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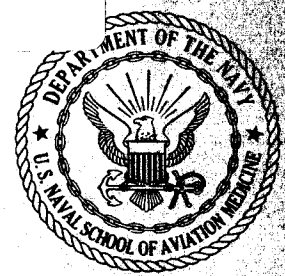
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SYMPTOMATOLOGY UNDER STORM CONDITIONS IN THE NORTH
ATLANTIC IN CONTROL SUBJECTS AND IN PERSONS WITH
BILATERAL LABYRINTHINE DEFECTS*

Robert S. Kennedy, Ashton Graybiel, Robert C. McDonough,
and Frederick D. Beckwith

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U. S. NAVAL SCHOOL OF AVIATION MEDICINE
U. S. NAVAL AVIATION MEDICAL CENTER
PENSACOLA, FLORIDA

SUMMARY PAGE

THE PROBLEM

To determine if labyrinthine defective subjects (L-D's) could be made seasick under severe weather conditions and to determine the comparative effects in normal subjects of whom many were highly resistant to motion sickness under various force environments.

FINDINGS

Ten L-D and twenty normal subjects sailed from North Sydney, Nova Scotia, to St. Pierre and return, the latter trip being made under extremely severe weather conditions. None of the L-D subjects manifested typical symptoms of motion sickness; one reported "gas in the stomach" and another "constriction in the throat and slight nausea--cerebral not gastrointestinal." Fifteen of the twenty normals vomited and five experienced severe or moderate malaise. All of the L-D subjects reported discomfort due to the physical conditions, and some were afraid. This fear bordered almost on panic in several of the normals, contributing to the stress, and was the origin of some of their symptoms.

Were it possible for motion sickness symptoms to be precipitated by fear, then the L-D subjects surely would have become sick. The fact that they did not suggests that, even in instances where motion sickness symptoms appear to be triggered by anxiety, the vestibular organs play an essential etiological role.

ACKNOWLEDGMENTS

Many persons of good will participated in this experiment. Special acknowledgment is due to all of the subjects, some of whom served as assistants, and to the Captain and crew of the MS MIQUELON.

INTRODUCTION

That many deaf persons are unsusceptible to motion sickness has been known since at least the time of James (1). Later work by Sjöberg (2) suggested that lack of labyrinthine function was responsible for resistance to seasickness and not a history of deafness per se. Sjöberg's study was in two parts: 1) Three young females who were selected out of thirty deaf persons failed to become sick when hoisted up and down by means of a crane, and 2) four dogs who previously became sick in the crane did not do so after bilateral labyrinthectomy. Recent attempts have been made to extend Sjöberg's studies by exposing larger groups of vestibular defective individuals to unusual force environments. In these studies normal males and labyrinthine defectives (L-D's) were subjected to: acrobatics in aircraft (3,4), head movements in the Pensacola Slow Rotation Room (5), changing linear forces in a counter rotating room (6), and weightlessness induced by flying Keplerian trajectories (7). None of the L-D subjects reported symptoms which were characteristic of motion sickness in any of the above circumstances. On the other hand, typical symptoms of motion sickness were observed in all of the control subjects in one or more of these force environments.

The present study was undertaken partly to determine if L-D subjects could be made seasick under severe weather conditions and partly to determine the comparative effects in normal subjects, many of whom were highly resistant to motion sickness under the conditions mentioned above.

PROCEDURE

THE SHIP

The ship used in this experiment (Figure 1) was the MS MICHELON (French), a round bottomed, wooden, sea-going tug, and former U. S. Army transport. It was short (145'), narrow (33' abeam), light (546 tons), shallow draft (15'6"), and lacked stabilization gear. When underway, these unusual dimensions occasioned a great deal of roll, but the ship was seaworthy.*

SUBJECTS

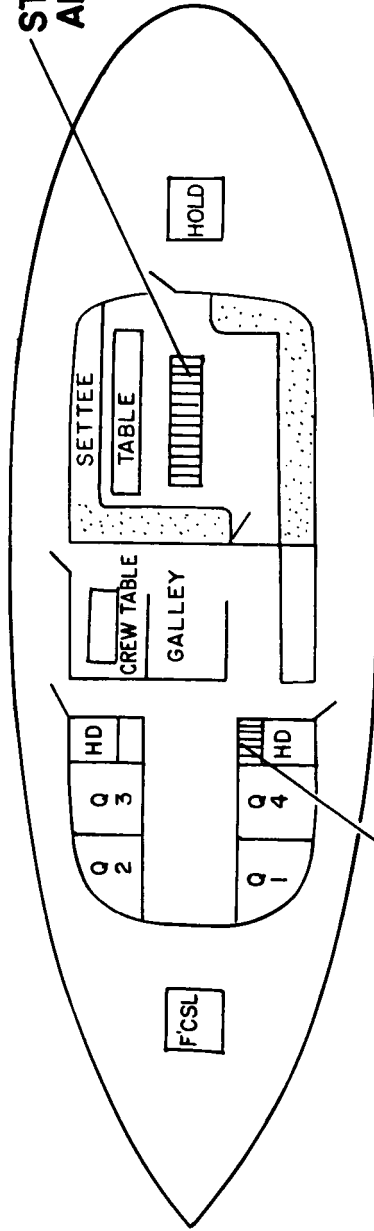
Twenty controls and ten labyrinthine defective (L-S) subjects comprised the experimental group. All were males in good health. The positive function of the vestibular apparatus was assessed by five tests: 1) threshold caloric (8), 2) counterrolling (9), 3) a new quantitative ataxia test battery (10), 4) Slow Rotation Room (SRR) performance (11), and 5) a Motion Sickness Questionnaire (MSQ) (12).

*As testimony to its being seaworthy: For several years it has been used as a year-round ferry and supply ship between North Sydney, Nova Scotia, and St. Pierre/Michelon, a French possession in the North Atlantic off the coast of Newfoundland. Heavy seas are routine during the winter months, and on some crossings even the ship's crew have reported seasickness.

SHIP'S LENGTH 145 feet
 BEAM 33 feet
 DRAFT 15 feet 6 inches

← 35' → | ← 20' → |

STAIRS TO CABIN D
 AND CREWS QUARTERS



ENTRANCE TO BRIDGE
 AND CABINS E & F

Figure 1

MS MIQUELON

1) Threshold Caloric--All the control subjects manifested a clear-cut nystagmic response above 34.4° C, all but two of them above 35.5° C. In the L-D subjects there was evidence of a nystagmic response in some instances to prolonged irrigation of the ear with water at or below 10° C, but its significance in terms of vestibular function was doubtful; in any event, it is altogether likely that no useful canal function remained in any of these subjects.

2) Counterrolling--The counterrolling index (13) was normal in the control subjects. Two of the L-D subjects manifested slight (far less than normal) roll, and it was negligible in the remainder.

3) Ataxia Test--The performance of the controls was far better than that of the L-D's (before practice, ref. 10), with one exception. The one exception was subject ZA who obtained a 50th percentile score on one portion of this test (Walking eyes open), and he has had much experience in ballet. All other L-D scores on all the other subtests were in the first percentile.

4) Slow Rotation Room--All the subjects were exposed to a standardized procedure, the Dial Test (14), aboard the SRR. The subjects rotated at 7.5 RPM and if symptom free at the conclusion of 100 dial settings, the speed was increased to 10 RPM and then similarly to 20 RPM. Some of the subjects terminated their exposure at either 7.5, 10, or 20 RPM, and three control subjects completed 20 RPM with only very minor symptoms. All the L-D's executed their test through 20 RPM and without symptoms of motion sickness.

5) Motion Sickness Questionnaire--The past histories of motion sickness in the control group presented a range of susceptibility. Nine of the control subjects were considered highly resistant to motion sickness because their backgrounds gave evidence of many occasions in which they might have experienced motion sickness and did not do so. Two were senior flight surgeons (BE, MC); two were retired Navy enlisted men (UP, TR); one was the research pilot (CA) who normally flies the airsickness profiles (i.e., acrobatics) in a research aircraft; three were regular volunteer laboratory research subjects (DE, VA, JD), and one was an experimenter (KE) from Slow Rotation Room studies; the other eleven members of the control group were of varying susceptibilities. Of the ten L-D's only two reported a past history of motion sickness. In each case these were single incidents which occurred in childhood and probably before meningitis had developed.

Results of Clinical Findings

The results of the findings from these five measures indicated that, while a normal range of vestibular function was manifested in the control group, this function was either absent or of no practical significance in the L-D group. The susceptibility to motion sickness was nil in the L-D subjects while the controls as a group were less susceptible than the average.

LOGISTICS

The experimental plan was to board the ship in Nova Scotia for a 200-mile trip to the island of St. Pierre, requiring about eighteen hours, after which a rest period was planned, and the group was to await calm or rough weather for the return trip, depending on the sea state encountered on the first crossing.* In addition to the assessment of motion sickness symptomatology, plans were made to measure biochemical changes, postural equilibrium, and egocentric visual localization of the horizontal. These findings will appear in separate reports. Measurement of cardiovascular changes (specifically orthostatic hypotension) were intended but were not done because the experimenters became incapacitated. The linear and angular accelerations of the craft were also to be measured at certain intervals, and these experimenters too became incapacitated.

Motion sickness symptomatology was scored after the method of Graybiel (15) and the major vestibular symptoms used in this diagnostic categorization are included in Table I (from ref. 15).

During the two voyages, all subjects remained mainly in the salon, aft, or central cabin area, amidships. Both areas were approximately equidistant from the center of gravity, and a similar acceleration environment existed in both.

The first crossing from Nova Scotia to St. Pierre was uneventful. The sea was calm, and the ship's Captain claimed that, considering the time of year, the trip was one of the smoothest he had experienced. Very mild symptoms of motion sickness were reported by only a few men and these rapidly ($<$ two hours) subsided. Since the first trip proved uneventful for experimental purposes, it was decided to await rough weather for the return voyage to the mainland.

On the afternoon of the fifth day ashore a storm moved by, and the experimental group boarded the ship that evening. Because of the darkness, external visual reference aboard ship was nil. The ship cleared the harbor at 2100, and the sea condition was very rough. Waves were estimated at 40 feet, and these produced an estimated roll of 40+ degrees. The Captain was requested to rate the sea-state on a ten-point scale using the first trip as 1 (the mildest) and to consider 10 the most severe in his experience. This trip was assigned 7. Winds of 40 knots (gusts to 80 knots) were encountered for most of the first eight hours underway, after which the weather subsided. Acceleration recordings taken (not necessarily at the height of the storm) showed scend of $>$ 3G and roll rate of $>$ 10 degrees per second. The entire trip lasted twenty-eight hours, which was half again as long as the first trip. A further testimony to the condition of the sea state is the fact that two larger commercial ships sailing through the storm foundered and broke up.

*The attempt was to prove the experimental hypothesis of "100 per cent sick in the control group and zero per cent in the L-D group."

Table 1

IMPORTANT VESTIBULAR SYMPTOMS* USED IN DIAGNOSTIC CATEGORIZATION			
PATHOG-NOMONIC	MAJOR	MINOR	DIAGNOSTIC TERMS
VOMIT- ING	RETCHING		VESTIBULAR SICKNESS: VOMITING OR TWO MAJOR SYM. OR ONE MAJOR & TWO MINOR MALAISE III: ONE MAJOR OR TWO MINOR OR ONE MINOR & TWO OTHER MALAISE I: ANY SUBJ. SYM. OR ANY SIGN USUALLY ASSOC. WITH SUBJ. SYM. MALAISE II: ALL OTHER
	NAUSEA III OR II	NAUSEA I	
	INC. SALIV. III OR II	INC. SALIV. I	
	PALLOR III	PALLOR II	
	COLD SWEAT III	COLD SWEAT II	
	DROWSINESS III	DROWSINESS II	

* IN RARE INSTANCES OTHER SYMPTOMS QUALIFY
 (Graybiel, ref. 15)

Table II

Maximum Symptomatology Experienced by 10 L-D (Alphabetically Listed) and 20 Control Subjects (Ranked by Sickness) During 28 Hours at Sea

Controls		L-D's	
Subject	Symptoms	Subject	Symptoms
SA	Emesis	DO	Drowsiness*
WH	Emesis	GR	Drowsiness
MC	Emesis	GU	Drowsiness
DA	Emesis	HA	Throat constriction
BE	Emesis		Slight nausea (see text)
UP	Emesis	JO	Drowsiness
ST	Emesis	LA	Salivation
RI	Emesis	MY	General discomfort
TR	Emesis	PE	Drowsiness
AL	Emesis	ST	Gas on the stomach
TD	Emesis	ZA	Drowsiness
CA	Emesis		
KE	Emesis		
TB	Emesis		
PO	Emesis		
OV	Malaise III		
JO	Malaise III		
DO	Malaise III		
VA	Malaise III		
DE	Malaise II		

*Drowsiness was reported by all ten after 0200.

RESULTS

Table II categorizes the maximum symptomatology experienced by the control group and the ten L-D subjects. The control group is ranked by time of emesis or degree of "sickness"; fifteen of the twenty in the group vomited, and five experienced severe or moderate malaise. One of the ten L-D subjects reported "gas on the stomach" and another "constriction in the throat." The latter also recorded "slight nausea" on his response form but when questioned later, he claimed it was "cerebral" and not "gastro-intestinal." All ten mentioned "general discomfort" due to the physical environment, six also experienced "drowsiness" due to the late hour, and one, salivation while eating. None of these L-D subjects, however, manifested symptoms which were considered to be typical of motion sickness.

The control subjects' rankings were compared with ratings of performance in the SRR and responses on the MSQ. The rating scale employed classified the subjects as: 1) far more susceptible than average, 2) more than, 3) average, 4) less than, and 5) far less susceptible than average. The correlation coefficients for these variables appear as Table III and all are statistically significant.

Table III

Correlations Among SRR Performance, MSQ Responses, and Seasickness for
Twenty Control Subjects

1. Seasick rank and SRR performance	$r = .829^*$
2. Seasick rank and MSQ response	$r = .533^*$
3. SRR performance and MSQ response	$r = .690^*$

*For $N = 20$ an r of $.537$ is significant at the $.01$ level.

DISCUSSION

The results of this experiment are clear-cut. None of the L-D subjects exhibited characteristic symptoms of seasickness whereas all the control subjects did. Over 70 per cent of the controls vomited and the rest qualified for Malaise III or II (cf. Table I). All of the L-D subjects reported discomfort from the physical environment, and some reported that they were afraid. On the other hand, many of the control subjects who expressed fear did not begin to record these fears in their diaries until after their seasickness symptoms subsided. This seems particularly noteworthy with respect to the psychogenic cause of motion sickness, since the L-D subjects were extremely anxious throughout the first evening and none vomited. Indeed they would not go to sleep, but secured themselves to chairs in the salon and tried to play cards. It is felt that were it possible for motion sickness symptoms to be precipitated by fear such as some experienced, then they surely would have become sick. However, the fact that they did not become sick suggests, if it does not prove, that even in other instances where motion sickness symptoms appear to be triggered by anxiety the vestibular organs play an essential etiological role. Stated differently, anxiety may modulate the severity of motion sickness symptoms, but inasmuch as the relative contribution of their influence upon the control subject's performance is unknown, in the absence of verifiable vegetative reactions in the L-D subjects it is suggested that the vestibular stimulus was the major contributing component.

As the sea condition became less violent, vomiting episodes were less frequent, and by the time the ship docked after twenty-eight hours at sea, most of the control subjects (but not all) had fully recovered.

The high correlations which were obtained between the pretests of susceptibility (SRR and MSQ) and the time or degree of seasickness indicate that a general factor exists and demonstrates the need for adequate evaluation and selection of subjects prior to their exposure to experimental conditions. For example, the effects of drugs, temperature, or various force environments or any experiment where few subjects are utilized or the same subjects are used more than once could be influenced by these factors.

In summary it is felt that: 1) If these L-D subjects are representative of the population from which they were drawn (and there is no reason to suspect they are not), then vestibular function is a necessary requirement for the experience of motion sickness symptoms under seagoing conditions; 2) susceptibility as observed in a very rough sea condition is highly correlated with a laboratory technique for producing canal sickness and with a past history of motion sickness.

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Motion sickness						
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Labyrinthine defective subjects						
Vestibular apparatus testing						
Stress						

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