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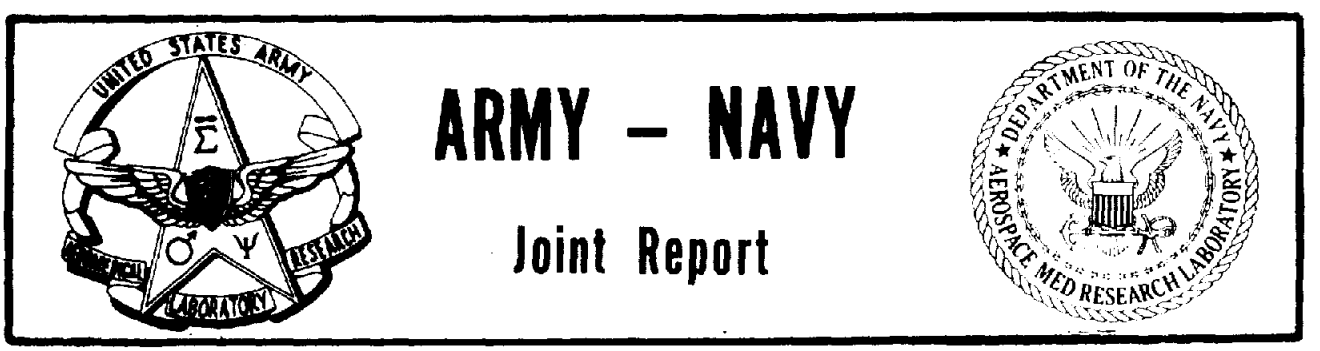
Rosalie K. Ambler and Fred E. Guedry, Jr.



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Past research has demonstrated the value of the Brief Vestibular Disorientation Test (BVDT) as a screening tool for student pilots. This study is concerned with the extension of this technique for use in assessing the potential Naval Flight Officer (NFO).

The rater BVDT procedure was used here, and in addition, a performance task involving a short-term memory task in the auditory mode was introduced in order to measure performance decrement. Representative groups of entering NFO students were first administered the performance task under the exact conditions of the previous BVDT procedure, but without rotation. After a 2-minute rest period, the procedure was repeated with rotation. Observer assessments were made during this rotation sequence. The results indicate that those students who later failed NFO training exhibited greater performance decrement under rotary conditions as compared to static than did successful students. Rater-type BVDT scores also indicated slightly greater sensitivity (.07 level of significance) to the vestibular stimulus for the failures than for the successes. It was concluded that this technique is of value in screening NFO's.

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Bureau of Medicine and Surgery
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SUMMARY PAGE

THE PROBLEM

Past research has demonstrated the value of the Brief Vestibular Disorientation Test (BVDT) as a screening tool for student pilots (1). This study is concerned with the extension of this technique for use in assessing the potential Naval Flight Officer (NFO).

FINDINGS

The rater BVDT procedure was used here, and in addition, a performance task involving a short-term memory task in the auditory mode was introduced in order to measure performance decrement. Representative groups of entering NFO students were first administered the performance task under the exact conditions of the previous BVDT procedure, but without rotation. After a two-minute rest period, the procedure was repeated with rotation. Observer assessments were made during this rotation sequence. The results indicate that those students who later failed NFO training exhibited greater performance decrement under rotary conditions as compared to static than did successful students. Rater-type BVDT scores also indicated slightly greater sensitivity (.07 level of significance) to the vestibular stimulus for the failures than for the successes. It was concluded that this technique is of value in screening NFO's.

RECOMMENDATIONS

It is recommended that the performance test portions of the procedure be cross-validated for both student NFO's and pilots.

ACKNOWLEDGMENTS

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INTRODUCTION

A Brief Vestibular Disorientation Test (BVDT) has been developed that involves observer, or rater, assessments of subjects' reactions elicited by subject-controlled head tilt during slow, whole-body rotation around an Earth-vertical axis. It has been reported that pooled judgments by three or more raters on pallor, sweating, facial expression, steadiness, recovery rate, and over-all reaction have been found to be statistically reliable measures and to be predictive of later success or failure in pilot training. Similar degrees of successful predictions have been reported by others (10, 11). It has also been demonstrated that the BVDT score significantly augmented the multiple correlation of existing aviation selection variables with the same criterion (1). This report is concerned with the extension of this technique for use in assessing the potential Naval Flight Officer (NFO) or nonpilot airborne technical specialist, who must perform complex tasks in a motion environment over which he has no control.

PROCEDURE

Test persons were 116 entering NFO students. Although the rater BVDT procedure as previously described was used here (1-3,8), emphasis was on a performance task involving short-term memory in the auditory mode. This was introduced in order to measure performance decrement. The rationale for interposing performance decrement measurement rather than simply replicating the exact procedures used for the pilot samples was based on experience with these pilot samples. It was evident that among individuals who were disturbed by disorientation stress, some were able to function in the flight-learning situation and others were not. The rater BVDT undoubtedly attained its validity from this latter group, and the former group probably lowered prediction coefficients. It was reasoned, therefore, that the sensitive individual who could continue to perform a mental task during the BVDT stimulus might also override his sensitivity in the aircraft situation and perform according to standards. Thus, it was considered possible that the superposition of performance tasks on the BVDT procedure might improve predictive power.

In developing the task used here, certain requirements were considered: 1) Since all previous BVDT data were obtained under eyes-closed conditions, any task involving the visual mode was not considered. 2) Brevity is necessary so it was important to have a task that would produce many data points in a short period of time. 3) The response mode and method of recording must be reasonably simple. The task developed was a variation of a procedure suggested by Williams and reported in a review by Galambos (5). Specifically, the task required the test person to monitor a series of random digits presented orally at the rate of two per second, and each time a zero was presented, to recall the two digits immediately preceding the zero, sum them, and report the sum orally. The task had eight data points, or zeros, per 30 seconds. At the 30-second points, a head movement was made according to a single word instruction by a voice different from the one producing the digit series. A zero never occurred during the head movement. The actual test consisted of a static run through the digits with the examinee seated in a motorized rotary chair with eyes closed. Head movement

instructions were given at 30-second intervals or at precisely the same points as the rater BVDT. After a 2-minute rest period the identical sequence was repeated with constant rotation speed of 15 rpm begun at time zero and stopped at 5 minutes and 30 seconds. The examinee was required to respond to the digits for 30 seconds after cessation of rotation. The digit series and all instructions were taped. A transcript of the taped instructions is contained in Appendix A. The examiner recorded the examinee's oral responses by marking a specially designed score sheet, which is included as Appendix B. All responses were retrievable data. Rights, wrongs, and omissions were immediately available for each of the segments within a run and for the total run. During this rotation sequence, three observers made independent ratings of each examinee. Rater estimates of pallor, sweating, facial expression, unsteadiness, speed of recovery, and over-all performance were recorded on a ten-point scale. Appendix C contains this rating sheet. The low point on the scale represented low sensitivity, or no effect. An individual rater's score was obtained by summing his judgments on the six factors. The rater BVDT score for a given student was the mean of these three individual ratings. Finally, each student was asked to complete a self-rate sheet regarding his own reactions to the "ride" or the rotary sequence. This rate-sheet is presented in Appendix D.

This over-all procedure, titled BVD-2P, produced four types of data:

1) Observer judgments or ratings
2) Subjective or self-ratings
3) Objective performance measures
4) Performance decrement as expressed by difference between static and rotary performance measures.

The 116 students experienced this BVD-2P procedure during their first or indoctrination week of Aviation Officer Candidate School. Approximately eight months after the last student was tested the training progress of the sample was determined according to a dichotomous criterion, satisfactory progress versus student separation, which was used in assessing the four types of test measures.

ANALYSIS AND RESULTS

OBSERVER JUDGMENTS

Table I presents a comparison between the means of the rater BVDT scores for the separations and non-separations.

These values indicate slightly greater sensitivity for the separations than for the non-separations, but the differences were of only borderline significance. This finding was not unexpected since concentration on a task during vestibular stimulation previously has been found to reduce physical symptoms (4, p. 306; 7, p. 385). Table II corroborates this point. The mean rater BVDT scores obtained under the performance conditions described here tended to be lower than those obtained earlier under the non-performance

conditions.* Any evaluation of the rater technique per se, therefore, should be apart from performance tasks.

Table I

Comparison of Rater BVDT Scores between Separations and Non-separations Obtained under Performance Test (BVD-2P) Conditions

	Separations	Non-separations	r pt. bis.
$\bar{x}$	13.88	11.21	.169 < .07
s.d.	9.51	4.40	
N	24	92	

Table II

Comparison of Rater BVDT Scores between Rater Only and Performance Versions of the Test

	Rater Only Condition**	Performance Test Condition
$\bar{x}$	13.46	11.81
s.d	6.13	5.94
N	465	116
	t = 2.61 < .01	

- - - - - - - - - -

*The decreased reactivity with the cognitive task in the present study is inferentially supportive of the notion (cf. Lacey et al.,9) that such tasks increase heart rate, diminish transmission along sensory pathways, and decrease the effectiveness of external stimuli, although this idea will have to be reconciled with the well-established fact that mental arithmetic increases vestibular nystagmus.

**From two previously reported samples which also were exposed to 15 rpm (1).

SELF-RATINGS

The mean comparisons for the self-ratings show no significant differences between the students who separated and those who have not separated (Table III). This is contrary to some previous results on student pilot samples; however, no data comparisons are appropriate here because the self-rate form used in this study was different from the previous one. Additionally, it is noted that although the students were instructed to respond to the effects of the "ride," some of them volunteered that they were also influenced by how favorably they perceived their own performance on the task in both the static and rotary modes. In this experimental format, therefore, the self-rating summary scores are judged to be of little value.

Table III

Comparison of Post Rotary Self-ratings between Separations and Non-separations Obtained under Performance Test (BVD-2P) Conditions

	Separations	Non-separations	r pt. bis.
$\bar{x}$	32.38	30.24	
s.d.	13.11	10.70	.077
N	24	92	

OBJECTIVE PERFORMANCE MEASURES

Table IV contains comparisons between the separations and non-separations for six sets of mean scores derived from the auditory performance task. The intercorrelations among these six scores, the above mentioned Rater BVDT score, the Self-Rate, and the criterion, are contained in Table V. The six performance scores examined were the number of correct responses, errors, and omissions for the entire time course under both static and rotary conditions. As seen from the point biserial correlation values, the strongest relationships with the dichotomous criterion of separation versus non-separation were obtained for the correct and omitted responses, and for these two the relationships in the rotary mode were stronger than in the static mode. The error score showed no discrimination in either mode.

The strength of the validity coefficients of the performance task in the static mode is a serendipitous finding that must be considered in evaluating the performance during rotation. The partial correlation technique was applied to determine the value of the rotary validity coefficients with the static validity held constant or partialed out. The Rotary Corrects Score correlation of .233 thus was reduced to .167, and the Rotary Omissions Score correlation of -.255 was reduced to -.190. This value indicates that

some significant validity remained for the performance task in the rotary mode. With respect to the significance of the correlation in the static mode, the possibility should not be overlooked that the threat of the imminent rotation experience, especially in individuals who are exceptionally apprehensive about unusual motion, could have contributed to this significant difference as well as the actual nature of the task. This question should be investigated further.

Table IV

Comparison of Six Performance Task Indices from BVD-2P between Separations and Non-separations

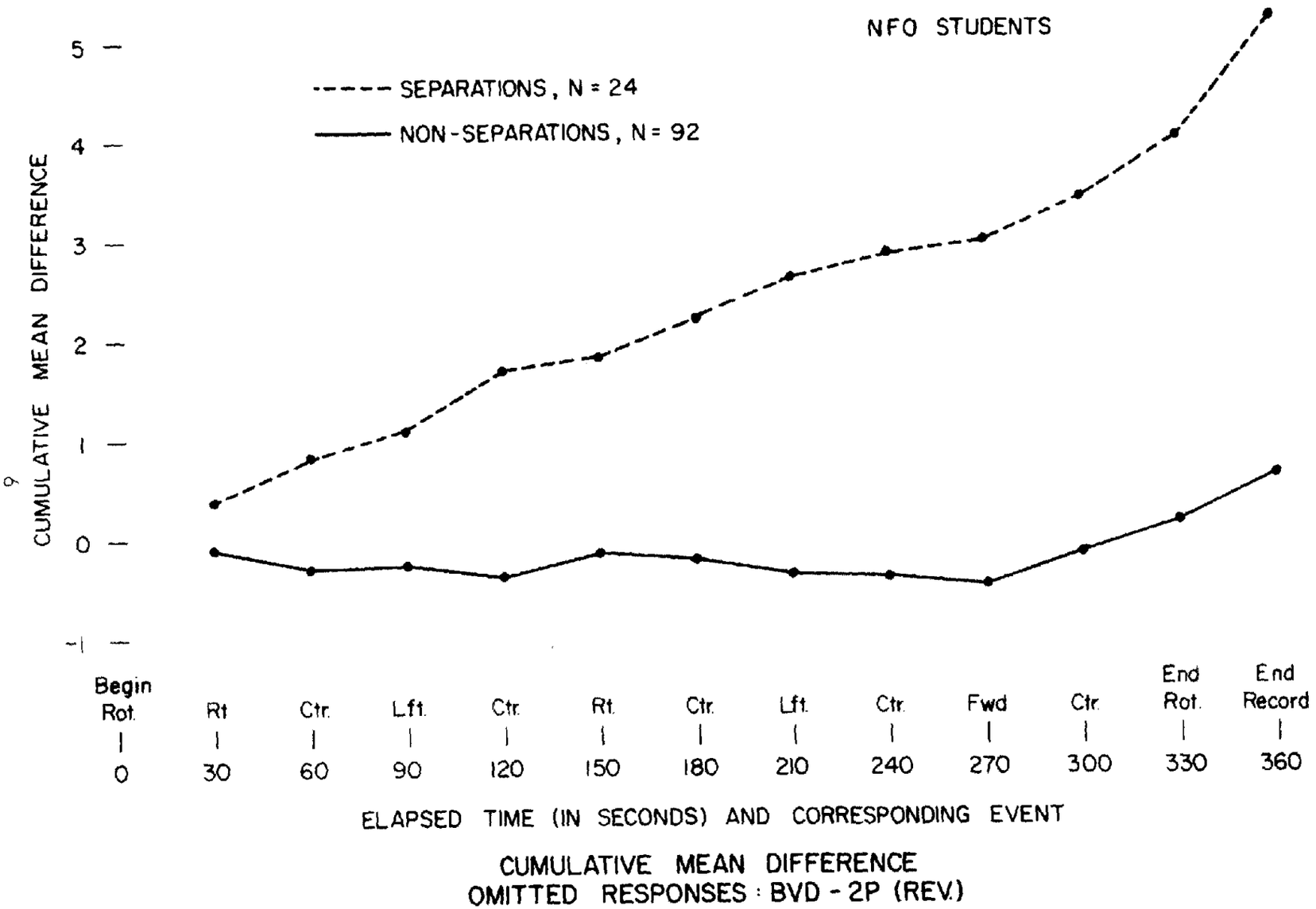
		Separations	Non-separations	r pt. bis.*
Static Correct	$\bar{x}$	51.96	57.53	
	s.d.	15.48	12.67	.168
Static Errors	$\bar{x}$	14.13	13.42	
	s.d.	10.14	7.03	-.037
Static Omissions	$\bar{x}$	30.63	25.07	
	s.d.	16.15	11.42	-.177
Rotary Correct	$\bar{x}$	50.58	59.73	
	s.d.	16.39	14.82	.233
Rotary Errors	$\bar{x}$	10.08	10.03	
	s.d.	8.73	6.19	.003
Rotary Omissions	$\bar{x}$	35.50	25.79	
	s.d.	17.42	13.90	-.255

*Two-tailed significance values: .10 = .155; .05 = .184; .01 = .242.

PERFORMANCE DECREMENT

The next level of analysis concerned an examination of performance decrement or the differences between the static and rotary modes on the performance task.

Figure 1 shows the time course curves of the cumulative mean differences between the static and rotary conditions for the number of omitted responses on the performance task. The broken line represents the data for separating students, and the solid line represents non-separating students. The F ratio between the two groups was significant at less than the 5 percent level. An examination of the two curves shows that the non-separations tended to improve over their static performance during the first half of the rotation procedure while the separations tended to deteriorate. The later portions of both curves are similar. In other words, both groups displayed decrement of response



CUMULATIVE MEAN DIFFERENCE
OMITTED RESPONSES : BVD - 2P (REV.)

Figure 1

Table V

Intercorrelation Matrix of Test Variables and Criterion*

Variables	1	2	3	4	5	6	7	8	9
1) Rater BVDT	1.000	.422	-.135	.201	.017	-.339	-.055	.357	-.181
2) Self-Rate		1,000	-.280	.079	.257	-.368	-.033	.379	-.077
3) Static Correct			1.000	-.398	-.827	.795	-.213	-.745	.168
4) Static Errors				1.000	-.181	-.357	.755	.023	-.037
5) Static Omission					1.000	-.631	-.233	.781	-.177
6) Rotary Correct						1.000	-.271	-.881	.233
7) Rotary Errors							1.000	-.177	.003
8) Rotary Omissions								1.000	-.255
9) Separations vs Non-separations									1.000

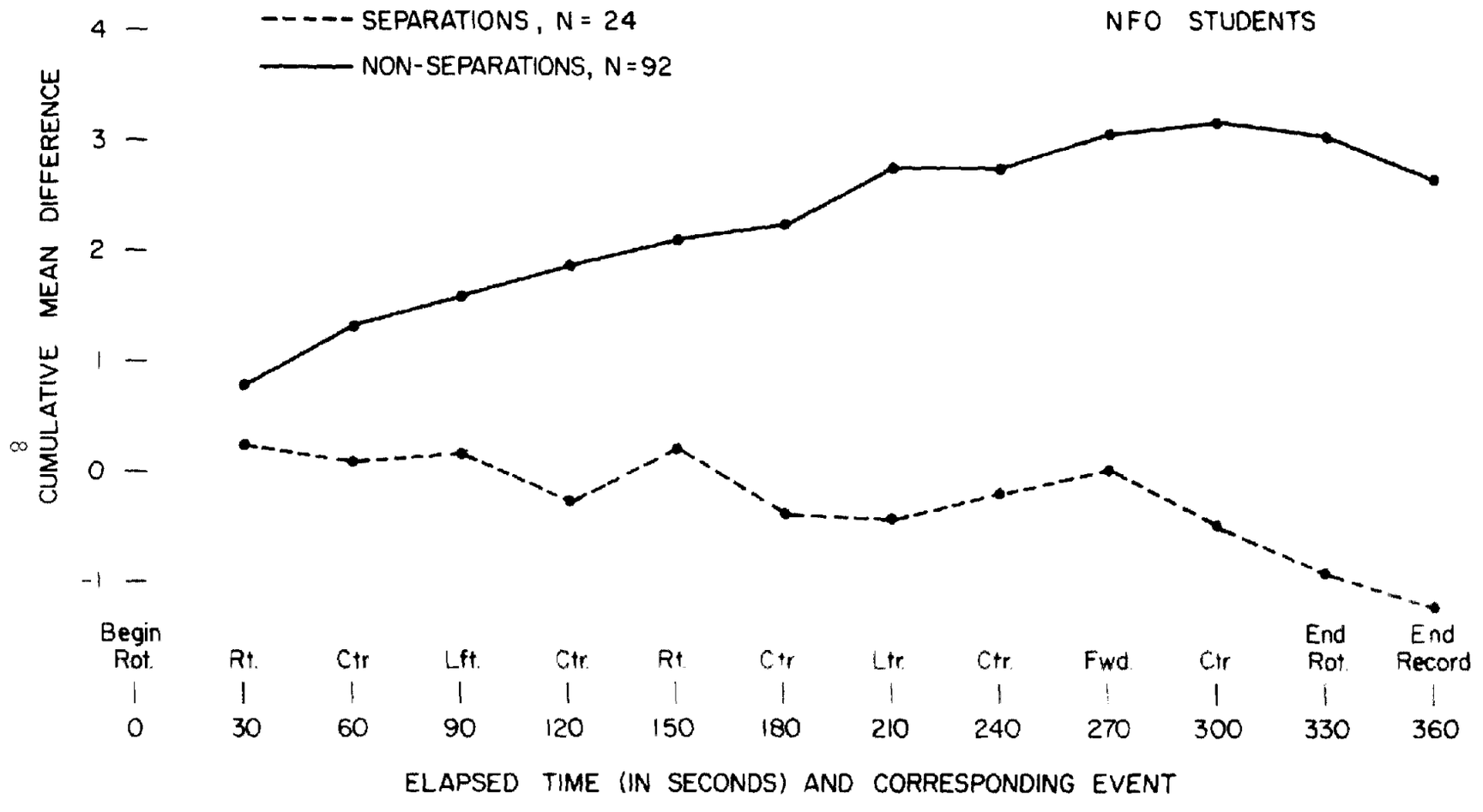
*Two-tailed significance values: .10 = .155; .05 = .184; .01 = .242.

production under rotary conditions as compared to static, but the separation group displayed the decrement much earlier in the time course than the non-separation. Similar curves (Figure 2) were obtained for the cumulative mean differences of correct responses, but the F ratio was significant only within the 10 percent level.

DISCUSSION AND CONCLUSIONS

The BVD stimulus is one which produces a conflictual sensory message from the inner ear by virtue of a cross-coupled Coriolis stimulus to the semicircular canals in one plane, while the otolith organs signal change in orientation in another plane. For a given head movement, the magnitude of the stimulus is directly related to angular velocity of the rotating device (6).

The evidence indicates that the BVD stimulus procedure, combined with the performance task approach, will be productive for screening nonpilot aircrew personnel. Additional data have been collected and are in the process of maturation. These will permit an attempt to replicate the key findings of this report and, if appropriate, will also prescribe standards to be used in conjunction with other predictors. Meanwhile, explorations of other performance tasks in the visual mode are underway.



CUMULATIVE MEAN DIFFERENCE
CORRECT RESPONSES: BVD - 2P (REV.)

Figure 2

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APPENDIX A

Transcript of BVD-2P Taped Instructions

INSTRUCTIONS FOR BVD-2P

There are two parts to this experiment. During the first part you are requested to sit in a comfortable upright position in the chair, to keep your eyes closed, to make certain head movements, and to monitor a series of numbers. Part I will last exactly 6 minutes. At the first 30-second point you will hear a female voice say the word, "right." As soon as you hear this instruction, move your head laterally to your right shoulder. Move it slowly to about a 45° tilt. Take about 3 seconds to complete the movement. You are to keep your head in this position for 30 seconds. You will then hear the instruction, "center." Return your head to the upright position slowly. Take about 3 seconds for each movement. A lateral movement means that the head is tilted to the side, not rotated around the vertical axis of the body. One way to assure a lateral movement is to keep the nose pointed straight ahead at all times. At the 1-minute and 30-second point you will hear the instruction, "left." Move your head to the left in the same manner as before. Thirty seconds later you will hear, "center," again. At 4 additional 30-second intervals, you will receive a head movement instruction in this manner. At 4-minutes and 30-seconds the instruction will be the word, "forward." This means that you are to move your head forward about 45°. At time 5 minutes you will hear the word, "center," again. You will then return to the upright position. You are to remain seated in an upright position with eyes closed during the last 60 seconds. (Pause.) Are there any questions? (Pause on tape and prepare to stop tape if questioned.)

The monitoring task requires that you listen to a continuing series of numbers. Each time you hear zero, you are to give the sum of the two numbers immediately preceding that zero. For example, you may hear 5, 9, 7, 2, 1, 3, 0. As soon as you hear the zero you should try to recall the 3 and the 1, add them, and report the number 4 in a clear, audible voice. You must respond quickly as the number series is continuing, and you must respond each time you hear zero. You must listen for the head movement instructions and perform the head movement while monitoring and responding to the numbers. To minimize confusion, the number series is given in a male voice. The head movement instructions at 30-second intervals are given in a female voice. Here is another example of the number series exactly as you will hear it during the experiment. This time you will hear the superimposed head movement instruction. For this example, the head movement instructions are closer than 30 seconds apart. Give the sum of the two numbers preceding each zero. Answer as quickly as you can in a clear, audible voice and move your head when directed. Ready. 4, 1, 6, 3, 4, 0, 9, 2, 5, 4, 0, 4, 9, 1, (right) 0, 4, 4, 6, 7, 2, 1, 0, 5, 3, 2, (center) 5, 6, 1, 9, 8, 0. (Pause.) Are there any questions? (Pause on tape and prepare to stop tape if questioned.)

Stand by to begin Part I. Ready. Close your eyes. Begin. (Number series starts here.) End of Part I. You may open your eyes and relax for a moment. (Stop tape.) (Rest 2 minutes.)

Part II is identical to Part I except that the chair will rotate slowly. The chair will stop rotating approximately 30 seconds after you have returned to center from the head forward position. However, you should keep your eyes closed and continue

responding to the number series until directed to stop. (Pause.) Are there any questions? (Pause on tape and prepare to stop tape if questioned.)

Stand by to begin Part II. Ready. Close your eyes. Begin rotation. (Number series starts here.) End of Part II. You may open your eyes. Thanks for your cooperation.

APPENDIX B

Score Sheet for BVD-2P

NAME _____ DATE _____ APL# _____

23	13	35	25	83	20 7	16	47	44	92	65	32	
15	03 4	10 6	06 7	98	96	34	46	17	70 9	01 11	06	5
75	67	93	47	83	76	08 7	06 10	17	46	27	45	
05 12	68	73	55	03 11	50 11	39	47	01 8	67	30 10	92	
54	72	25	83	26	38	27	95	24	02 13	24	30	5
50 9	07 9	90 14	80 11	20 8	92	46	62	03 6	66	14	75	
14	92	72	13	97	36	75	30 5	18	61	02 5	13	
87	52	62	25	59	15	08 12	48	28	05 7	43	40	7
10 8	39	06 8	22	19	80 13	92	40 12	85	71	19	86	
38	20 11	12	80 10	50 14	77	21	71	76	88	77	59	
97	43	74	71	74	95	20 3	43	10 7	79	20 9	36	
67	31	18	17	12	88	98	70 10	34	10 10	78	80	14
49	10 2	40 12	90 16	31	01 16	54	85	65	25	90 17	83	
09 13	61	97	61	95	79	04 9	16	30 8	42	18	73	
73	57	83	25	50 10	28	17	72	22	27	82	52	
12	03 12	98	56	56	28	19	55	68	22	65	25	
01 3	13	08 17	58	75	09 10	84	80 13	92	01 4	13	90	14
17	52	91	03 13	42	43	10 5	36	01 11	32	35	85	
42	83	69	73	04 6	68	28	84	81	08 5	07 8	95	
69	79	71	90 12	98	59	73	78	93	56	15	21	
04 15	05 16	92	47	49	70 16	37	56	75	87	17	82	
33	74	02 11	86	04 13	47	06 10	56	70 12	12	15	04	10
61	86	59	98	35	46	52	08 11	51	05 3	07 6	12	
28	09 14	66	71	80 13	79	13	85	56	63	71	73	
85	24	08 12	30 4	16	50 14	83	19	22	11	69	20	5
09 13	34	14	38	65	47	90 12	90 18	80 10	59	70 16	47	
38	42	43	44	37	85	65	82	74	05 14	92	37	
60 14	09 6	31	27	96	65	55	43	95	32	91	59	
49	79	01 4	07 9	04 15	05 11	30 8	09 7	06 14	53	98	85	
54	57	13	35	85	76	39	46	83	89	54	60	11
R												
W												
O												

B-1

APPENDIX C

Observer Rate Sheet

BVD Test Procedure

Rater's Name _____ Date _____

	Name									
Pallor										
Sweating										
Facial Expression										
Unsteadiness										
Slow Recovery										
Over-all										
TOTAL										
	Remarks									

APPENDIX D

Self-Rate Sheet (Rev.)

NAME _____ DATE _____

Check the following items at the appropriate point according to how this ride affected you:

1. Like ——— Dislike
2. No stomach effects ——— Strong effects
3. No dizziness ——— Strong dizziness
4. No sickness feelings ——— Strong feelings
5. Steady ——— Very unsteady
6. Hot ——— No change ——— Cold
7. Dry ——— Wet
8. Readiness for physical test ——— Non-readinesss
9. Readiness for aptitude test ——— Non-readiness
10. Not worried ——— Worried

Rate your reactions while accelerating and rotating.

11. No reaction ——— Strong reaction

Rate your reactions while decelerating and stopping.

12. No reaction ——— Strong reaction