggles were less comfortable that a helmet alone but no experimental run had to be aborted due to discomfort or strain and no long term physical effects were noted. No adverse head or helmet rotations were noted on the video tapes. The problem of ANVIS releasing from its mount at -3Gx must be looked into if this system is to be used operationally. Apart from that observation, there was no significant difference in the two goggle systems under acceleration.

Table-1 Acceleration Profiles

	Profile	G-Levels
1	+Gz Plateau	2 & 4
2	+Gy Plateau	1 & 2
3	SACM	+6Gz Peak
4	-Gz Plateau	1 & 2
5	+Gx Plateau	2 & 4
6	SACM	+6Gz Peak
7	-Gy Plateau	1 only
8	-Gx Plateau	2 & 4

Table-2 Average by run type

	Run Number							
	1	2	3	4	5	6	7	8
ANVIS	1.78	4.22	2.73	3.95	3.23	2.98	2.73	3.80
CATSEYES	2.27	4.23	3.47	3.47	3.53	3.73	3.58	3.00
Helmet Only	0.33	1.27	0.77	1.43	1.33	0.90	1.03	1.83

Table-3 Average by subject number

	Subject Number					
	1	2	3	4	5	6
ANVIS	1.95	2.38	4.21	3.85	2.88	3.83
CATSEYES	2.50	2.39	4.55	4.01	3.36	3.65
Helmet Only	0.30	1.20	0.68	1.73	1.63	1.15

Table-4 Statistics of answers to questions

	1		2		3		4		5	
CONFIG	AVE	SEM	AVE	SEM	AVE	SEM	AVE	SEM	AVE	SEM
ANVIS	3.69	0.24	4.06	0.18	3.51	0.25	1.27	0.26	3.38	0.26
CATSEYES	3.49	0.25	4.22	0.20	3.60	0.24	1.38	0.21	4.36	0.33
HELMET	1.71	0.14	0.35	0.06	2.04	0.20	0.81	0.15	0.65	0.10

T-Test Results

ANV vs. CAT	n.s.	n.s.	n.s.	n.s.	<0.01
CAT vs. HEL	<0.001	<0.001	<0.001	n.s.	<0.001
ANV vs. HEL	<0.001	<0.001	<0.001	<0.02	<0.001

GRAND AVERAGE

Configuration	Average	Standard Error of Mean
ANVIS	3.18	0.114
CATSEYES	3.41	0.122
HELMET	1.11	0.068

Test Pair	T	Significance level
ANVIS vs. CATSEYES	1.9	n.s.
ANVIS vs. HELMET	17.1	<0.001
HELMET vs. CATSEYES	17.8	<0.001

d.f.=95 for questios 1-5.
d.f.=479 for grand mean
n.s. = $p > 0.05$

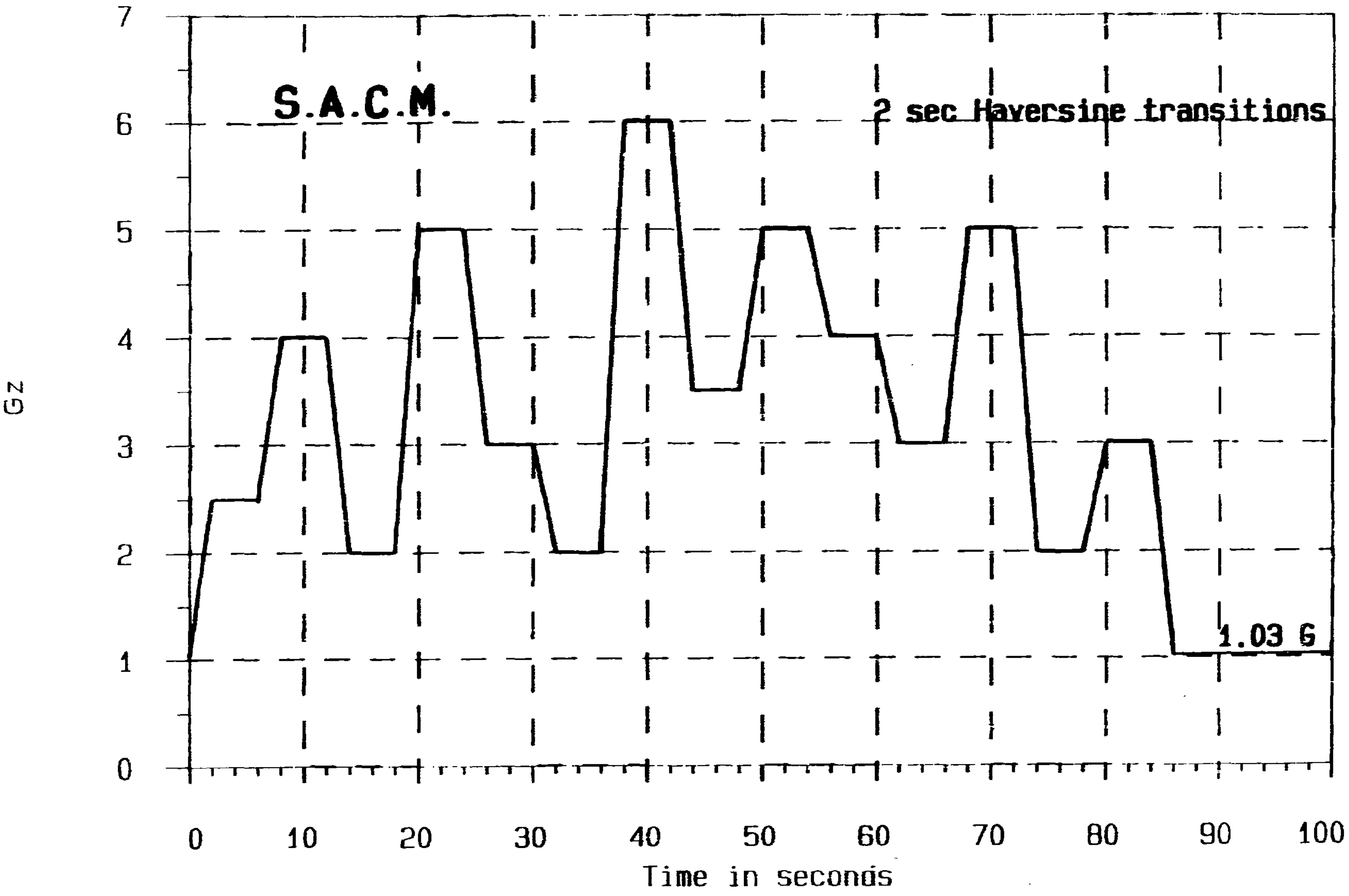
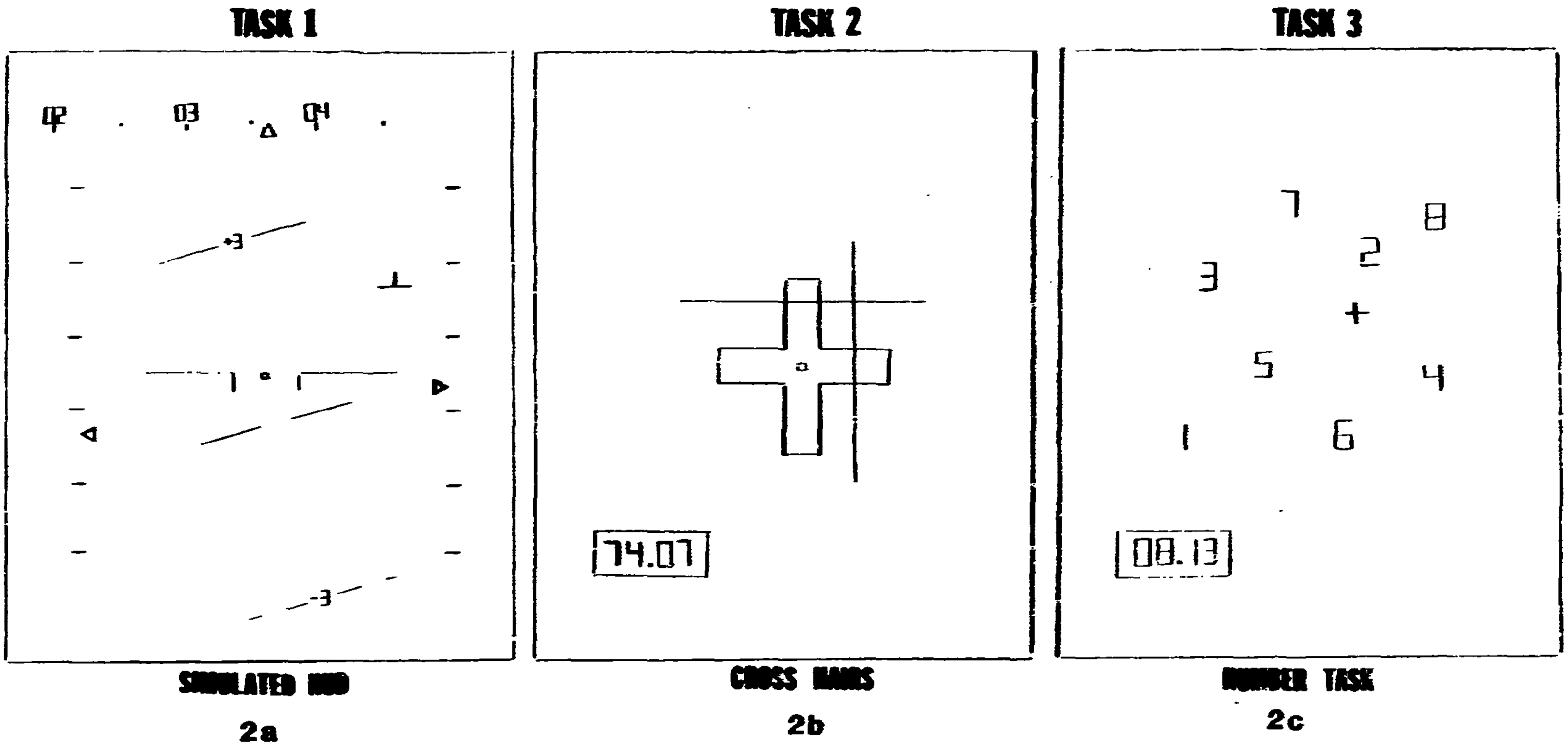


Figure 1 - SACM Profile



TASK 1
SIMULATED HUD
2a

TASK 2
CROSS HAIRS
2b

TASK 3
NUMBER TASK
2c

Figure 2 - Visual Tracking Tasks

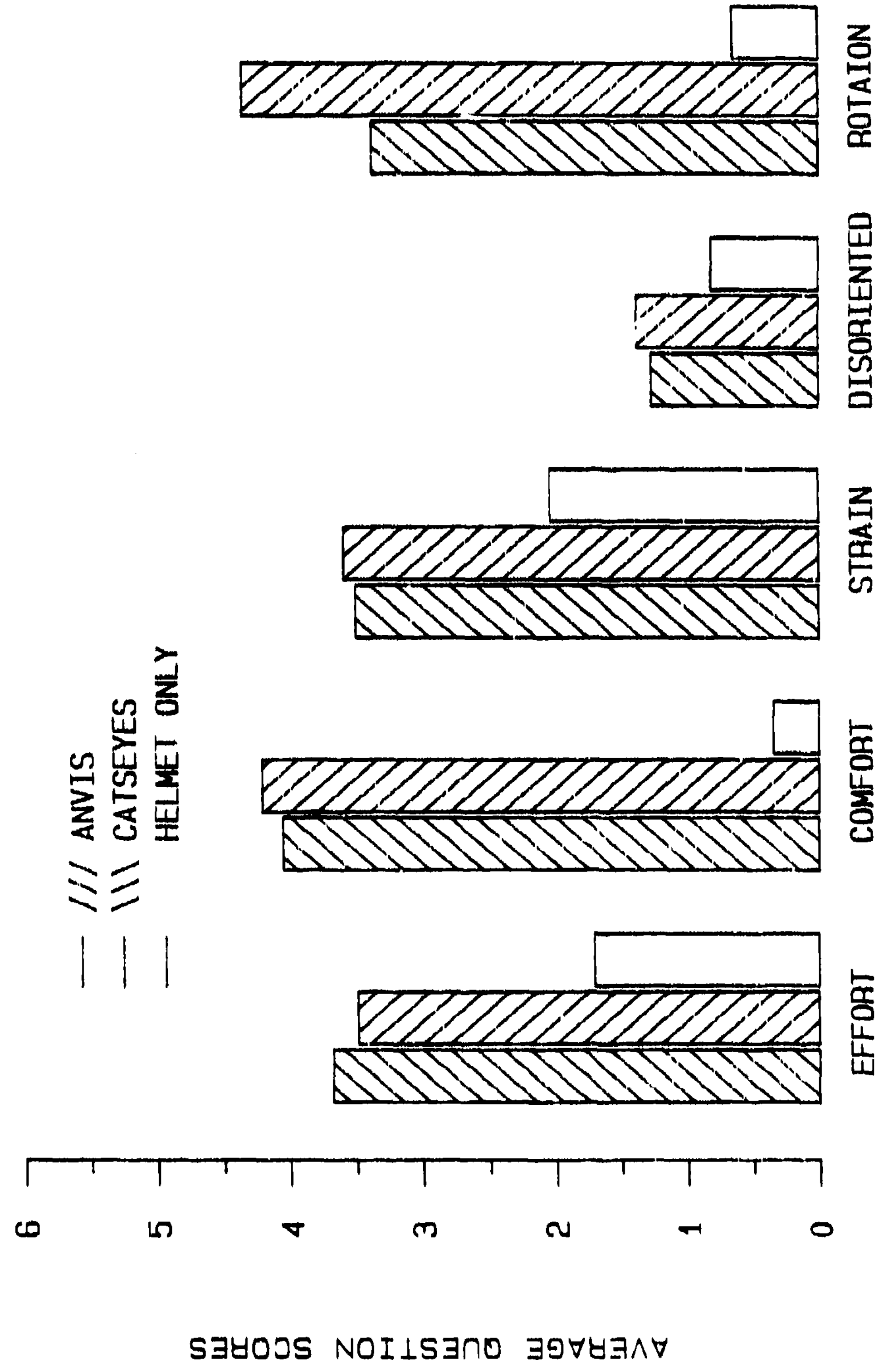


Figure 3 - Average of Question Scores

Figure 4 - CATSEYES Goggles

Figure 5 - ANVIS Goggles