ACCOMMODATION AND STEREOACUITY

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NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

REPORT NUMBER 711

Bureau of Medicine and Surgery, Navy Department

Research Work Unit M4306.03-2050DXC5.10

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SUMMARY PAGE

THE PROBLEM

To determine the causes of the marked decline in stereoacuity under water with a view toward remedial action.

FINDINGS

The major cause of the degradation of stereoacuity in water of even the greatest clarity is the increase in accommodation. This is brought about by two factors, (1) the production of a virtual image of the target at 3/4 its physical distance by the refraction of the light rays passing through the water-air interface of the face mask, and (2) the presence of higher contrast peripheral stimuli closer to the diver than the primary target.

APPLICATION

These results lead to the conclusion that at least part of the reduction in stereoacuity in the water can be reversed through the use of a face mask with compensating lenses which increase the apparent distance of the target.

ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit M4306.03-2050DXC5 — Evaluation of Sensory Aids and Training Procedures on Navy Divers' Visual Efficiency. The present report is No. 10 on that work Unit. It was approved for publication on 5 June 1972 and designated as Naval Submarine Medical Research Laboratory Report No. 711.

PUBLISHED BY THE NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

ABSTRACT

Stereoacuity and resolution acuity were measured (1) through apertures set at various distances from S and (2) through plus lenses producing an accommodative error for the target equal to that produced by the presence of the apertures. Stereoacuity was degraded by the apertures but not by the lenses, whereas resolution acuity was degraded by the lenses but not by the apertures. Although stereoacuity progressively declined with decreasing target-distance, it did not change significantly if accommodation remained constant. The decline of stereoacuity in the water is attributed to increased accommodation resulting from different sources and to the paucity of visual stimulation which is typical of the underwater scene and which is known to disrupt many visual processes (the so-called "Ganzfeld" effect).

ACCOMMODATION AND STEREOACUITY

INTRODUCTION

Stereoacuity under water is affected by the presence of peripheral stimuli.[1] Those which are near the plane of the observer degrade stereoacuity, whereas stimuli near the plane of the target improve it, compared to acuity in the absence of peripheral stimuli.

A recent report by Hennessy and Leibowitz[2] seemed to provide an explanation. They found that accommodation for a target is affected when the target is viewed through an aperture. The eye tries to accommodate for both target and aperture; to the extent that accommodation for the aperture occurs, accommodation for the target is in error. As the aperture is moved closer to the eye, the error of accommodation for the target increases. It seemed likely, therefore, that in our experiments the decline in stereoacuity as peripheral stimuli were moved closer to the observer was due to a compromise in accommodation for them and the target – the same compromise in accommodation found by Hennessy and Leibowitz. Furthermore, since the facemask itself acts as an aperture very close to the diver, it might also produce errors of accommodation which would contribute to the marked deterioration of stereoacuity in the water.

To show that this is, in fact, the explanation, it is necessary (1) to measure acuity under conditions similar to those which Hennessy and Leibowitz found to affect accommodation, and (2) to show that errors in accommodation of the magnitude found by them produces changes in stereoacuity similar to those produced in our experiments in the water. Accommodation could affect stereoacuity in at least two different ways: (1) An error in accommodation for the target (resulting from the aperture) could degrade stereoacuity by producing a blurred image, or (2) simply the activation of the accommodation mechanism might affect stereoacuity.

To test these alternatives, plus-lenses of the appropriate power were used to blur the retinal image during measurements of both resolution and stereoacuity. To test the effect of activation of the accommodative mechanism, minus-lenses – for which subjects can accommodate – were introduced in amounts equivalent to the degree of accommodation produced by the presence of Hennessy and Leibowitz's apertures.

I. Acuity Through an Aperture

Apparatus and Procedure

The experimental situation resembled that described by Hennessy and Leibowitz.[2] S sat in the center of a large room 6 m from a white wall against which a series of Landolt C's or a three-rod Howard-Dolman apparatus could be placed. Both the wall and the white back-plate of the Howard-Dolman were illuminated to 5 foot-Lamberts. At the viewing distance of 6 m, the Howard-Dolman (described elsewhere[1]) subtended 1.25 x 3.5° visual angle.

A movable screen, covered with white bainbridge board and measuring 1.7 m high and 2.5 m wide, could be positioned from 4 m to 7.5 cm from S at a constant luminance of 16 ft-L. At distances of 7.5 cm and 0.5 m the screen filled S's field of view, of course; at 1 m it subtended 60 x 70° visual angle and at 4 m it subtended 23 x 32°. It thus constituted a surround for the targets which, however, varied in size.

The center of the screen held one of a series of replaceable apertures. With the screen set at 4, 1, or .5 m from S, the apertures permitted a rectangular view of the target area corresponding to the size of the Howard-Dolman apparatus, 1.25 x 3.5°. At 4 and 1 m, only one rectangular aperture was used; at 0.5 and 7.5 cm two apertures were necessary, one adjustable for interpupillary separation. With the screen 7.5 cm away, apertures smaller than the diameter of the pupil were necessary to restrict the field of view to the size of the Howard-Dolman. Since this resulted in the appearance of a film befor S's eyes, the aperture size was increased until the film disappeared. The resulting apertures were 7 mm in diameter and permitted a circular field of view of slightly more than 5°.

S sat with his head positioned by a chin and forehead rest. He was carefully instructed as to the importance of positioning the adjustable apertures correctly, holding his head motionless, and continually checking to insure that both eyes had an unobstructed view of the target.

The four positions of the screen were presented in counterbalanced order. The stereoacuity thresholds were always measured first, followed by the resolution thresholds. Each set of thresholds was taken in a different counterbalanced order for each S, however. Viewing time was not limited; S was allowed to look until he had reached a decision.

Both resolution and stereoacuity thresholds were measured by the method of constant stimuli. For the former, a set of 4 to 8 Landolt C's was chosen which encompassed S's acuity, and each size target was presented in random order. The C was presented with the gap in one of four positions, 3, 6, 9, or 12 o'clock. These positions were given in haphazard order, but care was taken to present the 3 and 9 o'clock positions half the time and the 6 and 12 o'clock positions half the time. A frequency of seeing curve was drawn on cumulative probability paper and the 50 percent size taken as the threshold.

The stereoacuity data are given in terms of variability of the equidistance setting. The middle (movable) rod was set at various positions and S judged either "closer" or "farther" than the two outside rods. Again, a frequency of seeing curve was drawn on cumulative probability paper and the standard deviations read directly from the graph.

Subjects

Staff members of the Laboratory and enlisted men from the Naval Submarine School served as subjects. All enjoyed at least 20/25 uncorrected acuity in each eye, according to the Bausch and Lomb Ortho-Rater.

Results

The stereo and resolution acuity thresholds for the four distances of the screen are given for 12 Ss in Tables I and II. Figure 1 shows that mean stereoacuity progressively declined as the screen was moved closer to S

Table I. Precision of Stereoacuity (η_σ in seconds of arc) for Four Distances of the Screen.

S	4 m	1 m	.5 m	.075 m
SL	1.65	2.40	0.64	2.57
CM	1.38	1.84	0.92	2.30
SI	2.03	3.77	3.22	3.77
SR	6.45	12.00	8.75	5.06
MY	2.76	5.06	4.15	11.07
BZ	6.92	7.85	28.28	*
WR	2.76	5.06	4.15	7.38
AN	3.68	5.98	5.98	5.98
RS	4.62	6.92	13.86	22.18
EN	2.95	4.62	5.52	3.40
EG	10.15	10.15	17.56	14.79
MM	6.92	10.15	*	*
M	4.36	6.32	8.60	9.74
Mdn	3.31	5.49	5.75	6.68

*Could not be measured owing to the limitations of apparatus; highest value for subject used in computing the mean.

Table II. Resolution Acuity (gap of Landolt C in min arc visual angle) for Four Distances of Screen.

S	4 m	1 m	.5 m	.075 m
SL	0.58	0.59	0.55	0.55
CM	0.55	0.51	0.50	0.51
SI	0.59	0.58	0.59	0.59
SR	0.51	0.56	0.48	0.54
MY	0.62	0.61	0.63	0.58
BZ	1.20	1.37	1.23	1.23
WR	0.81	0.80	0.81	0.88
AN	0.46	0.51	0.48	0.53
RS	0.52	0.55	0.52	0.50
EN	0.59	0.56	0.64	0.63
EG	0.56	0.58	0.56	0.58
MM	0.64	0.66	0.65	0.64
M	0.64	0.66	0.64	0.65

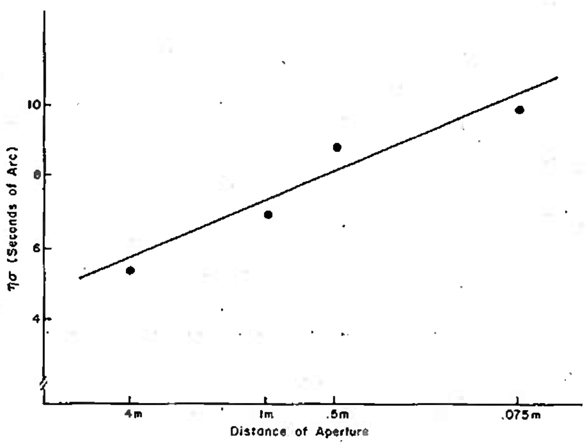

Fig. 1. Mean precision of stereoacuity (seconds of arc) for a target at 6 m seen through an aperture set at various distances from S.

(χ^2_r (3) = 16.1, p <.001, Friedman Anova by ranks). Resolution acuity remained unchanged (χ^2_r (3) = 1.4, p <.75). Stereo-thresholds were also obtained for four Ss with a dark screen; they were 10.8, 4.84, and 3.76 sec arc when the screen was at distances of 7.5 cm, 1, and 4 m respectively. The ratios of the thresholds with the screen at the near distances to that with the screen at 4 m were 2.63 and 1.25, comparable to the ratios of 2.73 and 1.45 obtained with the illuminated screen.

II. Acuity Through Positive Lenses

Tables I and II show that the position of the screen affects stereoacuity but not resolution acuity. The next step was to see if the change in stereoacuity could be produced by changes in accommodation of the magnitude which were induced by the presence of the screen. According to Hennessy and Leibowitz, the screen at 1 m from S induced a mean error of accommodation of about .25 D. and the screen at .5 m induced an error of about .6 D. Both stereoacuity and resolution acuity for targets at 6 m were therefore tested with S wearing .25 D. and .62 D. lenses and also empty trial frames, in counterbalanced order. The results are given in Table III and plotted in Fig. 2.

Table III. Stereoscopic and Resolution Acuity Measured Through the Screen and With Positive Lenses.

S	Precision of Stereoacuity (η_σ sec arc)			Resolution Acuity (visual angle of gap in min arc)		
	4 m	1 m	.5 m	4 m	1 m	.5 m
SL	1.65	2.40	0.64	0.58	0.59	0.55
CM	1.38	1.84	0.92	0.55	0.51	0.50
EG	10.15	10.15	17.56	0.56	0.58	0.56
EN	5.52	4.62	2.95	0.59	0.56	0.64
RS	4.62	6.92	13.86	0.52	0.55	0.52
LS	2.95	3.85	2.95	0.51	0.51	0.49
TD	2.12	4.25	6.00	0.58	0.59	0.59
WY	11.05	6.45	19.41	0.64	0.64	0.57
MB	1.85	10.15	9.22	0.65	0.63	0.65
RN	1.84	3.85	4.60	0.47	0.46	0.45
EH	8.30	6.45	7.38	0.64	0.64	0.65
BW	1.38	3.68	5.52	0.60	0.60	0.60
Mean	4.40	5.38	7.58	0.57	0.57	0.56
Mdn	2.54	4.44	5.76			

Table III. Stereoscopic and Resolution Acuity Measured Through the Screen and With Positive Lenses. (cont)

S	Precision of Stereoacuity (η_σ sec arc)			Resolution Acuity (visual angle of gap in min arc)		
	0.00 OD.	+.25 D.	+.62 D.	0.00 D.	+.25 D.	+.62 D.
SL	2.30	2.76	0.92	0.54	0.55	0.55
CM	2.76	2.30	2.30	0.52	0.52	0.59
EG	4.15	3.86	5.06	0.55	0.58	0.77
EN	3.22	3.68	3.22	0.59	0.54	0.63
RS	7.38	2.76	7.38	0.49	0.55	0.59
LS	1.48	1.85	2.58	0.51	0.50	0.49
TD	2.12	3.90	3.05	0.58	0.58	0.62
WY	11.05	12.94	8.30	0.64	0.60	0.62
MB	1.85	3.68	3.22	0.65	0.68	0.67
RN	1.84	3.40	1.38	0.47	0.47	0.48
EH	8.30	6.45	8.30	0.64	0.67	0.91
BW	1.38	3.60	4.15	0.60	0.64	0.85
Mean	3.99	4.26	4.16	0.56	0.58	0.65
Mdn	2.53	3.64	3.22			

It is clear that the screen and lenses have opposite effects. Mean stereoacuity declined as the screen was moved closer to S (χ^2_r (2) = 5.46, p <.10) but was not systematically affected by the positive lenses which produce the refractive error of the magnitude which Hennessy and Leibowitz found was produced by the screen (χ^2_r (2) = 0.79, p <.70). Conversely, resolution acuity was significantly degraded by the lenses (χ^2_r (2) = 7.17, p <.05), but it was not degraded by the screen (χ^2_r (2) = 2.54, p <.25). It is thus evident that the changes of accommodation induced by the presence of the screen are enough to degrade resolution acuity but not stereoacuity. The decline of steroacuity in the presence of the screen is, therefore, not attributable to errors of accommodation.

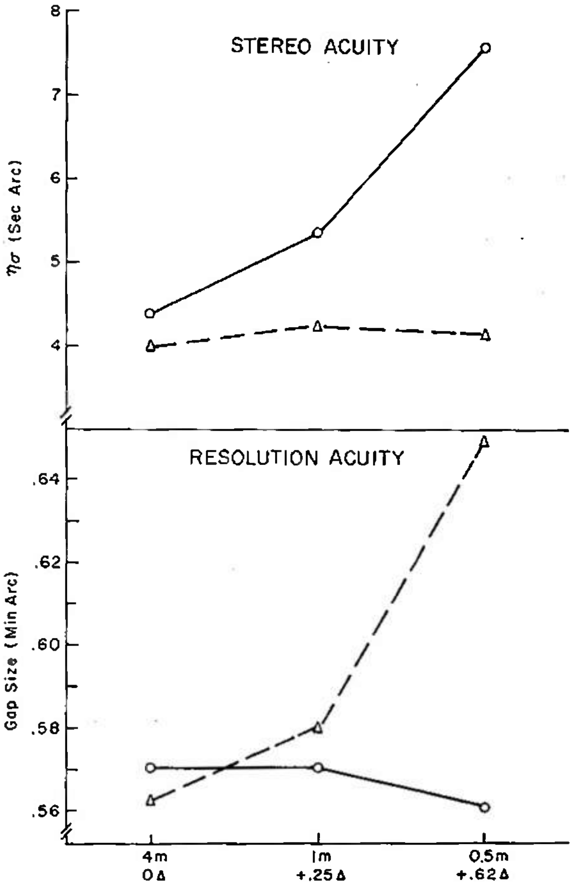

Fig. 2. Mean resolution acuity and precision of stereoacuity for targets at 6 m seen either through an aperture at various distances (0) from S or through plus lenses (Δ).

III. Stereoacuity under "Equivalent" Accommodation

Another factor which affects stereoacuity is degree of accommodation, or accommodative effort.[1] Our previous study showed that stereoacuity was degraded by the presence of a minus 2 D. spherical lens even though the Ss reported that the target apparatus was in focus.[1] We next sought to find out if equal accommodative efforts resulted in equal stereoacuity. When the eye is accommodated for a target at 2 m, it is exerting an accommodative force of 1/2 diopter; with the target at 4 m, the amount of accommodation is 1/4 diopter. If a -1/4 diopter lens is introduced into the latter situation, the S must now exert a force of accommodation of 1/2 diopter to focus on the target at 4 m while overcoming the effect of the lens. Thus his magnitude of accommodation is now the same as for the target at 2 m.

Stereoacuity thresholds were next measured for 21 Ss under three conditions, presented in counterbalanced order: with the target at 7 m (accommodation = .14 diopter) and at 1.12 m (accommodation = .89 diopter), and with a -.75 diopter lens at the 7 m distance which equated the degree of accommodation at that viewing distance to the degree of accommodation at 1.12 m. A second Howard-Dolman apparatus was constructed for use at 1.12 m which duplicated the visual subtense of the components at 7 m. The results are given in Table IV. The introduction of the -.75Δ lens significantly degraded stereoacuity ($p > .005$, Wilcoxon, one-tailed) as did the reduction of the target distance to 1.12 m ($p > .005$, Wilcoxon, one-tailed). However, there was no statistically significant difference between the thresholds at 1.12 m and 7 m when the lenses were worn ($p > .80$, Wilcoxon, two-tailed). These results indicate that equal effort of accommodation results in equal acuity thresholds. This conforms to previous findings that thresholds for targets at different distances are equal when the important variables are held constant.[3,4]

Table IV. Precision of Stereoacuity (η_σ in seconds of arc) Under Equivalent Accommodation at Two Target-Distances Compared with a Third Distance.

S	Target-distance and power of lens		
	7 m	7 m plus (-.75D.)	1.12 m
SL	1.24	1.62	1.57
CM	1.01	3.05	2.09
EN	1.74	1.74	1.57
EG	3.56	6.12	2.92
AX	3.74	2.50	6.26
BT	2.85	1.74	3.65
EH	3.39	3.26	2.92
MS	1.25	1.50	1.67
EY	1.70	2.12	3.65
BN	0.67	1.55	3.65
HX	2.65	2.15	3.13
WN	0.67	1.24	1.36
BH	23.71	*	9.88
CS	1.10	2.85	4.82
DM	3.05	3.73	5.00
GS	1.02	2.91	2.00
GT	1.37	5.28	4.40
HN	2.59	1.76	3.12
MY	4.05	*	12.50
NL	6.99	8.48	6.75
RE	1.50	2.38	2.82
Mean	3.33	4.39	4.08
Mdn	1.74	2.50	3.13

*Could not be measured owing to limitations of the apparatus.

IV. Stereoacuity and Apparent Target-Distance Under Water

The results in the preceding section made it quite clear that if critical variables such as accommodation are not held constant, then target-distance exerts a major effect on stereoacuity. This is of major interest for the study of steroacuity under water, of course, since the apparent distance of submerged objects is 3/4 their actual distance. Now it has long been reported that stereoacuity declines with decreasing target-distance, but previous studies have naturally kept constant such stimulus variables as the subtense of the test rods and their separation.[5] When the apparent distance of a target is altered in the water, these variables do not of course remain constant. It therefore seemed worthwhile repeating such an experiment without the usual controls. We accordingly measured stereoacuity at two pairs of distances, 6 and 4.5 m also 2.5 and 1.9 m, in order to see the effect of reducing a target-distance by the amount that would appear to take place in the water. These four conditions were given in counterbalanced order. The results are given in Table V and Fig. 3.

Table V. Precision of Stereoacuity (η_σ in seconds of arc) at Standard Target-Distance and 3/4 Distance.

S	Target-distance			
	6 m	4.5 m	2.5 m	1.88 m
SL	1.34	1.99	2.80	2.98
CM	2.24	2.30	2.52	2.86
EG	3.76	5.57	5.60	4.97
EN	1.79	2.39	4.48	4.97
HH	6.71	7.16	11.19	11.94
JD	3.13	6.84	9.51	7.96
GN	4.03	3.18	2.80	4.97
WZ	6.09	7.16	15.66	39.79
Mean	3.64	4.57	6.82	10.06
Mdn	3.44	4.38	5.04	4.97

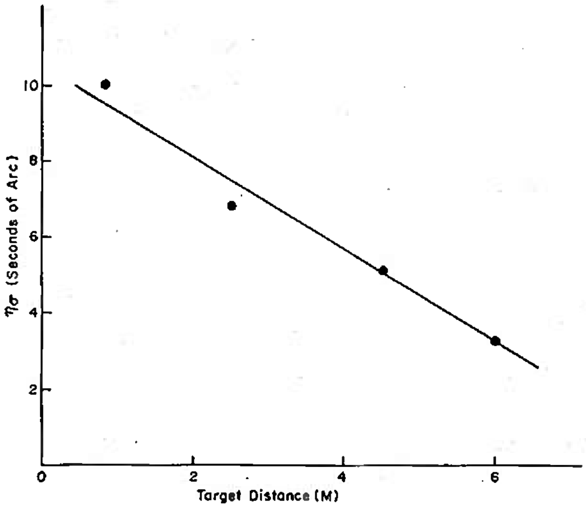

Fig. 3. Mean precision of stereoacuity for a target set at various distances from S.

Mean precision of stereoacuity declined significantly with decreasing distance (χ_r^2 (3) = 15.5, p < .01). Thus, the refractive distortion which produces a virtual image of an underwater target at 3/4 its true distance is enough to produce an appreciable degradation of stereoacuity.

DISCUSSION

Stereoacuity is affected by the presence of an intervening aperture. As the aperture is moved closer to S, stereoacuity is progressively degraded. Resolution acuity, on the other hand, is unaffected. Since Hennessy and Leibowitz have shown that the intervening aperture affects accommodation, it is tempting to conclude that the induced errors of accommodation are large enough to disturb stereoacuity but too small to affect resolution acuity. Thus it seems reasonable to assume that among the fluctuations of accommodation there is at least a brief moment of correct accommodation. This is sufficient for maximum resolution acuity, which requires only about 0.1 sec,[6] but not adequate for stereoacuity; maximum stereoacuity is found "when the duration is three seconds and longer, while for shorter durations down to 0.2 second, there is a fourfold to fivefold decrease in acuity."[7]

The second experiment, however, shows that errors of accommodation of the magnitude induced by the aperture are not the explanation. The prevention of correct accommodation with plus spherical lenses does not greatly affect stereoacuity but does degrade resolution acuity. We are, therefore, led to the conclusion that it is not the errors of accommodation that degrade stereoacuity but rather the magnitude of accommodation (and convergence) that is required to focus the target that affects stereoacuity. This is indicated by the fact that the introduction of negative spherical lenses of rather low power whose effects S can overcome with his own accommodation leads to a reduction of stereoacuity. It is also indicated by the reduction in stereoacuity with decreasing target distance, although once again the target is completely in focus. The degradation of stereoacuity produced by the introduction of peripheral stimuli near S[1] appears to be the result not of retinal blur from an induced error of accommodation for the target, but is rather the result simply of increased accommodation induced by the presence of the additional stimuli.

We conclude that two factors have degraded stereoacuity through the apertures. One is the Ganzfeld effect reported previously.[8,9] The second is the degree of accommodation. The essential difference between the presence of the apertures and the presence of the plus lenses is that the apertures induce an actual change in the subject's lenses, whereas the plus lenses leave S's lenses in a relaxed state. The presence of the minus lenses, in the third experiment, forces increased accommodation and produced a decline in stereoacuity. The importance of target distance, as shown in the third and fourth experiments, is that decreased target distance forces an increase in accommodation. A face mask with a compensatory lens which makes increased accommodation unnecessary should result in improved stereoacuity. This is now being tested.

In summary, stereoacuity is degraded by a factor of two or three in the water, even in water of the greatest clarity.[10,11] Two variables cause this degradation. The first is the increased accommodation which results primarily from the reduced apparent distance of the target. Also contributing to increased accommodation is the presence of other objects in the field of view which are closer than the target. Under these conditions, the eye attempts to accommodate for them as well as for the primary target, and there is thus a greater magnitude of accommodation than is required for the target. This phenomenon is much more powerful in the water than in the air because of the profound decrease in the contrast of targets with increasing distance. Thus, nearby objects are more visible and exert a disproportionate effect on accommodation compared to their effect in air. The second factor which tends to degrade stereoacuity is the so-called "Ganzfeld" effect, the disruption of many visual processes resulting from a paucity of visual stimuli, which is typical of the underwater scene.

REFERENCES

1. Luria, S. M. and Kinney, J. A. S., Peripheral stimuli and stereoacuity for Navy divers working under water. Naval Submarine Medical Center, Groton, Conn., NSMRL Rep. No. 654, Feb 1971.

2. Hennessy, R. T. and Leibowitz, H. W., The effect of a peripheral stimulus on accommodation. Perception & Psychophysics, 10, 129-132, 1971.

3. Ogle, K. N., Note on stereoscopic acuity and observation distance. J. Opt. Soc. Am., 48, 794-798, 1958.

4. Jameson, D. and Hurvich, L. M., Note on factors influencing the relation between stereoscopic acuity and observation distance. J. Opt. Soc. Am., 49, 639, 1959.

5. Graham, C. H., Visual Space Perception, in Vision and Visual Perception, C. H. Graham, Ed., Wiley, N.Y. 1965, p. 526.

6. Riggs, L. A., Visual Acuity, in Vision and Visual Perception, C. H. Graham, Ed., Wiley, N.Y. 1965, p. 339.

7. Ogle, K. N., Researches in Binocular Vision, Saunders, Phila. 1950, p. 136.

8. Luria, S. M., Stereoscopic and resolution acuity with various fields of view. Science, 164, 452-453, 1969. (NSMRL Rep. No. 557, Dec 1968).

9. Luria, S. M., Effect of limited peripheral cues on stereoacuity. Psychon. Sci., 24, 195-196, 1971.

10. Ross, H. E., Stereoscopic acuity under water. In J. N. Lythgoe & K. D. Woods (Eds.), Underwater Association Reports, 1966-67, London: T. G. Williams Industrial and Research Promotions Ltd. 1967, pp. 61-64.

11. Luria, S. M. and Kinney, J. A. S., Stereoscopic acuity under water. Amer. J. Psychol., 81, 359-366, 1968 (NSMRL Rep. No. 510, Feb 1968).

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Submarine Medical Research Laboratory	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
	2b. GROUP

3. REPORT TITLE

ACCOMMODATION AND STEREOACUITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Interim report

5. AUTHOR(S) (First name, middle initial, last name)

Saul M. Luria and Jo Ann S. Kinney

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
5 June 1972	12	11

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) NSMRL Rep. No. 711
b. PROJECT NO. M4306.03-2050DXC5.10	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Naval Submarine Medical Center Box 600, Naval Submarine Base NLON Groton, Connecticut 06340

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DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0102-014-6600

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Underwater vision						
Stereoacuity						
Accommodation						