AD731655

NAMRL-1142

RESPONSE FROM AROUSAL AND THERMAL SWEAT AREAS DURING MOTION SICKNESS

Joseph A. McClure, Alfred R. Fregly, Efrain Molina,

and Ashton Graybiel

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

August 1971

Approved for public release; distribution unlimited.

13

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 Aerospace Medical Research Laboratory
Naval Aerospace Medical Institute
Naval Aerospace Medical Center
Pensacola, Florida 32512

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE

RESPONSE FROM AROUSAL AND THERMAL SWEAT AREAS DURING MOTION SICKNESS

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

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

Joseph A. McClure, Alfred R. Fregly, Efrain Molina and Ashton Graybiel

6. REPORT DATE
26 August 1971

7a. TOTAL NO. OF PAGES
9

7b. NO. OF REFS
9

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.
MR041.01.01-012088FG

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
NAMRL-1142

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
.6 ✓

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES
This study was supported in part by Defence Research Board of Canada, Grant No. 9310-112

12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

The sweat response from the palm (an arousal sweat area) is compared with that from the dorsal hand and arm (a thermal sweat area) during the elicitation of motion sickness by vestibular stimulation. Both palmar and dorsal sweating were detected by using galvanic skin response techniques. In addition, the dorsal sweat response was monitored by an electrochemical sweat sensor.

The palmar sweat response is maximal during the first few head movements while a subject is rotating at constant velocity and quickly declines with continuation of the stimulus. This is typical of the arousal sweat response seen on the palm of the hand in response to any unusual sensory input. On the other hand, dorsal sweating has a definite latency, followed by a gradual increase in magnitude of the esponse. This is characteristic of most motion sickness symptomatology.

With two of the eight subjects an increase in environmental temperature was required to obtain a dorsal sweat response. This suggests that the neural activity evoked by vestibular stimulation is superimposed on that already existing as a result of the thermal state.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Arousal sweating						
Galvanic skin response						
Motion sickness						
Sweat sensors						
Thermal sweating						
Vestibular stimulation						

Approved for public release; distribution unlimited.

RESPONSE FROM AROUSAL AND THERMAL SWEAT AREAS DURING MOTION SICKNESS

Joseph A. McClure, Alfred R. Fregly, Efrain Molina,

and Ashton Graybiel

Bureau of Medicine and Surgery
MR041.01.01-0120B8FG

Defence Research Board of Canada
Grant No. 9310-112

Released by

Captain N. W. Allebach, MC USN
Officer in Charge

26 August 1971

NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY
NAVAL AEROSPACE MEDICAL INSTITUTE
NAVAL AEROSPACE MEDICAL CENTER
PENSACOLA, FLORIDA 32512

SUMMARY PAGE

THE PROBLEM

The purpose of this experiment was to demonstrate sweat responses from the palm (an arousal sweat area) and the dorsal hand and arm (a thermal sweat area) during the elicitation of motion sickness by vestibular stimulation.

FINDINGS

A sweat response can be obtained from the palmar aspect of the hand during the initial few head movements while a subject is rotating at constant velocity. This response is maximal on the first one or two head movements and quickly declines with continuation of the stimulus. At a varying time interval after the commencement of head movements, a distinct sweat response occurs on the dorsal aspect of the hand and arm, independent of the palmar response. The latency and gradually rising level of the dorsal response are characteristic of most symptomatology seen in motion sickness.

ACKNOWLEDGMENTS

Dr. McClure is an Assistant Professor in the Department of Otolaryngology, University of Toronto and St. Michael's Hospital, Toronto, Canada, where part of this work was carried out. The generous support of Dr. Walter H. Johnson and the technical assistance of Mr. Theron L. Trimble are gratefully acknowledged.

INTRODUCTION

During the course of evaluation studies on various physiological sensors, galvanic skin response (GSR) was investigated with regard to its value as a parameter in the detection of motion sickness onset. It soon became evident that the response from an arousal sweat area such as the palm of the hand was quite different from the response from a thermal sweat area such as the dorsal hand during the elicitation of motion sickness. This finding led to the present study which attempts to demonstrate these two sweat phenomena with apparently separate mechanisms.

Galvanic skin response has been used for many years (mainly by psychologists) because of its value as an indicator of arousal (3,7,8,9). Present theory suggests that this arousal response is due to changes in electrical resistance across the skin that occur as a result of presecretory and secretory activity in the eccrine sweat glands (3,7,8). Such arousal states induce a sympathetic response, part of which is the activation of some eccrine sweat glands. Activiation of these glands induces a breakdown of the semipermeability of the cellular membranes within the gland. This change in membrane permeability plus the secretion of sweat into the gland's tubular duct permits an easier flow of current across the skin layers. In effect, galvanic skin responses are a manifestation of activated sweat glands acting as parallel pathways of lowered resistance.

It should be noted at this point that GSR generally refers to arousal type sweat responses. However, in this paper the term will be used to refer to any sweat response detected by the method of altered skin resistance.

With the aforementioned theoretical considerations in mind, it was found that GSR could be used effectively as an indicator of the onset and progression of early sweat responses during motion sickness. Similar techniques to indicate the onset of sweating were used by Hemingway (5) during motion sickness studies and Behr et al. (2) during caloric stimulation studies.

PROCEDURE

SUBJECTS

Eight young men ranging in age from 17 to 21 years served as subjects. Seven of these subjects were Navy enlisted men who showed no abnormalities on extensive medical and vestibular testing. The eighth subject was a civilian who was in good health, although no specific medical or vestibular tests were carried out.

APPARATUS

Motion sickness was elicited by subject-induced head movements while the subject was on a motor-driven chair rotating at constant velocity about a vertical axis.

Changes in skin resistance were detected by using Beckman miniature skin electrodes (Model API-063A) and a Sanborn 350-12 GSR bridge as a constant current source. The current was passed in and out across the skin at two electrode sites. The voltage difference between the two electrodes was amplified by a high impedance d-c amplifier, and the output of the d-c amplifier was displayed on a direct-writing Brush recorder.

An electrochemical sweat sensor (6) was used in addition to the GSR to indicate the profuse sweating commonly seen during motion sickness. This sensor utilizes a $LiCl-H_2O-AlCl_3$ sensing element (1) and responds to the moisture content of air that is passed over the skin surface.

METHOD

Because it was not possible to record two GSR responses simultaneously in different areas due to electrical "cross-talk," each subject experienced two runs on separate days. On one run the GSR electrodes and the electrochemical sweat sensor were both placed on the dorsal hand and arm, as illustrated in Figure 1. On the other run the electrochemical sweat sensor remained on the dorsal hand, and the GSR electrodes were placed on the palmar aspect of the distal phalanges of the right thumb and little finger, as illustrated in Figure 2.

Each subject was rotated counterclockwise at an angular velocity that was known from previous experience to be effective in producing motion sickness. For each subject both runs were carried out at the same angular velocity. Subjects commenced side-to-side head movements at the request of the experimenter. Head movements were continued until profuse sweating occurred, as indicated by the electrochemical sweat sensor, or until the subject reached an endpoint that he estimated to be just prior to vomiting.

Control runs were also carried out in which the sensors were placed as in Figure 2, and the subject made side-to-side head movements with the chair stationary.

All runs were carried out in an environmental chamber in which a desired room temperature could be selected. Subjects entered the chamber in a resting physical state at least 15 minutes prior to the run. The chamber temperature was set at $75^{\circ}F$. During the run the air conditioning was turned off. However, at no time did the temperature rise more than $0.5^{\circ}F$ above the initial value. With three subjects who did not sweat at $75^{\circ}F$, the runs were carried out at $78^{\circ}F$.

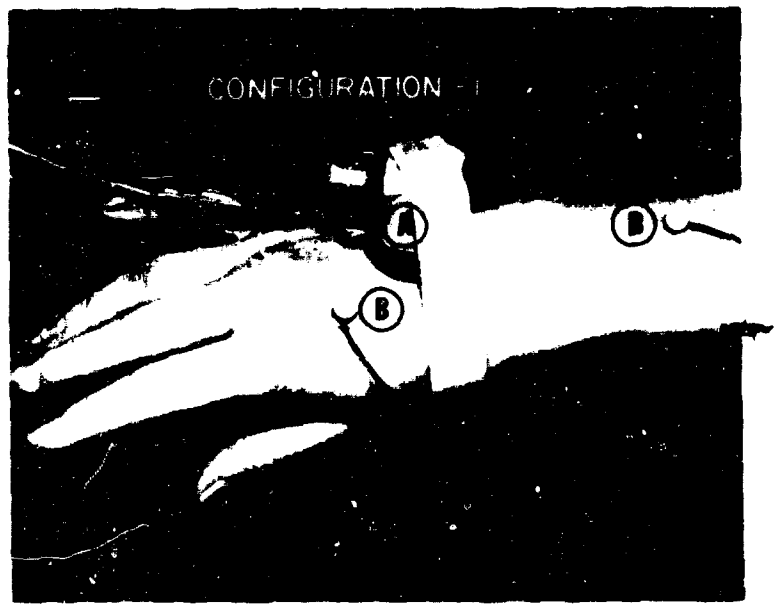

Figure 1

Configuration 1 with electrochemical sweat sensor (A) and GSR electrodes (B) on dorsal hand and arm areas.

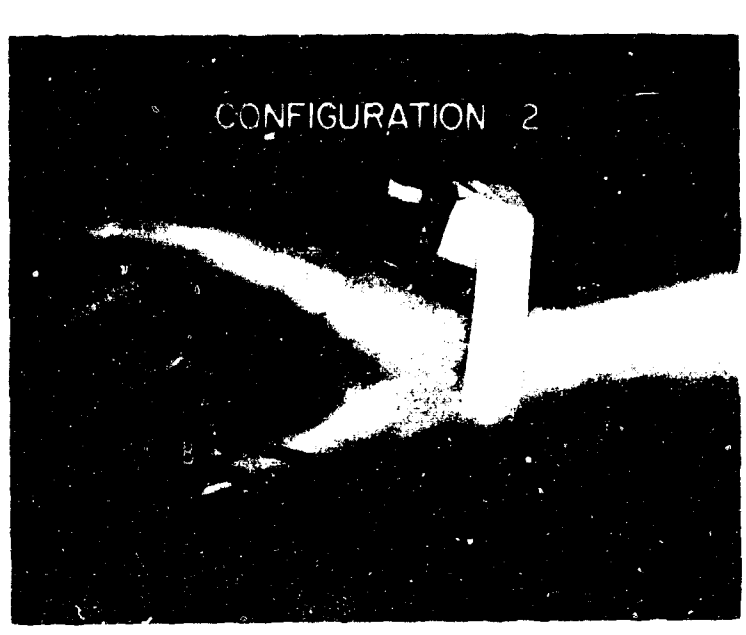

Figure 2

Configuration 2 with electrochemical sweat sensor (A) on dorsal hand and GSR electrodes (B) on palmar aspect of thumb and little finger.

RESULTS

Figure 3 illustrates the typical response from a subject, and compares the sensor activity for the two configurations. With the onset of head movements, all subjects demonstrated an immediate response from the palmar GSR as seen in the lower trace of Configuration No. 2. The response tended to be maximal during the initial few head movements and quickly declined with time in an exponential fashion. The small GSR response seen toward the end of the trace did not coincide with any known external stimuli. It is to be noted that the onset of the palmar GSR response occurred prior to the actual onset of the head movements. This early onset coincided with the time that the experimenter issued verbal instructions to begin head movements.

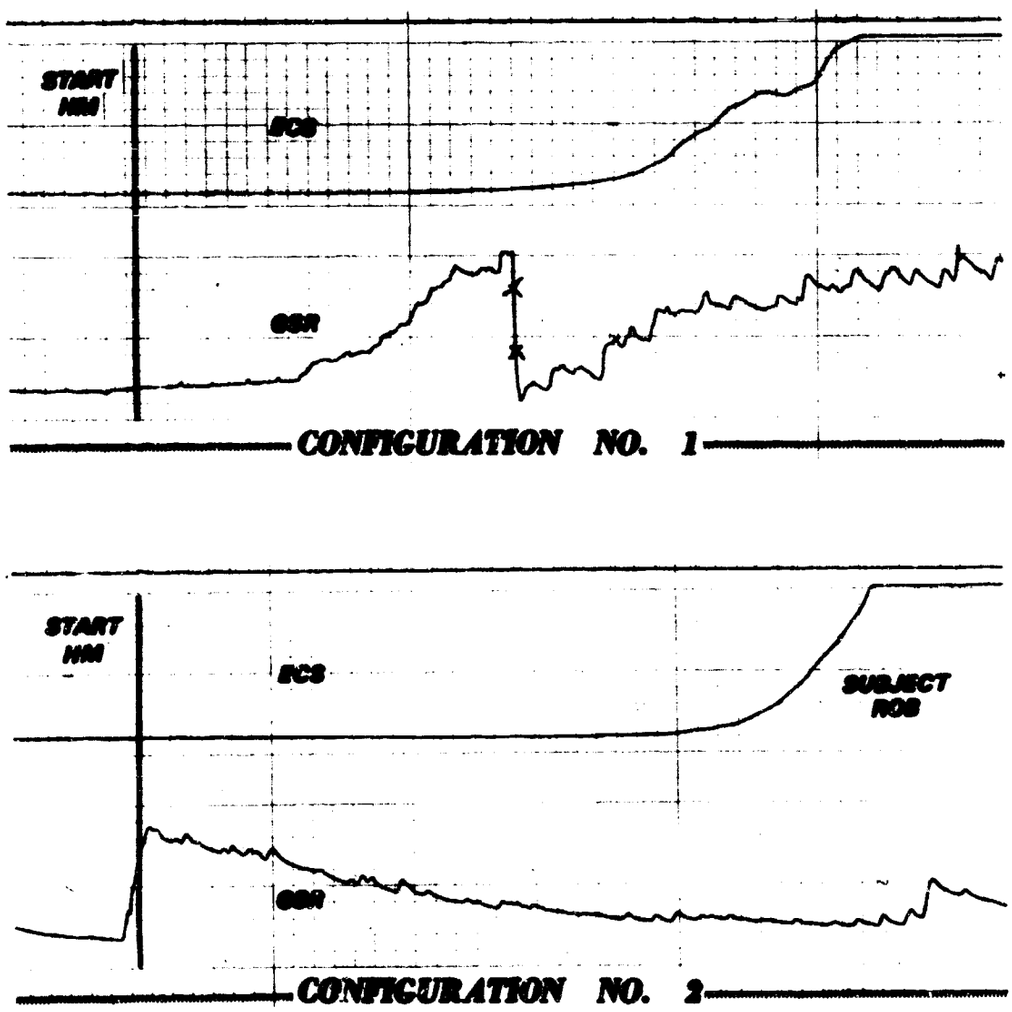

Figure 3

Typical dorsal and palmar sweat responses during continuous vestibular stimulation. ECS: electrochemical sweat sensor. GSR: galvanic skin response. HM: head movements. Paper speed 1 mm/sec.

In order to separate the effect of the auditory stimulus, runs were repeated on five of the subjects. On these runs verbal instructions were given to get ready for head movements, but the subject commenced head movements on his own some 10 to 15 seconds later. A typical result is shown in Figure 4, and clearly demonstrates a palmar GSR response following auditory stimulation and again following the onset of vestibular stimulation.

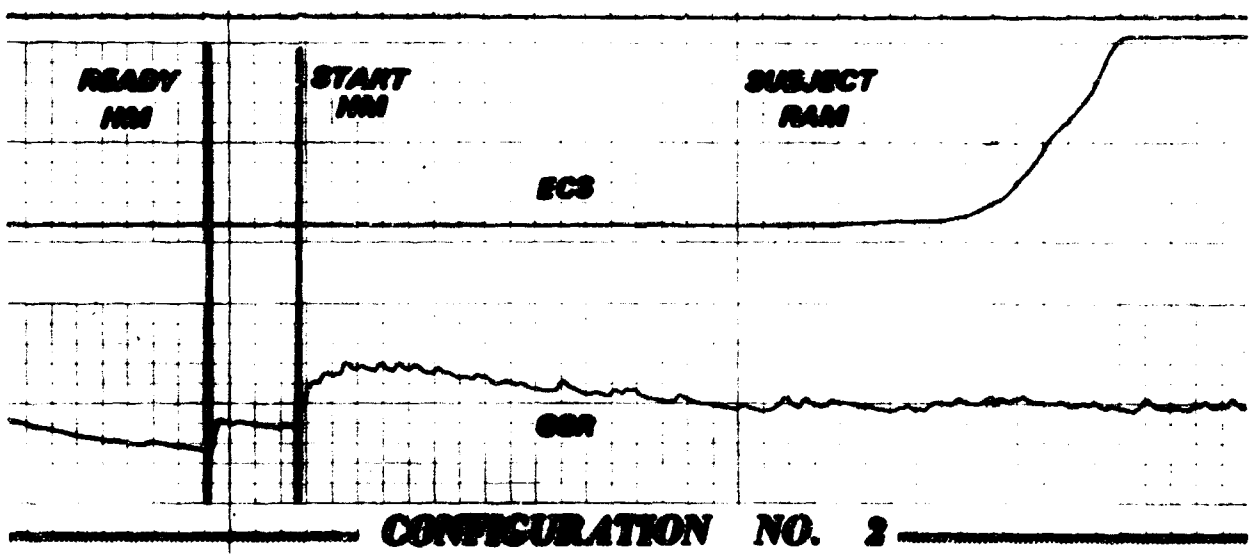

Figure 4

Typical palmar sweat response when experimenter's auditory command precedes actual onset of vestibular stimulation. ECS: electrochemical sweat sensor. GSR: galvanic skin response. HM: head movements. Heavy vertical lines indicate onset of auditory command and vestibular stimulation. Paper speed 1 mm/sec.

Referring again to Figure 3, it can be seen that with the initial few head movements, no response was recorded from the dorsal GSR, as illustrated in Configuration No 1, lower tracing, or from the electrochemical sweat sensor. However, during the development of motion sickness, all subjects but one demonstrated sweating on the dorsal hand and arm similar to that illustrated for Configuration No. 1 of Figure 3. It can be seen also that during the period of profuse sweat activity on the dorsal arm, very little activity was seen in the way of a similar response from the palmar GSR. In fact, for most subjects the palmar GSR continued to decline toward its resting level during the period of active dorsal sweating.

In Figure 5 the palmar sweat responses from a subject making head movements without rotation are illustrated. Dorsal sweat response did not occur in the runs without rotation. Palmar GSR responses were present in all cases but tended to be of lesser magnitude without rotation.

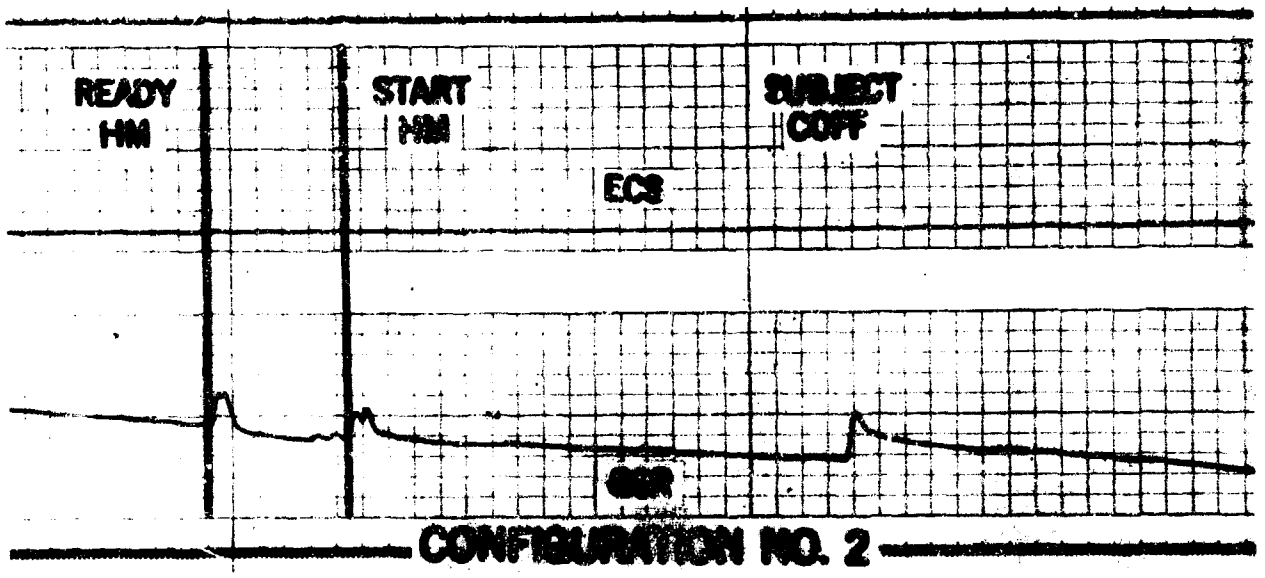

Figure 5

Typical palmar sweat response without chair rotation.

For two of the three subjects who did not show sweat activity on the dorsal area at 75°F, a typical response similar to that shown in Figure 3 was obtained by raising the environmental temperature to 78°F. The third subject did not sweat at either temperature although he still demonstrated the palmar GSR response at the commencement of stimulation.

DISCUSSION

The results clearly demonstrate that there are two distinct sweat responses that can be obtained at different times during exposure to vestibular stimulation.

The palmar response is greatest during the first few head movements. This represents a time when the subjective sensation of apparent body motion is new and probably of maximal intensity. The return of the palmar response to the resting level is suggestive of some form of adaptation that eliminates the response despite continued vestibular sensory input. Because of its short latency, palmar sweating would fall into the category of reflex vestibular phenomena (4) and would not constitute part of the motion sickness complex.

In more general terms, the palmar sweating seen in this experiment represents the typical arousal GSR response seen when an individual is first confronted with any sensory input of an unusual or threatening nature. This is borne out in Figure 4 where the palmar GSR is separated into an auditory and vestibular component. The trace in Figure 5 also supports this since responses can be obtained even without rotation.

Sweating on the dorsal hand area does not occur with the initial onslaught of sensory input. Instead, the sweating in this area has a latency usually of several minutes, and, once initiated, a gradual rising level of response with continued stimulation. This type of response is characteristic of most motion sickness symptomatology, and is typical of an integrative type function. In other words, with constant sensory input and once the threshold is reached, the response continues to rise within the limits of the system.

It was noted in two subjects that dorsal sweating was obtained only after the environmental temperature was raised 3°F. This strongly suggests that the neural pathways effecting the sweat response of motion sickness coincide with the pathways utilized in the response to thermal changes. This could be in the form of a summation of neural inputs from the vestibular and thermal systems or in the form of an alteration of the threshold level for thermal sweating brought about by vestibular stimulation.

CONCLUSIONS

The sweat response on the palm of the hand represents an arousal response which in this experiment was evoked in part by vestibular stimulation.

The sweating of motion sickness occurs in so-called thermal sweat areas, and the neural activity evoked by vestibular stimulation would appear to be superimposed on that already existing as the result of the thermal state.

The use of sweating as an indicator of motion sickness intensity is less reliable when environmental temperature is not controlled.

The value of using sensors to objectify responses during motion sickness has been demonstrated.

REFERENCES

1. Ackerman, U., A detector for the outbreak of sweating. Report No. 10. Toronto, Ontario, Canada: University of Toronto, Institute of Bio-Medical Electronics, 1969.

2. Behr, K., Preber, L., and Silfverskiold, B. P., Recording of the skin resistance in thermal and rotatory stimulation of the labyrinth. Acta Psychiat. Neurol. Scand., 30:741-748, 1955.

3. Darrow, C. W., and Gullickson, G. R., The peripheral mechanism of the galvanic skin response. Psychophysiol., 6:597-600, 1970.

4. Graybiel, A., Structural elements in the concept of motion sickness. Aerospace Med., 40:351-367, 1969.

5. Hemingway, A., Survey of research on the problem of airsickness in the Army Air Forces. Research Report No. 1. Randolph Field, Texas: Army Air Force School of Aviation Medicine, 1945.

6. McClure, J. A., Molina, E., and Fregly, A. R., A qualitative sweat sensor. NAMRL Report. Pensacola, Fla.: Naval Aerospace Medical Research Laboratory, 1971, in preparation.

7. Montagu, J. D., and Coles, E. M., Mechanism and measurement of the galvanic skin response. Psychol. Bull., 65:261-279, 1966.

8. Venables, P. H., and Martin, I., Skin resistance and skin potential. In: Venables, P. H., and Martin, I. (Eds.), A Manual of Psychophysiological Methods. New York: John Wiley and Sons, 1967. Pp. 53-102.

9. Wilcott, R. C., Palmar skin sweating vs. palmar skin resistance and skin potential. J. Comp. Physiol. Psychol., 55:327-331, 1962.